2.6 Student Performance and Learning Outcomes

2.6.1 Programme and course outcomes for all Programmes offered by the institution are stated and displayed on the website and communicated to teachers and students

S. No.	Content
1.	Notice for College and Department Orientations
2.	Link to the Course Syllabus Documents on the College Website
3.	Sample Syllabus of Courses with their Stated Course Outcomes
4.	Details and Proof of Faculty Participation in Course Making and Revision

Notice for College and Department Orientations

Gmail Divya Singh <divyasingh@ststephens.edu>

Fwd: Commencement Service, Orientation & Fresher's lunch

2 messages

Sanjeev Grewal <sanjeevgrewal@gmail.com> Tue, 15 Aug 2023, 2:47 PM
To: Poonam Kalra <poonam.kalra@ststephens.edu>, Leema <leema.mohan@ststephens.edu>, Abhishek Singh <abhisheksingh@ststephens.edu>, Anurag Malhotra <anuragmalhotra@ststephens.edu>, Manjula Singh <manjula.singh@ststephens.edu>, Divya Singh <divyasingh@ststephens.edu>, Saumaly Ghosh <saumaly@ststephens.edu>, Srishti Gupta <srishti@ststephens.edu>

---------- Forwarded message ---------
From: **Principal St. Stephen's College** <principal@ststephens.edu>
Date: Tue, 15 Aug, 2023, 2:38 pm
Subject: Commencement Service, Orientation & Fresher's lunch
To: RENISH ABRAHAM <bursar@ststephens.edu>, Malay Neerav <malayneerav@gmail.com>, Karen Gabriel <gabriel.karen@gmail.com>, Mahesh Gopalan <maheshgopalan@ststephens.edu>, Samuel John <samueljohnshekhar@gmail.com>, Sanjeev Grewal <sanjeevgrewal@gmail.com>, Archana Chopra <archana.chopra@ststephens.edu>, Jacob Cherian <jacob1cherian@gmail.com>, Vibha Sharma <vibha.sharma@ststephens.edu>, Ashutosh Dayal Mathur <admathur@ststephens.edu>, SHAMIM AHMED <dr.shamimahmed@yahoo.com>, Sunita Prasher <sprasher2011@yahoo.com>, Alphy Geever <alphyg93@gmail.com>, Silika Mohapatra <silikamohapatra@gmail.com>, Annie Samson <annie@ststephens.edu>, Rohit Mathew <rohit.mathew23@gmail.com>, Sanjay Rao Ayde <aydesanjayrao@gmail.com>
Cc: P S <pstoprincipal@ststephens.edu>

Dear Colleagues,

Greetings.
We are on the threshold of a new academic year. I wish each one of you and all our colleagues a fruitful and satisfactory year ahead.

- Tomorrow we formally begin our work and **I invite, on behalf of the Chairman, all of you who are interested in joining the Commencement Service at 8 am in the College Hall.** The Holy Communion service will be celebrated by the Chairman of the College and Bishop of Delhi, the Rt Revd Dr Paul Swarup. Our Chaplain, Revd Samuel will assist the Bishop.
- As is the tradition we will have the **orientation for the first-year Junior Members at 10 am in the College Hall.** Faculty will enter in procession from the staff Room at 9.45 am and the Senior Tutor is requested to ensure the order in which the faculty will proceed to occupy their positions on the stage.
- Following this, by **11.15 the Heads of Departments will lead their respective students for the Departmental Orientation** to the rooms specified for this.
- After this there will be the **Fresher's Lunch from 12.30 onwards i**n two batches. Batch composition will be announced by the Senior Tutor tomorrow.

PLEASE NOTE

1. Senior Officers of the College and HoDs should occupy the first two rows on the stage to facilitate easy access to the podium if they are asked to speak during the Orientation in the College Hall.
2. Classes for the second and third year Junior Members are suspended till 2 pm tomorrow on account of the Orientation.
3. All teaching faculty are requested to be present for the orientation from 9.30 am onwards tomorrow and also for lunch with the first-year Junior Members. HoDs to please ensure this.

Thank you and with all good wishes,

Prof John Varghese
Principal
St Stephen's College

Link to the Course Syllabus Documents on the College Website

https://www.ststephens.edu/syllabi/

Sample Syllabus of Courses with their Stated Course Outcomes

UNIVERSITY OF DELHI

CNC-II/093/1(26)/2023-24/

Dated:23.10.2023

N O T I F I C A T I O N

Sub: Amendment to Ordinance V

[E.C Resolution No. 14-1/-(14-1-3/-) dated 09.06.2023 and
EC Resolution No.27-1 (27-1-5) dated 25.08.2023]

Following addition be made to Appendix-II-A to the Ordinance V (2-A) of the Ordinances of the University;

Add the following:

Syllabi of Semester-IV, V and VI of the following departments under Faculty of Social Sciences based on Under Graduate Curriculum Framework -2022 implemented from the Academic Year 2022-23 :

(i) Economics

SEMESTERS–VI

DEPARTMENT OF ECONOMICS

Category I

(B.A. Honours in Economics in three years)

DISCIPLINE SPECIFIC CORE COURSE -16 (DSC-16): International Trade

Course title & Code	Credits	Duration (per week)			Eligibility Criteria	Prerequisite
		Lecture	Tutorial	Practical / Practice		
International Trade – ECON016	4	3	1	0	Class 12th with Mathematics	Introductory/Principles of Microeconomics

Learning Objectives

The Learning Objectives of this course are as follows:

- This course introduces the basics of international trade theory and examines the effects of trade policies for domestic and world welfare. It covers bother classical and new trade theories.
- This course develops a systematic exposition of models that try to explain the composition, direction, and consequences of international trade.
- Apart from the introduction to theoretical models, students will also be exposed to real-world examples and casestudies.

Learning outcomes

The Learning outcomes of this course are as follows:

- The students would be able to understand the main theoretical and empirical concepts in international trade that equip them with a thorough analytical grasp of trade theories, ranging from Ricardian comparative advantage to intra-industry trade.
- It familiarises students with the main issues in trade policy and with the basic features of theinternationaltradingregime.

Syllabus

UNIT I: Neoclassical Trade Theories (15 hours)
Ricardian trade theory of comparative advantage. Gains from trade. Comparative advantage with many goods; Specific factor model; income distribution and trade policy, international factor mobility models; Standard Trade Model, economic growth, immiserizing growth and intertemporal trade; Heckscher-Ohlin theory; factor price equalisation, Rybczynski and Stolper-Samuelson theorems, Heckscher- Ohlin-Vanek Model, Offercurve.

UNIT II: New trade theories and firms in the global economy (15 hours)
External Economies of Scale, learning curve, intra-industry trade, monopolistic competition and firm responses to trade; international Location of Production, horizontal and vertical multinationals; Gravity model, Firms in the global economy. Global value chain and offshoring of goods and services.

UNIT III: International Trade Policy Concerns (15 hours)
Instruments of trade policy, static welfare analysis of tariffs, quotas and subsidies. Equivalence of tariffs and quotas. Effective rate of protection. Export subsidies and countervailing duties; Oligopoly and International trade. Strategic tradepol-icy; International Agreements: Trade, Labour and Environment Multilateralism, WTO, RegionalTradeAgreementsandNewProtectionism

Recommended readings

- Feenstra, R., Taylor, A. (2014). *International Trade*, 3rd ed. Worth Publishers. (Abbreviation used:FT)
- Krugman, P., Obstfeld, M., Melitz, M. (2018). *International Economics - Theory and Policy*, 11th ed. Pearson Education. (Abbreviation used: KOM)
- Gandolfo, G. (2014), *International Trade Theory and Policy (with contribution fromFedericoTrionfetti*)2nded.,Springer.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE -17 (DSC-17): Development Theory and Experience

Course title & Code	Credits	Duration (per week)			Eligibility Criteria	Prerequisite
		Lecture	Tutorial	Practical/ Practice		
Development Theory and Experience – ECON017	**4**	**3**	**1**	**0**	**Class 12th with Mathematics**	**NIL**

Learning Objectives

The Learning Objectives of this course are as follows:

- It highlights the dynamic interconnections between the social and economic aspects of the development process.
- In particular, the course deals with the macro and micro aspects of demography, fertility choices and gender bias.
- It also discusses the process of migration through elaborate models highlighting the rural-urban sectoral interrelationships.
- It describes the peculiar characteristics of rural institutions which shape contracts across labour, land and credit markets in the rural economy.
- It discusses the efficiency of such contracts even while they deviate from the traditional competitive marketcontracts.

Learning outcomes

The Learning outcomes of this course are as follows:

- This course updates the students the unprecedented progress that has been made in many parts of the developing world—but fully confronts the enormous problems and challenges experienced during the recent decades.
- The student would understand the wide diversity of development approaches adopted across the developing world, and the differing positions in the global economy held by developing countries.
- This will help them understand better the economic development policy and programmesacrossemployedbyWorldBankandnationaleconomies.

Syllabus

UNIT I: Demography, Gender and Development (12 hours)
Demographic concepts; birth and death rates, age structure, fertility and mortality; demographic transitions during the process of development; gender bias in preferences and outcomes and evidence on unequal treatment within households; connections between income, mortality, fertility choices and the impact of intra-household gender inequality (in allocation of resources) and labour markets as genderedinstitutions.

UNIT II: Migration and Development (9 hours)
Models of migration, sectoral dynamics and the relationship between rural and urban sectors.

UNIT III: Land, Labour and Credit Markets (12 hours)
The distribution of land ownership; land reform and its effects on productivity; contractual relationships between tenants and landlords; land acquisition; nutrition and labor productivity; informational problems and credit contracts; micro-finance; inter-linkages between rural factor markets.

UNIT IV: Institutions and coordination (12 hours)
The determinants of democracy; alternative institutional trajectories and their relationship with economic performance; within-country differences in the functioning of state institutions; state ownership and regulation; government failures and corruption.

Recommended readings

- Acemoglu, D., & Robinson, J. A. (2006). *Economic origins of dictatorship and democracy*. Cambridge UniversityPress.
- Robinson, J. A., & Acemoglu, D. (2012). *Why nations fail: The origins of power, prosperity and poverty*. London:Profile.
- Perkins, D. H., Radelet, S. C., Lindauer, D. L., & Block, S. A. (2013). *Economics of Development*. 7th Edition, New York: WW Norton &Company.
- Todaro, M. P., & Smith, S. C. (2020). *Economic Development*. PearsonUK.
- Debraj Ray (2009), *Development Economics*, Oxford University P r e s s
- RobertT.Jensen(2010),*EconomicOpportunitiesandDifferencesinHumanCapital:ExperimentalEvidenceforIndia*,NBERWorkingPaperNo.16021.
- Pitt, Mark, Mark Rosenzweig and Nazmul Hassan. (1990). "Productivity, Health and Inequality in the Intrahousehold Distribution of Food in Low- income Countries."*AmericanEconomicReview*,80(5):1130-1156.
- Elson, Diane (1999) Labour markets as gendered institutions: Equality, Efficiency andEmpowermentIssues,*WorldDevelopment*,vol27(3),p611-627.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

DISCIPLINE SPECIFIC CORE COURSE -18 (DSC-18): Indian Growth and Development

Course title & Code	Credits	Duration (per week)			Eligibility Criteria	Prerequisite
		Lecture	Tutorial	Practical/ Practice		
Indian Growth and Development	**4**	**3**	**1**	**0**	**Class 12th with Mathematics**	**NIL**

Learning Objectives

The Learning Objectives of this course are as follows:

- Using appropriate analytical frameworks, this course reviews major trends in economic indicators of macro and development issues and policy debates in India in the post-Independence period, with particular emphasis on paradigm shifts and turning points.
- This course intends to give an introduction to students as to how they could explore problems related to the Indian economy by familiarizing them with the research studies on areas relating to economic development and policy in India with an emphasis on contemporary debates.

Learning outcomes

The Learning outcomes of this course are as follows:

- The students should be able to understand the development paradigm adopted in India since independence and evaluate its impact on economic as well as social indicators of progress.
- The students will acquire ability to explore current policy debates and contribute to policy making in an informed way using relevantdatabases.

Syllabus

UNIT I: Economic Growth since Independence (12 hours)
Major features of the economy at independence; growth under different policy regimes—goals, constraints, institutions and policy framework; an assessment of performance—sustainability and regional contrasts; structural change, savings and investment

UNIT II: Sectoral Performances and Concerns (12 hours)
Issuesinagriculture,industryandservices.

UNIT III: Inclusive Growth - trends and patterns, Distributional Issues and Policies Demography, Poverty and Unemployment (9 hours)

UNIT IV: Economic Policies and their Impact (12 hours)
Evolution of macroeconomic framework applied in Indian economy and its impact, fiscal policy; financial and monetary policies; trade and investment policy, five-year plans

Recommended readings

- Ahluwalia,M.S.(2019),"India'seconomicreforms:AchievementsandNextSteps", *Asian Economic Policy Review*, 14(1), 46-62.
- Bosworth, B., Collins, S. M., & Virmani, A. (2007). *Sources of growth in the Indian economy*. Working Paper no. 12901,NBER.

- Pulapre Balakrishnan, (2007), "The Recovery of India: Economic Growth in the Nehru Era", *Economic and Political Weekly*, November 10-23, 2007.
- Krishnamurty, K. (2002), Macroeconometric Models for India: Past, Present and Prospects *Economic and Political Weekly*, October 19, 2002.
- Arvind Subramanian and Josh Felman (2021) India's Stalled Rise-How the State HasStifledGrowth,*ForeignAffairs*on14.12.2021.
- Acharya, S. and Mehrotra, S. (2020), The Agricultural Market Reforms: Is there a trade-off between efficiency and equality? Working Paper Series, Institute of HumanDevelopment.
- Shah, Mihir (2007), Rural Credit in 20th Century India: Overview of History and Perspectives,*EconomicandPoliticalWeekly*,Vol.42,IssueNo.15,14April2007.
- NagarajR(2013),India'sDreamRunUnderstandingtheBoomandItsAftermath,
- *Economic and Political Weekly* Vol 48, No. 20,May 18, 2013.
- Chanda, R. (2019), India's Services Sector; trends, opportunities and challenges,in Uma Kapila(ed.), *Indian economy-2: Macroeconomic policies, Sectoral Develop- ments andPerformance*.
- Dipak Mazumdar and Sandip Sarkar (2009) "The Employment Problem in India and the Phenomenon of the 'Missing Middle' *The Indian Journal of Labour Eco- nomics*, Vol. 52, No. 1,2009
- Chakraborty, Achin, (2015), Reforming Labour Markets in States: Revisiting the FutilityThesis,*EconomicandPoliticalWeekly*,May16.
- Thomas, J. J. (2020). 'Labour Market Changes in India, 2005–18', *Economic and Political Weekly*, 55(34),57.
- James, K.S., &Srinivas Goli (2016), "Demographic Changes in India: Is the Coun- try Prepared for the Challenge?" *Brown Journal of World Affairs*, Fall/Winter 2016, Volume XXIII, IssueI.
- Desai, S. (2015), "Demographic deposit, dividend and debt", *The Indian Journal of Labour Economics*, 58, 217-232.
- Drèze,JandKhera,R.,2016,'RecentSocialSecurityInitiativesinIndia'Available athttp://dx.doi.org/10.2139/ssrn.2800699.
- Vijay Joshi, (2016), *India's Long Road: The Search for Prosperity*, Allen Lane, Gurgaon, Ch2.
- Rakesh Mohan, (2019), *Moving India to a new Growth Trajectory: Need for a ComprehensiveBigPush*,BrookingsIndia,Section1and2,9-30.
- Jagdish Bhagwati and Arvind Panagariya, (2012), *India's Tryst with Destiny*, CollinsBusiness,Noida,pp.4-5,32-38.
- PanagariyaA(2020),*IndiaUnlimited:ReclaimingtheLostGlory*,Chapter2.
- Jean Dreze and Amartya Sen, (2013), *India: An Uncertain Glory*, Allen Lane, chapters 2, 3 (pp. 72-80only).
- Kumar, R., & Patibandla, M. (2009). *Institutional dynamics and the evolution of the Indian economy*,Springer.
- McCartney,M.(2019).*TheIndianEconomy*.AgendaPublishingLimited.
- Goyal, A. (Ed.). (2019). *A Concise Handbook of the Indian Economy in the 21st Century*.OxfordUniversityPress.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

COMMON POOL OF DISCIPLINE SPECIFIC ELECTIVE (DSE) COURSES
FOR semester-IV/V/VI

Discipline Specific Elective 6 (DSE-6): Advanced Econometrics

Semester	Course title & Code	Credits	Duration (per week)			Eligibility Criteria	Prerequisite
			Lecture	Tutorial	Practical/ Practice		
V/VII	Advanced Econometrics – ECON036	4	3	1	0	Class 12th with Mathematics	Basic Econometrics (ECON024)

Learning Objectives

The Learning Objectives of this course are as follows:

- A prerequisite for this course is the knowledge of concepts in the Basic Econometrics course.
- It builds on the compulsory Basic Econometrics course and teaches students a broad set of commonly used econometric methods.
- These include estimating models with limited dependent variables, the use of instrumental variables to estimate models with endogenous regressors, as also estimation methods for time series and panel data sets.

Learning outcomes

The Learning Outcomes of this course are as follows:
Students will learn the theoretical and practical basis for techniques widely used in empirical research and consider their application in a wide range of estimation problems.

Syllabus

UNIT I: Stages in empirical econometric research (3 hours)

UNIT II: The linear regression model: The matrix approach, Review of model specification, estimation and testing (6 hours)

UNIT III: Limited dependent variables: Logit and Probit models for binary responses, Tobit models for truncated data. (9 hours)

UNIT IV: Selected Topics: Instrumental variable estimation, Simultaneous equation models, Experiments and Quasi-Experiments. (9 hours)

UNIT V: Dynamic econometric models: distributed lag models, autoregressive models; Panel data models and estimation techniques (9 hours)

UNIT VI: Introduction to econometric software (R/GRETL/EViews/Stata: ANY ONE); publicly available data sets and software will be used to estimate models and apply the techniques learnt. (9 hours)

Recommended readings

- Wooldridge, J. (2014). Introduction to econometrics: A modern approach, 5th ed. Cengage Learning.
- Asteriou, D and Hall, Stephen G, Applied Econometrics, 4th Edition, 2021, Pal- grave Macmillan.
- James Stock and Mark Watson, Introduction to Econometrics, 4th Edition, 2019, Pearson.
- Gujarati, D., Porter, D. (2012). Basic econometrics, 5th ed. McGraw-Hill.
- Gujarati, D. (2014). Econometrics by Final Examinationple, 2nd ed. Palgrave Macmillan.
- G.S. Maddala and Kajal Lahiri, Introduction to Econometrics, 4th Edition, 2012, Wiley.
- Badi H. Baltagi, Econometrics, 5th Edition, 2011, Springer.
- J. Johnston and J. DiNardo (2001), Econometric Methods, Fourth Edition, Irwin Mcgraw Hill

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Discipline Specific Elective 8 (DSE-8): Economics of Health

Semester	Course title & Code	Credits	Duration (per week)			Eligibility Criteria	Prerequisite
			Lecture	Tutorial	Practical/ Practice		
V/VII	Economics of Health– ECON038	4	3	1	0	Class 12th Pass	Introductory/Principles of Microeconomics

Learning Objectives

The Learning Objectives of this course are as follows:

- Health is important not only for human well-being but also for economic growth. This course provides a framework to understand the need for the study of health economics and the relationship of health with the GDP of a nation.
- The course also looks at the determinants of health, the demand for health and the need for government intervention in provision of health care. Economic evaluation / health technology assessment is also covered in the course.

Learning outcomes

The Learning Outcomes of this course are as follows:

- The students will learn the economic dimensions of health, determinants of health and microeconomic tools for the study of health care and expenditure.
- The course will enable the students to apply the theory to understand the various policies and market mechanisms in the field of health care. They will also be equipped with the fundamental techniques of economic evaluation of health interventions.

Syllabus

UNIT I: Health Economics (12 hours)
Significance and linkages with the economy:
The need for health economics as a discipline of study, importance of health in the development of an economy and its relationship with macroeconomic performance

UNIT II: Theoretical foundations of Health Economics (12 hours)
Demand for health and health care services, determinants of health, market failure and rationale for public intervention; and health insurance

UNIT III: Economic Evaluation of Health Sector (12 hours)
Cost-effective Analysis, cost-benefit analysis, cost-utility analysis

UNIT IV: Health Systems (9 hours)
An overview of international health systems and Indian experiences, and healthcare financing

Recommended readings

- Phelps, C. E. (2017). Health economics. Routledge
- Jay Bhattacharya Timothy Hyde Peter Tu (2014), Health Economics, Palgrave Macmillan
- William, Jack. (1999) Principles of Health Economics for Developing Countries, World Bank

Institute Development Studies.
- Glied, S., & Smith, P. C. (Eds.). (2013). The Oxford Handbook of Health Eco- nomics. Oxford University Press.
- Situational Analysis: Backdrop to the National Health Policy 2017, Ministry of Health and Family Welfare, Government of India
- Mills, A., & Hsu, J. (2014), "Health services in low-and middle-income countries: financing, payment, and provision", Encyclopedia of Health Economics, pp 422- 434

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Discipline Specific Elective 9 (DSE-9): Environmental Economics

Semester	Course title & Code	Credits	Duration (per week)			Eligibility Criteria	Prerequisite
			Lecture	Tutorial	Practical/ Practice		
V/VII	Environmental Economics– ECON039	4	3	1	0	Class 12th Pass	Introductory/Principles of Microeconomics

Learning Objectives

The Learning Objectives of this course are as follows:

- This course provides basic knowledge of environmental economics, its relationship with microeconomics and welfare economics, to present and explains the significance and application in the present environmental challenges.
- It aims to describe and comprehend various environmental policies by deploying various policy instruments and to understand and measure the various market and non-market benefits of environmental policies.
- The course addresses the problems related to climate change, transboundary environmental problems, and challenges related to trade and the environment also.

Learning outcomes

The Learning Outcomes of this course are as follows:
The students will learn the trade-offs of economy and environment, and related challenges. They will comprehend the role of state and institutions to minimise the trade-offs.

Syllabus

UNIT I: Introduction to Environment Economics (9 hours)
What is environmental economics? review of microeconomics and welfare eco- nomics; Overview of environmental problems in India

UNIT II: Design and Implementation of Environmental Policy (12 hours)
Overview; Pigouvian taxes and effluent fees; tradable permits; choice between taxes and quotas under uncertainty; implementation of environmental policy.

UNIT III: Measuring the Benefits of Environmental Improvements (12 hours)
Non-market values and measurement methods; risk assessment and perception.

UNIT IV: International Environmental Problems (12 hours)
Transboundary environmental problems; economics of climate change; trade and environment.

Recommended readings

- Charles Kolstad. Intermediate Environmental Economics, Oxford University Press, 2nd edition (2012).
- Roger Perman, Yue Ma, James McGilvray and Michael Common. Natural Resource and Environmental Economics, Pearson Education/Addison Wesley, 4th edition (2011).
- Robert N. Stavins (ed.). Economics of the Environment: Selected Readings, W.W. Norton, 6th edition (2012).

- Don Fullerton and Robert Stavins (1998). "How Economists See the Environment." Nature, Vol. 395, Oct 1, 1998, pp. 433-434.
- State of Environment Report: India 2009 (Ministry of Environment and Forests, Government of India, 2009): Chapter 2 (State and Trends of the Environment): Land. Air, Water, Biodiversity (p. 9 to 71).
- Schmalensee, Richard and Robert N. Stavins (2017). "The design of environmental markets: What have we learned from experience with cap and trade?" Oxford Review of Economic Policy, Vol. 33, No. 4, pp. 572-588.
- Blackman, Allen, Li, Z., and Liu, A. A. (2018). "Efficacy of command-and-control and market-based environmental regulation in developing countries," Annual Review of Resource Economics, Vol. 10, pp. 381-404.
- Jonathan Harris and Brian Roach (2018). Environmental and Natural Resource Economics: A Contemporary Approach, Routledge.
- Nordhaus, William D. (2013). Climate Casino: Risk, Uncertainty, and Economics for a Warming World, Yale University Press.
- Richard Newell, William Pizer and Daniel Raimi (2013). "Carbon markets 15 years after Kyoto: Lessons learned, new challenges," Journal of Economic Perspectives, Vol. 27, No. 1, pp. 123-46.
- Stern,N.(2008) The economics of climate change, American Economic Review, 98(2): 1–37.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Discipline Specific Elective 10 (DSE-10): Gender and Development

Semester	Course title & Code	Credits	Duration (per week)			Eligibility Criteria	Prerequisite
			Lecture	Tutorial	Practical/ Practice		
V/VII	Gender and Development– ECON040	4	3	1	0	Class 12th Pass	NIL

Learning Objectives

The Learning Objectives of this course are as follows:

- This course aims to deepen students' understanding on the main theoretical approaches used in gender analysis of development issues, and understanding of the differential impacts of development interventions on women and men.
- The course aims to enable students to become familiar with the gender theories, use of these theories to Final Examination in detail issues of production (formal and informal work), reproduction (health, child survival, and fertility), the family/household nexus (where production and reproduction meet), and gender biases and inequality in terms of health, education, labour and inheritance.

Learning outcomes

The Learning Outcomes of this course are as follows:
The course aims at making students to be aware about the issues and concepts of gender and development, importance of mainstreaming gender, gender and work relations and gender bias and inequality.

Syllabus

UNIT I: Conceptualising and theorizing gender and development (12 hours)
Concepts in gender and development studies: Distinction between gender and sex, patriarchy and matriarchy; women in development (WID) and women and development (WAD)

UNIT II: Mainstreaming gender (12 hours)
Institutionalization of gender in growth and development, gender and bureaucracy, intra-household bargaining, changing gender relations and gender budgeting.

UNIT III: Work and Gender Relations (Inside/Outside the House) (12 hours)
Gender dynamics within a household, bargaining models, balance of productive and reproductive roles of women, agency, inheritance, unpaid work, marriage, and bride price.

UNIT IV: Gender and Inequality (9 hours)
Gender bias and gender inequality in terms of opportunities available: health and education, occupational segregation and gender wage gap.

Recommended readings

- Anderson, S. (2007). The economics of dowry and brideprice. Journal of Economic Perspectives, 21(4), 151-174.
- Aizer, A. (2010). The gender wage gap and domestic violence. American Economic Review, 100(4), 1847-59.
- Heath, R. (2014). Women's access to labor market opportunities, control of household resources, and domestic violence: Evidence from Bangladesh. World Development, 57, 32-46.
- Goel, P. A., & Barua, R. (2021). Female education, marital assortative mating, and dowry: Theory and evidence from districts of India. Journal of Demographic Economics, 1-27.
- Rai, S. M., Brown, B. D., & Ruwanpura, K. N. (2019). SDG 8: Decent work and economic growth–A gendered analysis. World Development, 113, 368-380.
- Kantor, P. (2003). Women's empowerment through home–based work: Evidence from India. Development and Change, 34(3), 425-445
- Neetha, N. (2018). Migration, gender and care economy. Routledge India
- Boeri, N. (2018). Challenging the gendered entrepreneurial subject: Gender, development, and the informal economy in India. Gender & Society, 32(2), 157-179.
- World Bank. (2011). World development report 2012: Gender equality and development. The World Bank.
- Kabeer, N. (2003). Gender Mainstreaming in Poverty Eradication and the Millennium Development Goals: A handbook for policy-makers and other stakeholders. Commonwealth Secretariat.
- Coles, A., Gray, L., &Momsen, J. (Eds.). (2015). The Routledge handbook of gender and development. Routledge.
- Blakemore, J. E. O., Berenbaum, S. A., & Liben, L. S. (2013). Gender Development. Psychology Press.
- Momsen, Janet (2020). Gender and Development. Routledge. 3rd Edition
- Moser, C. (2012). Gender Planning and Development (pp. 63-87). Routledge.
- Andrea Cornwall et al (eds): Feminisms in Development: Contradictions, Contestations and Challenges (Zed 2007).
- Cecile Jackson & Ruth Pearson (eds.): Feminist Visions of Development: Gender Analysis and Policy (Routledge, 1998)
- Agenor, P. R., & Canuto, O. (2015). Gender equality and economic growth in Brazil: a long-run analysis. Journal of Macroeconomics, 43, 155-172.
- Nilsson, P. (2013). Gender and development: The challenge of mainstream. Consilience, (10), 125-135.
- Cornwall, A., Harrison, E., & Whitehead, A. (2007). Gender myths and feminist fables: The struggle for interpretive power in gender and development. Development and Change, 38(1), 1-20.
- Agarwal, B. (1997). "Bargaining" and gender relations: Within and beyond the household. Feminist economics, 3(1), 1-51.
- Doss, C. (2013). Intrahousehold bargaining and resource allocation in developing countries. The World Bank Research Observer, 28(1), 52-78.
- Kabeer, N. (2005). Gender equality and women's empowerment: A critical analysis of the third millennium development goal. Gender & Development, 13(1), 13-24.
- Folbre, N. (2006). Measuring care: Gender, empowerment, and the care economy. Journal of Human Development, 7(2), 183-199.
- Jayachandran, S. (2015). The roots of gender inequality in developing countries, Economics, 7(1), 63-88.
- Mitra, A., Bang, J. T., & Biswas, A. (2015). Gender equality and economic growth: Is it equality of opportunity or equality of outcomes? Feminist Economics, 21(1), 110-135.
- Dercon, S., & Singh, A. (2013). From nutrition to aspirations and self-efficacy: gender bias over time among children in four countries. World Development, 45, 31-50.
- Azam, M., & Kingdon, G. G. (2013). Are girls the fairer sex in India? Revisiting intra-household allocation of education expenditure. World Development, 42, 143- 164.
- Nguyen, C. P. (2021). Gender equality and economic complexity. Economic Systems, 45(4), 100921.
- Jayachandran, S., & Pande, R. (2017). Why are Indian children so short? The role of birth order and son preference. American Economic Review, 107(9), 2600-2629.

- Barcellos, S. H., Carvalho, L. S., & Lleras-Muney, A. (2014). Child gender and parental investments in India: Are boys and girls treated differently?. American Economic Journal: Applied Economics, 6(1), 157-89.
- Joy, L. (2000). Do colleges shortchange women? Gender differences in the transition from college to work. American Economic Review, 90(2), 471-475.
- Mbaye, L. M., & Wagner, N. (2017). Bride price and fertility decisions: Evidence from rural Senegal. The Journal of Development Studies, 53(6), 891-910.
- Babcock, L., Recalde, M. P., Vesterlund, L., & Weingart, L. (2017). Gender differences in accepting and receiving requests for tasks with low promotability. American Economic Review, 107(3), 714-47.
- Pande, R. (2015). 'I arranged my own marriage': arranged marriages and post-colonial feminism. Gender, Place & Culture, 22(2), 172-187.
- Bertrand, M., & Mullainathan, S. (2004). Are Emily and Greg more employable than Lakisha and Jamal? A field experiment on labor market discrimination. American economic review, 94(4), 991-1013.
- Duraisamy, M., & Duraisamy, P. (2016). Gender wage gap across the wage distribution in different segments of the Indian labour market, 1983–2012: exploring the glass ceiling or sticky floor phenomenon. Applied Economics, 48(43), 4098-4111.
- LEE, Jong-Wha; Wie, Dainn (2017). Wage Structure and Gender Earnings Differentials in China and India. World Development, 97, 313–329

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Discipline Specific Elective 11 (DSE-11): Law and Economics

Semester	Course title & Code	Credits	Duration (per week)			Eligibility Criteria	Prerequisite
			Lecture	Tutorial	Practical/ Practice		
V/VII	Law and Economics – ECON041	4	3	1	0	Class 12th Pass	Intermediate Microeconomics II: Market, Government and Welfare - ECON010

Learning Objectives

The Learning Objectives of this course are as follows:

- Law and Economics is an interdisciplinary course, devoted to understanding laws and legal institutions using the tools of economic theory.
- This is essentially an economic analysis of the laws.
- Topics include an introduction to legal institutions and legal analysis, application of economic concepts to the law of property, contracts, torts and criminal law and anti-trust law.

Learning outcomes

The Learning Outcomes of this course are as follows:
This course is designed to gain familiarity with basic facts and application of economic principles to analyse a wide range of legal issues, and better understanding the economic consequences of laws and regulations.

Syllabus

UNIT I: Concepts of Law and uses of foundations of Economics (6 hours)
Tools for Law and Economics: Efficiency criteria in Welfare Economics; Coase theorem; Prisoners' Dilemma

UNIT II: Economics of Tort (Accident) Law/ Liability Rules (6 hours)
Liability for accidents and harms; product liability; efficiency of liability rules; efficiency-compensation trade-off.

UNIT III: Economics of Property Law (6 hours)
Property rights and their role in resource allocation; Coase theorem; Legal remedies for breach of property rights and their economic effects, Eminent Domain (Market and non-market mechanism for land transfer)

UNIT IV: Intellectual Property Rights (IPRs) (6 hours)
Patents, Copyright and Trademarks. Cost and benefits of private IPRs; Individual rights vs common good

UNIT V: Economics of Contract Law (6 hours)
Legal contract; Role of Contracts for functioning of markets; Incomplete contracts; Efficient contracts; Damages measures and their efficiency properties.

UNIT VI: Economics of Criminal Law (6 hours)
Economics of Crime and Law Enforcement; Crime Vs Tort; Repeat Offenders; Death Penalty

UNIT VII: Anti-trust laws, Competition Policy (3 hours)

UNIT VIII: Legal Process (6 hours)
Litigation – its causes and consequences; Benefits of legal certainty

Recommended readings

- Miceli, Thomas J. , "The Economic Approach to Law" 3rd Edition Stanford University Press, 2017 (Indian edition, MPP House, 2020)
- Cooter, Robert and Thomas Ulen, Law and Economics, Sixth Edition, Addison Wesley 2013, ISBN 9780132540650. Free here Law and Economics, 6th edition (jku.at)
- Pal, Malabika, Economic Analysis of Tort Law - The Negligence Determination. Routledge, 2020.
- Bag, Sugata, Economic Analysis of Contract Law: Incomplete Contracts and Asymmetric Information. Springer/Palgrave, 2018.
- Basu, Kaushik, The Republic of Beliefs: A New Approach to Law and Economics, Princeton University Press, 2018
- Singh, Ram (2021) Land for Development: Market Versus Non-Market Mechanisms in S.Mani and C.G. Iyer (eds.) India's Economy and Society, Springer, pp.187-204.
- Bhattacharjea, Aditya. "Competition policy: India and the WTO." Economic and Political Weekly (2001): 4710-4713.
- Competition Commission of India, Competition Act of India 2002, https : //www.cci.gov.in/sites/

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Discipline Specific Elective 12 (DSE-12): Open Economy

Semester	Course title & Code	Credits	Duration (per week)			Eligibility Criteria	Prerequisite
			Lecture	Tutorial	Practical/ Practice		
V/VII	Open Economy Macroeconomics – ECON042	4	3	1	0	Class 12th Pass	Intermediate Macroeconomics II (ECON011)

Learning Objectives

The Learning Objectives of this course are as follows:

- The course is designed with the objective of introducing the students to the standard macroeconomic issues in an open economy framework using the Mundell-Fleming model and the exchange rate overshooting model.
- It further exposes them to the models of banking and currency crises which try to make sense of the risks and vulnerabilities in an interdependent economy.
- The course would give an exposure to contemporary concerns in the global economy and the challenges it poses to policy making.

Learning outcomes

The Learning Outcomes of this course are as follows:

- The student would get a good exposure towards the process of macroeconomic policy- making in an open economy and the challenges involved.
- The course would facilitate learning the art of building macro-models in an open economy context. It would also enable the student to relate it to the contemporary issues.
- The student would learn to appreciate contemporary issues by relating the real world data to the theory in this regard.

Syllabus

UNIT I: Introduction to Open Economy Macroeconomics (10 hours)
Intertemporal long run budget constraint, how much can a country borrow, external wealth, external assets and liabilities, net international investment position, financial flows and valuation effects, Feldstein Horioka Puzzle, Harberger-Laursen- Metzler effect, Foreign Exchange Market. An overview of the spot and forward markets, swaps, options and derivatives. Uncovered and Covered Interest Parity. Covered Interest Arbitrage.

UNIT II: Macro-modelling of the Open Economy (20 hours)
Mundell-Fleming model (with Flexible Prices). Dornbusch's exchange rate overshooting model with stability conditions. Monetary Approach to Balance of Payments. PPP and long run monetary approach, Balassa –Samuleson effect and non-tradables, Fisher effect. Portfolio and macroeconomic equilibrium in an open economy. 3 equation model for the open economy. Currency crises (first, second and third generation models). Optimum currency areas and monetary union.

UNIT III: International Monetary System and Policy Co-ordination (15 hours)
Classic specie price flow mechanism and the Gold Standard. Fixed exchange rate system under Bretton Woods. Triffin dilemma and the collapse of the Bretton Woods, SDRs, international consistency condition. Financial trilemma. International liquidity and demand for international reserves. Government policies to- wards capital market, exchange and capital controls. Central bank intervention, sterilization.

Prospects of Macroeconomic policy co-ordination in an open economy, Policy reaction function, Hamada diagram

Recommended readings

- Feenstra, Robert and Taylor, Alan (2020) International Macroeconomics, 3rd ed., Worth Publishers
- Feenstra, Robert and Taylor, Alan (2014) International Economics, 3rd ed., Worth Publishers
- Pugel, T International Economics, 16th ed., McGraw-Hill Education
- Gandolfo, Giancarlo (2016) International Finance and Open Economy Macroeconomics, Springer.
- Krugman, P., Obstfeld, M. and Melitz (2018) International Economics - Theory and Policy, 11th ed., Pearson Education.
- Carlin, Wendy and Soskice, David (2015) Macroeconomics: Institutions, Instability and the Financial System
- Wickens, Michael(2012) Macroeconomic Theory. Princeton University Press.
- Sorenson, Peter B and Whitta-Jacobson, Hans Jorgen(2010) Introducing Advanced Macroeconomics: Growth and Business Cycles. McGraw Hill Education

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Discipline Specific Elective 13 (DSE-13): Modern Political Economy

Semester	Course title & Code	Credits	Duration (per week)			Eligibility Criteria	Prerequisite
			Lecture	Tutorial	Practical/ Practice		
V/VII	Modern Political Economy – ECON043	4	3	1	0	Class 12th Pass	NIL

Learning Objectives

The Learning Objectives of this course are as follows:

- This course will use the methodology and tools of economics to study the implications of various political institutions and processes that determine the quantum, scope, and nature of the state's intervention in the economy.
- Political actors are assumed to be goal-oriented and political outcomes are explained by the interaction between these actors within their institutional environment.
- This course will complement the Public Economics course as its focus will be on the positive implications of the state's interventions rather than the normative aspects.

Learning outcomes

The Learning Outcomes of this course are as follows:

- The students will learn to apply the economic paradigm to the study of political action and policy formation, and how economic and political forces may shape the incentives and constraints of policymakers and other political actors.
- They will understand the role of political institutions in shaping the actions of the state and the resulting outcomes.

Syllabus

UNIT I: Collective choice and redistribution (12 hours)
Insurance motive; public good motive; fairness motive; allocative efficiency; determination of redistribution, Majority voting and direct democracy; unanimity rule; Con- direct cycles; one dimensional median voter theorem; multidimensional issues and median voter theorem; agenda manipulation; simple variations of majority voting such as the Borda rule and approval voting

UNIT II: Representative democracy: two-party competition; and multi-party competition (12 hours)
Downsian model; deterministic voting; cycles and median voter theorems; competition in a constrained policy space; uncovered set and valence values; model with probabilistic voting model and an application to taxation, proportionality, and electoral rules; goals of multiple parties; coalition formation with one-dimensional issue space; coalition formation with multi-dimensional issue space; strategic voting.

UNIT III: Rent-seeking; Tariffs and Political economy of taxation (12 hours)
Basic model of rent-seeking and variations; rent-seeking via regulation; effects of tariffs, quotas, and voluntary export restraints; corruption, Distortions, and Diamond-Mirrlees production efficiency theorem.

UNIT IV: Dictatorship; origins and Lobbying (9 hours)
Model of public goods provisioning; Win- Trobe's model, Interest groups, lobbying, and collective action; Olsonian model of collective action; Downsian models

Recommended readings

- K. Shepsle and M. Bonchek (1997), *Analyzing Politics: Rationality, Behavior, and Institutions*, W. W. Norton
- D. Mueller (2003), *Public Choice III*, Cambridge University Press.
- K. Arrow (1963), *Social Choice and Individual Values*, Yale University Press.
- H. Demsetz (1968), Why regulate utilities? *Journal of Law and Economics* XI: 55-66.
- A. Dixit (1996), *The Making of Economic Policy*, MIT Press.
- A. Downs (1957), *An Economic Theory of Democracy*, Harper and Row.
- A. Krueger (1974), The political economy of a rent-seeking society, *American Economic Review* LXIV: 291-303.
- M. Olson (1965), *The Logic of Collective Action*, Harvard University Press.
- W. Niskanen (1995), *Bureaucracy and Public Economics*, Edward Elgar.
- D. North (1990), *Institutions, Institutional Change and Economic Performance*, Cambridge University Press.
- A. Shleifer (2005), Understanding Regulation, *European Financial Management* 11 (4); 439-451.
- A. Shleifer and R. Vishny (1993), Corruption, *Quarterly Journal of Economics* 108 (3): 599-617.
- Kiser, E., &Karceski, S. M. (2017). Political economy of taxation. *Annual review of political science*, 20, 75-92.
- Acemoglu, D., Golosov, M., &Tsyvinski, A. (2010). Dynamic Mirrlees taxation under political economy constraints. *The Review of Economic Studies*, 77(3), 841- 881.

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Discipline Specific Elective 14 (DSE-14): Public Economics

Semester	Course title & Code	Credits	Duration (per week)			Eligibility Criteria	Prerequisite
			Lecture	Tutorial	Practical/ Practice		
V/VII	Public Economics – ECON045	4	3	1	0	Class 12th Pass	Intermediate Microeconomics II (ECON010)

Learning Objectives

The Learning Objectives of this course are as follows:

- Public economics is the study of government policy from the points of view of economic efficiency and equity.
- The course deals with the nature of government intervention and its implications for allocation, distribution and stabilization problems.
- Inherently, this study involves a formal analysis of government taxation and expenditures.
- The subject encompasses a host of topics including public goods, market failures and externalities.
- The course is divided into two sections, one dealing with the theory of public economics and the other with the Indian public finances.

Learning outcomes

The Learning Outcomes of this course are as follows:

- The course aims to introduce students to the main theoretical and empirical concepts in public economics, equip students with a thorough analytical grasp of implications of government intervention for allocation, distribution and stabilization, and familiarise students with the main issues in government revenues and expenditure.
- At the end, the students should be able to demonstrate their understanding of the public economics.

Syllabus

UNIT I: Public Economic Theory (30 hours)

- Role of Public Sector - Justification of the Public Sector; Public Sector Growth; Excessive Government
- Political Economy of Public Sector - Public Mechanisms for allocation; Market and Non-Market Mechanism; Theory of Rent Seeking
- Taxation - Economic Effects of Tax; Tax incidence; Dead Weight Loss and Distortion; Efficiency and Equity Considerations; Optimal taxation; Commodity tax; Ramsey rule.

UNIT II: Indian Public Finances (15 hours)

- Tax System – Indian Tax system; Structure and Reforms. Budget, Deficits and Public debt

Recommended readings

- Cullis, J., Jones, P. (1998). Public finance and public choice, 2nd ed. Oxford University Press.
- Hindriks, J., Myles, G. (2013). Intermediate public economics, 2nd ed. MIT Press.
- Stiglitz, J. E. and Rosengard J. K. (2015). Economics of the Public Sector, 4th ed., W. W. Norton.
- Rao, M. Govinda and Sudhanshu Kumar (2017). "Envisioning Tax Policy for Accelerated Development in India," Working Paper No. 190, National Institute of Public Finance and Policy (NIPFP).

- Srivastava, D K et al. (2021), Taxing Petroleum Products: Sharing Revenue Space between Centre and States, Economic and Political Weekly, Vol. 56, Issue No. 9, 27 Feb, 2021.
- Bajaj & Dutt (2020), "Financing of fiscal response to COVID-19: a pragmatic Alternative", Indian Economic Review, Vol. 55. (Suppl 1): S149 - S160, Budget at Glance 2021-22.
- Chakraborty, Lekha (2021), Union Budget 2021-22: The Macroeconomic Frame- work, Economic and Political Weekly, Vol. 56, Issue No. 9, 27 Feb, 2021.
- Latest Economic Survey and Budget Documents.
- Other recent contributions in literature.

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Discipline Specific Elective 15 (DSE-15): Research Methodology for Economics

Semester	Course title & Code	Credits	Duration (per week)			Eligibility Criteria	Prerequisite
			Lecture	Tutorial	Practical/ Practice		
VI/VII	Research Methodology for Economics – ECON044	4	3	1	0	Class 12th Pass	NIL

Learning Objectives

The Learning Objectives of this course are as follows:

- The course offers the conceptual and methodological issues in details that go into successful conduction of a scientific research.
- That includes the theoretical and methodological approaches in measurement, proposing and testing hypotheses, scientific communication and the ethical issues in the practice of science.

Learning outcomes

The Learning Outcomes of this course are as follows:

- The students will lean framing research problems, identifying gaps in literature and scientific approaches to conduct both theoretical and empirical research.
- This course will build the capacity to conduct research in the fourth year at the undergraduate level.

Syllabus

UNIT I: Starting a Research Paper (9 hours)
Forming an economic hypotheses; Components of a Research Paper

UNIT II: Sources of Data and Literature (9 hours)
Familiarizing students with a wealth of Secondary Datasets that are available;
Exposing students to the basics of compiling data from Websites; outlets and search engines to study the literature

UNIT III: Creating New Data (9 hours)
Surveys and Experiments

UNIT IV: Analyzing Data (9 hours)
Data Discovery; Causal Inference; Big Data

UNIT V: Writing a Research Paper (9 hours)
Style of writing a Research Paper and Communicating the Results

Recommended readings

- Jacobson, M., Neugeboren, R. H. (2005). Writing Economics. United States: Harvard University. (link)
- Pinker, S. (2014). The Sense of Style: The Thinking Person's Guide to Writing in the 21st Century. United Kingdom: Penguin Publishing Group.

- Greenlaw, S. A. (2005). Doing economics : a guide to understanding and carrying out economic research. Boston: Cengage Learning.
- Thomson, W. (2001). A Guide for the Young Economist. United States: MIT Press.
- Glewwe, Paul; Todd, Petra. 2022. Impact Evaluation in International Development : Theory, Methods and Practice. Washington, DC: World Bank. (link)
- John A. Rice (2007). Mathematical Statistics and Data Analysis, 3rd ed. Thomson Brooks/Cole.
- Deaton, Angus. The analysis of household surveys (reissue edition with a new preface): A microeconometric approach to development policy. World Bank Publications, 2019.
- Haaland, Ingar, Christopher Roth, and Johannes Wohlfart. "Designing information provision experiments." JEL forthcoming
- Duflo, Esther, and Abhijit Banerjee, eds. Handbook of field experiments. Volumes 1& 2. Elsevier, 2017
- List, John A."Why Economists Should Conduct Field Experiments and 14 Tips for Pulling One Off." The Journal of Economic Perspectives, vol. 25, no. 3, American Economic Association, 2011, pp. 3-15,(link).
- Huntington-Klein, N. (2021). The effect: An introduction to research design and causality. Chapman and Hall/CRC.
- John Cochrane's Writing Group Webpage (link)

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Discipline Specific Elective 16 (DSE-16): Financial Economics

Semester	Course title & Code	Credits	Duration (per week)			Eligibility Criteria	Prerequisite
			Lecture	Tutorial	Practical / Practice		
IV/VI/VIII	Financial Economics – ECON046	4	3	0	1	Class XII with Mathematics	Introductory Mathematical Methods for Economics/ Basic Statistics

Learning Objectives

- To equip students with essentials tools for understanding Finance at undergraduate level.
- To enable students to use modelling techniques to solve Financial Economics concepts.
- To develop necessary skill and knowledge for financial problem solving

Learning outcomes

- After studying this course, students would be able to understand the basic concepts of finance and financial variables.
- They would develop an understanding of basics of finance including interest rates, annuity, and cash flow.
- The analytical approach adopted in this paper will strengthen and channelise their skills for more advance approaches in finance.

SYLLABUS OF DSE: FINANCIAL ECONOMICS

Unit 1. Deterministic cash-flow streams (12 Hours)
Basic theory of interest; discounting and present value; internal rate of return; evaluation criteria; fixed-income securities; bond prices and yields; interest rate sensitivity and duration; immunisation; the term structure of interest rates; yield curves; spot rates and forward rates.
Berk, DeMarzo
Chapter 4: Time Value of Money (all sections)
Chapter 6: Valuing Bonds (all sections)
Chapter 7: Investment Decision Rules (all sections)
Brealey, Richard A., Myers, Stewart, C., Allen, Franklin:
Chapter 5: Net Present Value and Other Investment Criteria (Section 5.3, pages 107-115)
Bodie, Kane, Marcus
Chapter 14: Bond Prices and Yields (Section 14.1-14.3, Pages 445-460,
Chapter 15: Term Structure of Interest Rate (Section 15.1-15.5, Pages 487-504)
Chapter 16: Managing Bond Portfolios (Section 16.1, 16.3, Pages 515 – 525, 535 – 543)

Unit 2. Single-period random cash flows (12 Hours)
Random asset returns; portfolios of assets; portfolio mean and variance; feasible combinations of mean and variance; mean – variance portfolio analysis; the Markowitz model; risk-free assets
Bodie, Kane, Marcus
Chapter 7: Optimal Risky Portfolio (Section 7.1 – 7.3, 7.4 Pages 205-218 till Example 7.3, 220 – 228)

Berk, DeMarzo
Chapter 11: Optimal Portfolio Choice and CAPM: (Sections 11.1 – 11.6, pages 351 – 378)

Unit 3. Capital Asset Pricing Model (CAPM) (12 Hours)
The capital market line; the capital asset pricing model; the beta of an asset and of a portfolio; security market line; use of the CAPM model in investment analysis and as a pricing formula. Arbitrage pricing theory(APT) and multi-factor model of risk and return.
Bodie, Kane, Marcus
Chapter 9: Capital Asset Pricing Model (Section 9.1, Pages 291-300)
Chapter 10: Arbitrage pricing theory(APT) and multi-factor model of risk and return.
Berk, DeMarzo
Chapter 11: Optimal Portfolio Choice and CAPM: (Sections 11.7 – 11.8 , pages 379 - 399)
Brealey, Richard A., Myers, Stewart, C., Allen, Franklin
Chapter 8: Portfolio Theory and the Capital Asset Pricing Model (Section 8.4, pages 199-203)
David G. Luenberger:
Chapter 7: The Capital Asset Pricing Model (Section 7.3 & 7.7, Pages 177 – 179, 187 - 190)

Unit 4. Market Efficiency & Behavioural Finance(09 Hours)
Bodie, Kane, Marcus
Chapter 11: Efficient Market Hypothesis (Sections 11.1-11.2, 11.4, Pages 349 – 357, 362-63)
Chapter 12: Behavioural Finance & Technical Analysis
Brealey, Richard A., Myers, Stewart, C., Allen, Franklin
Chapter 13: Efficient Markets &Behavioral Finance (Sections 13.2, 13.5, Pages 314 – 318, 329-333)

Practical Component (30Hours)

1. Present Value and Net Present Value
2. Internal Rate of Return and Loan Tables \
3. Multiple Internal Rates of Return
4. Future Values and Applications
5. Continuous Compounding
6. Analyzing the Cash Flows by NPV or IRR
7. Portfolio Models
8. Calculating Efficient Portfolios When There Are No Short-Sale Restrictions

Reference for Practical:
Simon Benninga, Financial Modelling, MIT Press, Third Edition, 2008:
Chapter 1: Basic Financial Calculations (Sections: 1.2, 1.3, 1.4, 1.6, 1.8)
Chapter 7: The Financial Analysis of Leveraged Leases(Sections: 7.1, 7.2, 7.3)
Chapter 8: Portfolio Models
Chapter 9: Calculating Efficient Portfolios When There Are No Short-Sale Restrictions

Essential/recommended readings
Bodie, Kane & Marcus, Investments McGraw Hill 10th Edition, 2014
Berk, DeMarzo, Corporate Finance, Pearson, 3rd Edition, 2014
Brealey, Richard A., Myers, Stewart, C., Allen, Franklin, Principles of Corporate Finance, McGraw Hill 10th Edition, 2011
David G. Luenberger, Investment Science, Oxford Press, 1998
Simon Benninga, Financial Modelling, MIT Press, Third Edition, 2008

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Discipline Specific Elective 17 (DSE-17): Money and Financial Markets

Semester	Course title & Code	Credits	Duration (per week)			Eligibility Criteria	Prerequisite
			Lecture	Tutorial	Practical/ Practice		
IV/VI/VIII	Money and Financial Markets – ECON047	4	3	1	0	Class 12th Pass	Introductory Macroeconomics

Learning Objectives

The Learning Objectives of this course are as follows:

- This course exposes the theory and functioning of the monetary and financial sectors of the economy. It highlights the organization, structure, and role of financial markets and institutions.
- It also discusses interest rates, monetary management, and instruments of monetary control.
- Financial and banking sector reforms and monetary policy with special reference to India are also covered.

Learning outcomes

The Learning Outcomes of this course are as follows:
This allows students to understand current monetary policies and financial market out- comes. It also enables them to critically evaluate policies and role of the central bank.

Syllabus

UNIT I: Money (9 hours)
Understanding concept and functions of money, Measurement of money supply, Analytics and methodology of computation of money supply, Theories of money supply determination

UNIT II: Financial markets: an Introduction (12 hours)
Role of financial markets and institutions, Money and Capital markets: Pricing and other analytical issues, Financial derivatives: Futures, Options and Swaps, Financial markets in India: Organization, Structure and Reforms in India

UNIT III: Interest Rates (12 hours)
Determination of interest rates, Sources of interest rates differentials and risk, Theories of term structure of interest rates, Interest rates in India

UNIT IV: Central Banking and Monetary policy (12 hours)
Central Bank: Functions and Balance Sheet, Monetary Policy: Targets and instruments, Monetary management in an open economy, Monetary Policy Framework in India: Evolution and current scenario, critical evaluation, Emerging issues in Monetary policy- Changing payment mechanism, Cryptocurrency and others

Recommended readings

- F J Fabozzi et al: Foundations of Financial Markets and Institutions Pearson
- F S Mishkin , S G Eakins, T Jayakumar, R K Pattnaik : Financial Markets and Institutions Pearson
- N Jadhav: Monetary Policy, Financial stability and Central Banking in IndiaMacmilla

- Report of the Working Group: Money Supply Analytics and Methodology of Compilation, 1998 Annual Report; Master Circular - Prudential Norms on Capital Adequacy - Basel I Framework - 2011; RBI Bulletin; Report of Currency and Finance (latest).
- Dua, P., "Monetary Policy Framework in India", Indian Economic Review, Vol. 55, Issue 1, June 2022
- Ghate, C., &Kletzer, K. M. (Eds.). (2016). Monetary policy in India: A modern macroeconomic perspective. Springer.
- Various publications of RBI and other agencies / institutions

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Discipline Specific Elective 19 (DSE-19): Behavioural Economics

Semester	Course title & Code	Credits	Duration (per week)			Eligibility Criteria	Prerequisite
			Lecture	Tutorial	Practical/ Practice		
VI/VIII	Behavioural Economics – ECON049	4	3	1	0	Class 12th Pass	Game Theory and Strategic Interactions (ECON013)

Learning Objectives

The Learning Objectives of this course are as follows:

- This course introduces departure in behaviour predicted by standard economic theories to provide insights into the new and evolving area of Behavioural Economics.
- First, it outlines the common ideas and theories of Behavioural Economics using the basic mathematical techniques and standard concepts of microeconomics. The empirical basis for the theories of Behavioural Economics is discussed briefly with particular emphasis on the role and nature of experiments.
- The last segment of the course discusses the policy implications of these experiments and policy lessons that have been implemented as a result of empirical support to the theories of behavioural economics.
- The course explains the origin of Behavioural Economics in terms of anomalies in be- haviour that deviate from predicted rational behaviour. It introduces the common ideas and theories of Behavioural Economics. It further familiarise the student with the different types of experiments used for empirical studies.
- The students would demonstrate the policy lessons derived from theories of Behavioural Economics.

Learning outcomes

The Learning Outcomes of this course are as follows:

- This course equips students to contrast the outcomes of standard classical microeconomic theories with real outcomes, to apply the theories that explain anomalies/deviations from rational predicted behaviour.
- It communicate the basic theories of behavioural economics cogently and critically Final Examination in the findings from experiments in terms of their applicability to public policy settings.

Syllabus

UNIT I: Biases/Anomalies and Overview (15 hours)
Some Common Anomalies from Benchmark Theories; Overview of Behavioural Economics

UNIT II: Common Ideas and Theories (15 hours)
Heuristic Thinking; Risk Preferences and Reference-Dependent Preferences; Time Preferences; Social Preferences; Probabilistic Reasoning and Beliefs; Limited Attention; Limited Rationality

UNIT III: Empirical Applications and Policy Suggestions (15 hours)

Methods: Natural experiments, Lab experiments, Field experiments, Survey; Empirical Applications and Policy Suggestions

Recommended readings

- Bernheim, B. Douglas, Stefano DellaVigna, and David Laibson. Handbook of Behavioral Economics-Foundations and Applications. Volumes 1 & 2. Elsevier, 2019.
- Dhami, Sanjit. The Foundations of Behavioral Economic Analysis. Oxford University Press, 2016.
- Angner, Erik. A Course in Behavioral Economics. Bloomsbury Publishing, 2020.
- Thaler, Richard H.. Misbehaving: The Making of Behavioral Economics. New York: WW Norton, 2015.
- Thaler, Richard H., and Cass R. Sunstein. Nudge: Improving Decisions about Health, Wealth, and Happiness. Yale University Press, 2008

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Discipline Specific Elective 20 (DSE-20): Comparative Economic Development

Semester	Course title & Code	Credits	Duration (per week)			Eligibility Criteria	Prerequisite
			Lecture	Tutorial	Practical/ Practice		
VI/VIII	Comparative Economic Development – ECON050	4	3	1	0	Class 12th Pass	NIL

Learning Objectives

The Learning Objectives of this course are as follows:

- This course investigates selected issues in industrialization and development experiences and debates in comparative historical perspective.
- The course focuses on a set of countries (Britain, Japan and East Asian economies) which followed diverse trajectories of growth to achieve their industrial transition.
- It compares the outcomes of these diverse trajectories on sectoral change, intersectoral relations, labour processes and industrial relations.
- It also compares the role of the state in facilitating the respective trajectories.

Learning outcomes

The Learning Outcomes of this course are as follows:
The students will be able to learn critical factors affected economic development in a historical perspective and assimilate materials from diverse narratives. It will help them to think in an interdisciplinary manner.

Syllabus

UNIT I: Introduction (6 hours)
Theoretical issues and comparative historical background.

UNIT II: Agricultural transformation and its role in industrialization (6 hours)
Agrarian and land relations, production and productivity, agrarian surplus in industrial development. Case studies: Britain, Japan and East Asia.

UNIT III: The industrialization process of Britain, Japan and East Asia (6 hours)

UNIT IV: East Asian Development (9 hours)
A Theoretical Debates (Is it a miracle or not? Is it market or the state? Flying Geese Model? Can we have an "East Asian Model"? Lessons for the other countries.)

UNIT V: The factory system and making of the industrial working class. Case studies: Britain, Japan and EastAsia (6 hours)

UNIT VI: The role of the state in industrial and developmental transitions. Case studies: Britain, Japan and East Asia. (6 hours)

UNIT VII: Export Oriented Development in East Asian Countries? Trade and Industry. (Export-Oriented Industrialization (EOI) vs Import-substitution Industrialization (ISI) - International Context and Domestic Requirements. Importance of trade for underdevelopment vs development.) (6 hours)

Recommended readings

- Hughes, J., Cain, L. (1994). American Economic History, 4th ed. HarperCollins College Publishers.
- Hayami, Y. (1975). A century of agricultural growth in pre-war Japan: Its relevance to Asian development. University of Minnesota Press.
- Hobsbawm, E. (1968). Industry and empire: An economic history of Britain since 1750. Weidenfeld & Nicholson.
- Hobsbawm, E. (1984). Worlds of labour: Further studies in the history of labour. Weidenfeld & Nicolson.
- Johnson, C. (1982). MITI and the Japanese miracle: The growth of industrial policy 1925-1975. Stanford University Press.
- Macpherson, W. (1995). The economic development of Japan 1868-1941. Cam- bridge University Press.
- Norman, E. (2007). Japan's emergence as a modern state: Political and economic problems of the Meiji period. University of British Columbia Press.
- Okochi, K., Karsh, B., Levine, S. (1974). Workers and employees in Japan: The Japanese employment relations system. Princeton University Press.
- Maddison, Angus (2001). The World Economy, Vol. 1: A Millennial Perspective. OECD.
- G.M. Walton and H. Rock-off History of the American Economy, Eleventh Edition. Harcourt Brace Jovanovich.
- Sven Beckert (2015), Empire of Cotton- A Global History, Vintage.
- Michael Merrill, "Cash is Good to Eat: Self-Sufficiency and Exchange in the Rural Economy of the U.S.," Radical History Review, (Winter 1976-77), 42-71.
- Allan Kulikoff, "The Transition to Capitalism in Rural America," William and Mary Quarterly 46 (1989): 120-44.
- Paul David, "Technology, History, and Growth," in Paul David, Technical Choice, Innovation and Economic Growth (Cambridge, 1975).
- Gordon, Edwards, and Reich, Segmented Work, Divided Workers, ch. 4
- Naomi Lamoreaux, The Great Merger Movement in American Business, 1895-1904.
- Lipset, "Radicalism or Reformism: The Sources of Working-Class Politics," American Political Science Review 77:1 (Mar. 1983), 1-18.
- Sheila Collins and Gertrude Goldberg, When Government Helped: Learning from the Successes and Failures of the New Deal. Oxford, Oxford University Press: 2013.
- Morton Horwitz, The Transformation of American Law, 1870-1960 (New York, 1992).
- Edward Baptist, The Half has Never Been Told: Slavery and the Making of American Capitalism. New York, Basic Books, 2014.
- Myers, R.H., 1991. How did the modern Chinese economy develop? - a review article. The Journal of Asian Studies, 50(3), pp.604-628.
- World Bank 1993. The East Asian Miracle, New York, Oxford University Press.
- Rodrik, D, 1994, 'King Kong Meets Godzilla' in A.Fishlow et al., Miracle or Design? - Lessons from the East Asian Experience, Washington, D.C., Overseas Development Council.
- Cheng, T, Haggard, S and Kang, D, 1998, 'Institutions and Growth in Korea and Taiwan: The Bureaucracy', Journal of Development Studies, vol. 34, no. 6.
- Best, M, 1990, New Competition, Cambridge, Polity Press.
- Amsden, A, 1992. Asia's Next Giant: South Korea and Late Industrialization, OUP
- Amsden, A, 1985, 'The State and Taiwan's Economic Development' in P. Evans, D. Rueschemeyer and T. Skocpol, 1985, eds., Bringing the State Back In, Cambridge, Cambridge University Press.
- Chang, H.J., 2006. The East Asian development experience: The miracle, the crisis and the future. Zed Books.
- Morrissey, O. and Nelson, D., 1998. East Asian economic performance: miracle or just a pleasant surprise?. World Economy, 21(7), pp.855-879.
- Crafts, N., 1999. East Asian growth before and after the crisis. IMF Staff Papers, 46(2), pp.139-166.
- Waldron, S., Brown, C. and Longworth, J., 2006. State Sector Reform and Agri- culture in China. The China Quarterly, (186), p.277.
- Krugman, Paul (1994), "The Myth of Asia's Miracle," Foreign Affairs, Vol.73 Issue 6.

- Hau, Shiping (2017), "Introduction: East Asian Development Model,"
- Kuznets, Paul (1988), "An East Asian Model of Economic Development: Japan, Taiwan, and South Korea," Economic Development and Cultural Change, Vol.36 No.3.
- Cline, William (1982), "Can the East Asian Model of Development be Generalized?"
- World Development, Vol.10 Issue 2.
- Aoki, Masahiko (2013), "Historical Sources of Institutional Trajectories in Eco- nomic Development: China, Japan and Korea Compared."
- Lawrence & Weinstein (2001), "Trade and Growth: Import Led or Export Led? Evidence from Japan and Korea" in Stiglitz &Yusurf.
- Weiss, John (2005), Export and Industrial Policy: Lessons from East Asian Miracle Experience
- Dregger, Christian and Herzer, Dierk (2013), "A Further Final Examination of the Export-Led Growth Hypothesis," Empirical Economics Vol.45 Issue 1.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Discipline Specific Elective 21 (DSE-21): Corporate Finance and Governance

Semester	Course title & Code	Credits	Duration (per week)			Eligibility Criteria	Prerequisite
			Lecture	Tutorial	Practical/ Practice		
VI/VIII	Corporate Finance and Governance – ECON051	4	3	1	0	Class 12th Pass	Game Theory and Strategic Interactions (ECON013)

Learning Objectives

The Learning Objectives of this course are as follows:

- The field of corporate finance has undergone a tremendous mutation in the past three decades, specially after the global financial crisis. A substantial and important body of empirical work has provided a clearer picture of patterns of corporate financing and governance, and of their impact for firm behavior and macroeconomic activity.
- This course aims to introduce the conceptual foundation of those issues. It will introduce firm'sbehavour of finance choice in the presence of tax distortions, transaction costs, informational asymmetries etc.

Learning outcomes

The Learning outcomes of this course are as follows:

- The students will understand the variety of institutions running corporate business in present day world and will be familiar with the strategies to govern them effectively.

Syllabus

UNIT I: An economic overview of corporate institutions (9 hours)

UNIT II: Corporate Governance (9 hours)
Separation of ownership and control, managerial incentives, investor's activism, takeover, leverage buyout

UNIT III: Corporate Financing and Agency Costs Outside Financing Capacity (6 hours)

UNIT IV: Determination of borrowingcapacity (6 hours)

UNIT V: Corporate financing under asymmetric information (9 hours)

UNIT VI: Exit and voice: Passive and active monitoring (6 hours)

Recommended readings

- Tirole, J. (2010). The theory of corporate finance. Princeton universitypress.
- Vernimmen, P., Quiry, P., & Le Fur, Y. (2022). Corporate finance: theory and practice. John Wiley &Sons.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Discipline Specific Elective 22 (DSE-22): Economics of Education

Semester	Course title & Code	Credits	Duration (per week)			Eligibility Criteria	Prerequisite
			Lecture	Tutorial	Practical/ Practice		
VI/VIII	Economics of Education – ECON052	4	3	1	0	Class 12th Pass	Introductory /Principles of Microeconomics

Learning Objectives

The Learning Objectives of this course are as follows:

- This course discusses the economic aspects of current issues in education, using both economic theory and econometric tools.
- Topics include discussion of basic human capital theory, production of education, costing and finance of education, the growing impact of education on earnings and earnings inequality, the labour market for teachers, implications of the introduction of technology (computers) on education, the effectiveness of mid-career training for adult workers, the roles of school choice, and educational outcomes and inequality in demand for education and educational outcomes.

Learning outcomes

The Learning outcomes of this course are as follows:

- This course will develop skills amongst the students to conduct research and analysis in the field of economics of education.

Syllabus

UNIT I: The Role of Education in Human Development (12 hours)
Macro issues in education, human capital theory, returns to education, signalling theory, education and labour market outcomes, costs and benefits of education, education production analysis and early childhood education.

UNIT II: Analysis of School Education (12 hours)
Challenges, educational interventions and attainments, financing, accountability and standards

UNIT III: Higher Education and Training (9 hours)
Issues of higher education in India, role of internship and apprenticeship in improving labour market outcomes

UNIT IV: Education and Inequality (12 hours)
Inequality in uptake and outcomes, and the role of affirmative action.

Recommended readings

- Bradley, S., & Green, C. (Eds.). (2020). The Economics of Education: A Com- prehensiveOverview.
- Lovenheim, M., &Turner, S. E. (2017). Economics of education. Macmillan Higher Education.
- Altinok, Nadir, and Geeta Kingdon. "Newevidence on class size effects: A pupil fixed effects approach." Oxford Bulletin of Economics and Statistics 74, no. 2 (2012):203-234.

- Angrist, Joshua D., and Victor Lavy. ”UsingMaimonides’ rule to estimate the effect of class size on scholastic achievement.” The Quarterly Journal of Economics 114, no. 2 (1999):533-575
- Abhijit Banerjee, Shawn Cole, Esther Duflo, Leigh Linden. “Remedying Education: Evidence from Two Randomized Experiments in India”, QuarterlyJournalofEconomics,122,No.3,Aug2007,Pages1235–1264.
- Hanushek, Eric A. ”Assessingthe effects of school resources on student performance: An update.” Educational evaluation and policy analysis 19, no. 2 (1997a): 141-164.
- Hanushek, Eric A. ”Outcomes, incentives, and beliefs: Reflections on analysis of the economics of schools.” Educational Evaluation and Policy Analysis 19, no. 4 (1997b):301-308.
- Hattie, John. ”Theparadox of reducing class size and improving learning out-comes.”Internationaljournalofeducationalresearch43,no.6(2005):387-425.
- Hanushek, E. A., Machin, S. J., &Woessmann, L. (Eds.). (2016). Handbook of theeconomicsofeducation.Elsevier.
- Ronald G., Ehrenberg and Robert S., Smith. Modern Labor Economics: Theory and Public Policy, 11th edition, Addison Wesley
- Hanushek, Eric A., 2005, Economic Outcomes and School Quality, International AcademyofEducationandInternationalInstituteforEducationalPlanning.
- Majumdar, M. (2017). Access, success, and excess: Debating shadow education in India. In Routledge Handbook of Education in India (pp. 273-284). Routledge India.
- Blatchford, P., & Mortimore, P. (1994). The issue of class size for young children in schools: What can we learn from research?. Oxford review of education, 20(4), 411-428.
- Kingdon, G. G., &Teal, F. (2007). Does performance related pay for teachers improve student performance? Some evidence from India. Economics of Education Review, 26(4),473-486.
- Kingdon, G. G. (2020). The private schooling phenomenon in India: A review. TheJournalofDevelopmentStudies,56(10),1795-1817.
- Varughese, A. R., &Bairagya, I. (2021). Interstate variation in household spending on education in India: Does it influence educational status?. Structural Change andEconomicDynamics,59,405-415.
- Haveman, R., & Smeeding, T. (2006). The role of higher education in social mobility. The Future of children,125-150.
- Afridi, F., Barooah, B., & Somanathan, R. (2020). Designing effective transfers: Lessons from India’s school meal program. Review of Development Economics, 24(1),45-61.
- Singh, A., Park, A., &Dercon, S. (2014). School meals as a safety net: an evaluation of the midday meal scheme in India. Economic Development and Cultural Change, 62(2),275-306.
- Afridi, F., Barooah, B., & Somanathan, R. (2020). Improving learning outcomes throughinformationprovision:ExperimentalevidencefromIndianvillages.Journalof Development Economics, 146, 102276.
- Banerjee, A. V., Cole, S., Duflo, E., & Linden, L. (2007). Remedying education: Evidence from two randomized experiments in India. The Quarterly Journal of Economics, 122(3),1235-1264.
- Coate, Stephen, and Glenn C. Loury (1993) ‘Will Affirmative Action Policies EliminateNegativeStereotypes.’AmericanEconomicReview83(5),1220–1240
- Cullen, Julie Berry, Brian A Jacob, and Steven Levitt (2006) ‘The effect of school choice on participants: Evidence from randomized lotteries.’ Econometrica 74(5), 1191–1230
- Kingdon, G. G. (2007). The progress of school education in India. Oxford Review ofEconomicPolicy,23(2),168-195
- Borooah, V. K. (2012). Social identity and educational attainment: the role of caste and religion in explaining differences between children in India. Journal of Development Studies, 48(7),887-903.
- Chin, A. (2005). Can redistributing teachers across schools raise educational attainment? Evidence from Operation Blackboard in India. Journal of development Economics, 78(2),384-405.
- Ghosh, P., &Bray, M. (2018). Credentialism and demand forprivate supplementary tutoring: A comparative study of students following two Examination boards in India. International Journal of Comparative Education and Development.
- Gandhi Kingdon, G. (2002). The gender gap in educational attainment in India: Howmuchcanbeexplained?.JournalofDevelopmentStudies,39(2),25-53.
- Azam, M., & Kingdon, G. G. (2013). Are girls the fairer sex in India? Revisiting intra-household allocation of education expenditure. World Development, 42, 143- 164.

- Asadullah, M. N. (2005). The effect of class size on student achievement: Evidence from Bangladesh. Applied Economics Letters, 12(4),217-221.
- Tholen, G., Brown, P., Power, S., &Allouch, A. (2013). The role of networks and connections in educational elites' labour market entrance. Research in Social Stratification and Mobility, 34,142-154.
- Silva, P., Lopes, B., Costa, M., Melo, A. I., Dias, G. P., Brito, E., & Seabra, D. (2018). The million-dollar question: can internships boost employment?.StudiesinHigher Education, 43(1),2-21.
- Wright, E., &Mulvey, B. (2021). Internships and the graduate labour market: how upper-middle-class students 'get ahead'. British Journal of Sociology of Education, 42(3),339-356.
- Deshpande, A. (2005). Affirmative action in India and the UnitedStates.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Discipline Specific Elective 23 (DSE-23): Forecasting Methods for Economics

Semester	Course title & Code	Credits	Duration (per week)			Eligibility Criteria	Prerequisite
			Lecture	Tutorial	Practical/ Practice		
VI/VIII	Forecasting Methods for Economics – ECON053	4	3	1	0	Class 12th Pass	Basic Econometrics (ECON024)

Learning Objectives

The Learning Objectives of this course are as follows:

- This course builds on the compulsory Basic Econometrics course and teaches students a broad set of commonly used econometric methods for forecasting econometric variables.
- These include both quantitative and qualitative Forecasting Techniques including VAR, VECM, ARIMA etc.

Learning outcomes

The Learning outcomes of this course are as follows:

- Students will learn the theoretical and practical basis for forecasting techniques widely used in empirical research and consider their application in a wide range of problems.

Syllabus

UNIT I: Basics of Forecasting (6 hours)
Tools for forecasting, forecasting methods and applications, forecast horizon

UNIT II: Quantitative Forecasting Techniques (9 hours)
Definition,TimeSeries-Naïve,Average, Simple Moving Average, Weighted Moving Average, Exponential Smoothing; Fore- cast Errors Accuracy, Trend Projection, Seasonal Indexes, Holt's, winter's Model, Linear Regression. Smoothing Techniques, Exponential smoothing methods, Decomposition methods.

UNIT III: Box-Jenkins Methodology: Unit roots; Autoregressive models, moving average models, mixed autoregressive and moving average models; Identification, estimation, diagnostic checking and Forecasting (9 hours)

UNIT IV: Forecasting with Multiple Regression Models (6 hours)

UNIT V: Cointegration, Granger Causality, Error Correction (6 hours)

UNIT VI: Qualitative Forecasting Techniques (9 hours)
Definition, Delphi, Precautions in administering Delphi, Sales force composite, Consumer Panel Survey, Nominal group, and their Drawbacks.

Recommended readings

- Spyros G. Makridakis, Steven C. Wheelwright, Rob J Hyndman (2008), Forecast- ing: Methods and Applications, WileyPublications.

- Dimitrios Asteriou and Stephen G. Hall, 4th edition, Applied Econometrics, 2021, PalgraveMacmillan.
- Hyndman, R.J., & Athanasopoulos, G. (2021) Forecasting: principles and practice, 3rd edition, OTexts: Melbourne, Australia.OTexts.com/fpp3.
- Asteriou, D and Hall, Stephen G, Applied Econometrics, 4th Edition, 2021, Palgrave Macmillan.
- James Stock and Mark Watson, Introduction to Econometrics, 4th Edition, 2019, Pearson.
- Wooldridge, J. (2014). Introduction to econometrics: A modern approach, 5th ed. Cengage Learning.
- Gujarati, D., Porter, D. (2012). Basic econometrics, 5th ed.McGraw-Hill.
- Badi H. Baltagi, Econometrics, 5th Edition, 2011,Springer.
- J. Johnston and J. DiNardo (2001), Econometric Methods, Fourth Edition, Irwin McgrawHill
- G.S. Maddala and Kajal Lahiri, Introduction to Econometrics, 4th Edition, 2012, Wiley.
- Diebold, F.X. (2017), Forecasting, Department of Economics, University of Pennsylvania.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Discipline Specific Elective 24 (DSE-24): History of Economic Thought

Semester	Course title & Code	Credits	Duration (per week)			Eligibility Criteria	Prerequisite
			Lecture	Tutorial	Practical/ Practice		
VI/VIII	History of Economic Thought – ECON054	4	3	1	0	Class 12th Pass	NIL

Learning Objectives

The Learning Objectives of this course are as follows:

- This course intends to acquaint students to an evolution of the history of economic thought from its initial thinkers to ideas of institutionalism and the reinvention of liberalism.
- The course will discuss selected authors on economic theory to understand them within the framework of intellectual debate and change.
- The idea is to expose students to the milestones in economic theory and provide a more holistic understanding of the evolution of contemporary economics.
- The course attempts to fulfil the need to integrate thehistoryofeconomicswiththeteachingoftheprinciplesofeconomics.

Learning outcomes

The Learning outcomes of this course are as follows:

- The students will develop an understanding of the historical antecedents and methodological premises of the theories in economics.
- They will also have a grounding in the set of ideas that inform academic debates and the making of policies related to the economyinthecontemporaryworld.

Syllabus

UNIT I: Introduction (9 hours)
Why study economic thought; history of economic thought or his- tories of economic thought.

UNIT II: The surplus approach and the rise of political economy (9 hours)
Value, Price, Money, Income Distribution, Macroeconomic Setting, Growth and Trade: Reading Adam Smith, David Ricardo and Karl Marx.

UNIT III: Marginalism and Keynesianism (9 hours)
Utility, technology and price : Jevons, Menger, Walras and Marshall. Keynes, Kalecki and the principle of effective demand.

UNIT IV: Institutionalism and Evolutionary Economics (9 hours)
Industrial and Pecuniary employments in Thorstein Veblen; labour as an overhead cost: competition and Knowledge – perfect, imperfect and Rivalrous; Schumpeter: creative destruction, innovation and business cycle.

UNIT V: Neoliberalism and Post-Keynesianism Theory, policy, critique and prospects. Milton Friedman (9

hours)

Recommended readings

- Munday, S. C. (1996). A Brief History of Economic Thought. In Current Developments in Economics (pp. 15-32). Palgrave,London.
- Roncaglia, Alessandro (2017). *A Brief History of Economic Thought*. Cambridge UniversityPress
- Sandelin, B., Trautwein, H. M., &Wundrak, R. (2014). A short history of economic thought.Routledge.
- Medema, S. G., & Samuels, W. J. (2013). The history of economic thought: a reader. Routledge.
- Backhouse, R.E., 1987. A history of modern economic analysis. BasilBlackwell.
- Schumpeter, Joseph A: "The Development of Economics as a Science" in Economic Doctrine and Method. New York, OUP. 1954, Chapter 1, pp 9-44
- Kaul, Nitasha: Imagining Economics Otherwise, Encounters With Identity/Difference. Firstpublishedin2008,Reprint2009.Routledge,NewDelhi,pp73-79
- Foley, D. 2009. Adam's Fallacy: A Guide to Economic Theology. Cambridge, MA andLondon,England:HarvardUniversityPress.
- Galbraith, J.K., 1987. A history of economics: The past as the present. London: H. Hamilton.
- Foley, D. 2009. Adam's Fallacy: A Guide to Economic Theology. Cambridge, MA andLondon,England:HarvardUniversityPress.
- Hunt, E.K. and Lautzenheiser, M., 2015. History of economic thought: A critical perspective. Routledge.
- Martins, N.O., 2013. The Cambridge revival of political economy. Routledge.
- Mazzucato, M., 2018. The value of everything: Making and taking in the global economy. HachetteUK.
- Medema, S.G. and Samuels, W.J., 2013. The history of economic thought: a reader. Routledge
- Screpanti, E. and Zamagni, S., 2005. An outline of the history of economic thought. OUPOxford.
- Temin, P. and Vines, D., 2014. Keynes: useful economics for the world economy. MITPress.
- Vaggi, G. and Groenewegen, P., 2016. A concise history of economic thought: Frommercantilismtomonetarism.Springer.
- Gustafsson, B., Knudsen, C. and Uskali, M. eds., 1993. Rationality, institutionsand economic methodology.Routledge.
- Veblen, T B: The Engineers and the Price System. New York, Augustus M Kelley, 1965. Pp27-51
- Commons, J R: Institutional Economics. AER, Volume 21 1931, pp648-657
- Clark, J M: Studies in the Economics of Overhead Costs. University of Chicago Press, 1923. Pp357-385
- Stigler: Perfect Competition, "Historically Contemplated", in JPE, vol. 65, Number 1, February 1957, pp 1-17
- Kirzner, I: Competition Regulation and the Market Process: An Austrian Perspective. (Link to beprovided).
- Friedman, M: " Neo Liberalism and its Prospects", from The Collected Works of MiltonFriedmanpp89-93
- Chernomas, Robert and Hudson, Ian: The Profit Doctrine. Pluto Press. Chapter Title: 'Milton Friedman: The Godfather of the Age of Instability andInequality.
- Bo Sandelin, Hans-Michael Trautwein, Richard WundrakA Short History of Eco- nomic Thought. Routledge. Third Edition.2014.
- Daron Acemoglu, Francisco A. Gallego, and James A. Robinson Institutions, Human Capital and Development. NBER Working Paper No. 19933. February2014.
- Daron Acemoglu, Simon Johnson, and James Robinson. Institutions as the Fundamental Cause of Long-Run Growth. NBER Working Paper No. 10481. May 2004
- Heilbroner,R.L.(1986).*TheWorldlyPhilosophers*.NewYork,Simon&Schuster.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Discipline Specific Elective 25 (DSE-25): Industrial Organisation

Semester	Course title & Code	Credits	Duration (per week)			Eligibility Criteria	Prerequisite
			Lecture	Tutorial	Practical/ Practice		
VI/VIII	Industrial Organisation – ECON055	4	3	1	0	Class 12th Pass	Game Theory and Strategic Interactions (ECON013)

Learning Objectives

The Learning Objectives of this course are as follows:

- The course assumes knowledge of intermediate microeconomics and game theoretical tools. The students should also be comfortable with applications of calculus.
- This course studies imperfectly competitive market and primarily focuses on firms' strategies in oligopolistic market environments.
- This is the foundation course which aims to prepare the students for further study and research.
- Along with classical models of industrial organisation, the course also covers some contemporary topics like mergers and acquisitions, patents, advertising and networks.
- The learning from this course would be useful to understand and analyse different anti-competitive practices of the firms and theneedfordesigningbettercompetitionpolicyforregulatingthemarket.

Learning outcomes

The Learning outcomes of this course are as follows:

- The students will be able to learn classical models in imperfectly competitive market, understand why regulation of firms is necessary.
- They willbeabletorelatemodernissuesofindustrialorganisation

Syllabus

UNIT I: Imperfectly Competitive Market Product Differentiation, Bertrand, Cournot, Hotelling, Salop, Monopolistic Competition (6 hours)

UNIT II: Dynamic Models of Oligopoly, Cartels, Collusion and Entry Deterrence, Anti-trust (9 hours)

UNIT III: VerticalRelationandVerticalRestraint;DoubleMarginalization,SuccessiveOligopoly, Raising Rival's Cost, Resale Price Maintenance (RPM), Exclusive Dealing (6 hours)

UNIT IV: Mergers and Acquisitions, Horizontal and Vertical Integration (6 hours)

UNIT V: Technology, Innovation, R&D; Market structure and innovation, R&D, Patents, Technology Transfer (6 hours)

UNIT VI: Networks; network Effects, Markets for a Single Network Good and Several Net- workgoods (6 hours)

UNIT VII: Advertisement; Social Costs and Benefits of Advertising, Market Structure, Advertising as Barrier to Entry, Product Differentiation and Competition (6 hours)

Recommended readings

- Cabral, L. M. B. (2017), *Introduction to Industrial Organization*. Second edition, Cambridge, Mass: MITPress.
- Church, J. R., and Roger Ware, (2000), *Industrial Organization: A Strategic Ap- proach.*Boston: Irwin McGraw Hill.
- Shy,O.,(1995),*IndustrialOrganization-TheoryandApplications*,MITPress.
- Watson, J., (2013) *Strategy: An Introduction to Game Theory*, W. W Norton &Company.
- Waldman,D.andJansenE.,(2013),*IndustrialOrganization:MarketsandStrategies* (second edition),Pearson.
- Belleflamme,P.,andPeitz,M.(2010),*Industrialorganization:marketsandstrategies*.Cambridge,UK,CambridgeUniversityPress.
- Tirole , J. (1988), *The theory of industrial organization*, Cambridge, MA: MIT Press.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Discipline Specific Elective 26 (DSE-26): Introduction to Causal Inference

Semester	Course title & Code	Credits	Duration (per week)			Eligibility Criteria	Prerequisite
			Lecture	Tutorial	Practical/ Practice		
VI/VIII	Introduction toCausal Inference–ECON056	4	3	2	0	Class 12th Pass	Basic Econometrics (ECON024)

Learning Objectives

The Learning Objectives of this course are as follows:

- This course intends to provide students with the essential econometric tools required for causal inference analysis.
- The course will give an overview about potential outcomes framework,datadesignandanalysis.

Learning outcomes

The Learning outcomes of this course are as follows:

- The students will be able to understand, design and implement various techniques of causal inference for data analysis as a tool for research.
- The students will be able to do anindependentresearchprojectbasedonthetechniquestheywilllearninthiscourse.

Syllabus

UNIT I: Potential Outcomes Framework (9 hours)
Causal Inference and Potential Outcomes Framework

UNIT II: Research Design (9 hours)
Observational data and experimental data; sample selection

UNIT III: Methods of Analysis (9 hours)
Overview: Ordinary Least Squares (OLS) and Limited Dependent Variables (LDV) Models, Instrumental Variables

UNIT IV: Panel Data (including Difference-in-Difference) (9 hours)
Regression Discontinuity Design (RDD); Introduction to Matching

UNIT V: Hands-on Training (9 hours)
Project work using econometric software (EViews/ R/Stata/EXCEL/SPSS/Julia)

Recommended readings

- Huntington-Klein, N. (2021). The effect: An introduction to research design and causality. Chapman andHall/CRC.
- Imbens, G. W., & Rubin, D. B. (2015). Causal inference in statistics, social, and biomedical sciences. Cambridge UniversityPress.
- Stock, J. H., &Watson, M. W. (2015). Introduction to econometrics (3rd updated edition).
- Rosenbaum, P. (2018). Observation and experiment. Harvard UniversityPress.

- Angrist, J. D., & Pischke, J. S. (2014). *Mastering metrics: The path from cause toeffect*.Princetonuniversitypress.
- Imai, K. (2018). Quantitative social science: An introduction. Princeton UniversityPress.
- Cunningham, S. (2018). Causal inference: The mixtape (V. 1.7)
- Gertler, Paul J.; Martinez, Sebastian; Premand, Patrick; Rawlings, Laura B.; Vermeersch, Christel M. J.. (2016). *Impact Evaluation in Practice, Second Edition. Washington*,DC:Inter-AmericanDevelopmentBankandWorldBank.
- White, H., Raitzer, D. A. (2017). Impact Evaluation of Development Interventions: A Practical Guide. Philippines: Asian DevelopmentBank.
- Glewwe, P., &Todd, P. (2022). Impact Evaluation in InternationalDevelopment.
- Carolina Arteaga,The effect of human capital on earnings: Evidence from a reform at Colombia's top university, Journal of Public Economics, Volume 157, 2018, 212- 225
- Bertrand, M., & Mullainathan, S. (2004). Are Emily and Greg more employable than Lakisha and Jamal? A field experiment on labor market discrimination. AmericanEconomicReview,94(4),991-1013.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Discipline Specific Elective 27 (DSE-27): Introduction to Macroeconomic Dynamics

Semester	Course title & Code	Credits	Duration (per week)			Eligibility Criteria	Prerequisite
			Lecture	Tutorial	Practical/ Practice		
VI/VIII	Introduction to Macroeconomic Dynamics – ECON057	4	3	1	0	Class 12th with Mathematics	Advanced Mathematical Methods for Economics (ECON009) And Intermediate Macroeconomics

Learning Objectives

The Learning Objectives of this course are as follows:

- This is a course which introduces the student to the basics of macroeconomic modelling through dynamic optimization.
- This includes Bellman equation, Euler's equation, Hamiltonian techniques and optimal control approaches.

Learning outcomes

The Learning outcomes of this course are as follows:

- The student gets insights about the construction of abstract macroeconomic models.
- This enables appreciation of a good body of macroeconomic literature in different spheres.
- The course would prove to particularly useful for those interested in pursuing macroeconomicsasafieldofresearchandinquiry.

Syllabus

UNIT I: Dynamic Optimization (15 hours)
Difference equations; differential equations; phase plane analysis; dynamic optimization

UNIT II: Infinite Horizon and Overlapping Generations model (15 hours)
Optimal growth, Ramsey Cass Koopmans model; overlapping generations model, Diamond Dybvig Model

UNIT III: Optimal Control Theory (15 hours)

Recommended readings

- Hoy,Livernois,McKenna,Rees,Stengos(2011),*MathematicsforEconomics*,Addison- Wesley.
- Chiang,AlphaC(1992),*ElementsofDynamicOptimization*,McGrawHill.
- Romer, David (2019) *Advanced Macroeconomics*. McGrawHillIndia.
- Barro,RobertandSalaiMartin,Xavier(2004)*EconomicGrowth*.SecondEdition
- Blanchard, Olivier and Fischer, Stanley (1996), *Lectures on Macroeconomics*, Pren- tice Hall. Eastern EconomyEdition.

- Turnovsky, Stephen(1995) *Methods of macroeconomic dynamics* Prentice Hall In- dia. Eastern EconomyEdition.
- Heijdra, Ben (2017) *Foundations of Modern Macroeconomics*. Oxford.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Discipline Specific Elective 28 (DSE-28): Labour Economics

Semester	Course title & Code	Credits	Duration (per week)			Eligibility Criteria	Prerequisite
			Lecture	Tutorial	Practical/ Practice		
VI/VIII	Labour Economics– ECON058	4	3	1	0	Class 12th Pass	Introductory /Principles of Microeconomics

Learning Objectives

The Learning Objectives of this course are as follows:

- The curriculum is an introduction to labor economics, with an emphasis on applied microeconomic theory and empirical methods critical to microeconomic analysis, as well as the link between research and public policy.
- This course particularly focuses on some of the core theories on labor economics e.g.labor supply, labor demand, role of human capital, incentives, agency, efficiency wages, wage differential and discrimination. The main objective of this course is to enlighten students with some core topics in labor economics with some of the important empirical methods.

Learning outcomes

The Learning outcomes of this course are as follows:

- The students will be able to understand basic theories of labor markets, issues of un- employment, and forms of employment.
- They will learn to critically analyse labour markets in diverse settings including in the macroeconomic context.
- This course will enable the students to evaluate the government policies on labor market critically.

Syllabus

UNIT I: Labor Supply (Static and Intertemporal) (9 hours)
Measuring the Labor Force, Basic Facts about Labor Supply, The Worker's Preferences, The Budget Constraint, The Hours of Work Decision, To Work or Not to Work? The Labor Supply Curve, Estimates of the Labor Supply Elasticity, Labor Supply of Women, Labor Supply over the Life Cycle, Policy Application: Welfare Programs and Work Incentives, Policy Application: The Earned Income Tax Credit, Policy Application: The Decline in Work Attachment among Older Workers.

UNIT II: Labor Demand (9 hours)
The Production Function, The Employment Decision in the Short Run, The Employment Decision in the Long Run, The Long-Run Demand Curve for Labor, The Elasticity of Substitution, Marshall's Rules of Derived Demand, Factor Demand with Many Inputs, Overview of Labor Market Equilibrium, Adjustment Costs and Labor Demand, Trade and Labor Demand, Policy Application: Affirmative Action and Production Costs, Policy Application: The Employment Effects of Minimum Wages Application: Rosie the Riveter as

an InstrumentalVariable

UNIT III: Human Capital (6 hours)
Education in the Labor Market: Some Stylized Facts, The Schooling Model, Education and Earnings, Estimating the Rate of Return to Schooling, Do Workers Maximize Lifetime Earnings? Schooling as a Signal, Post school Human Capital Investments, On-the-Job Training, On-the-Job Training and the Age-Earnings Profile, Policy Application: School Construction in Indonesia, Policy Application: School Quality and Earnings, Policy Application: Evaluating Government Training Programs

UNIT IV: Incentives, Agency and Efficiency Wages (6 hours)
Moral Hazard, Moral Hazard with Limited Liability, Multitasking, Career Concerns, and Applications, Efficiency Wage Models

UNIT V: Wage Differential and Wage Structure (9 hours)
The Market for Risky Jobs, The Hedonic Wage Function, Compensating Differentials and Job Amenities, The Earning Distribution, Measuring Inequality, The Wage Structure: Basic Facts, Inequality across generations. Policy Application: How much is a life worth? Policy Application: Safety and Health Regulations, Policy Application: Health Insurance and the Labor Market, Policy Application: Why did wage inequalityincrease?

UNIT VI: Discrimination (Race and Gender) (6 hours)
Race and Gender in the Labor Market, The Discrimination Coefficient, Employer Discrimination, Employee Discrimination, Customer Discrimination, Statistical Discrimination, Experimental Evidence on Discrimination, Measuring Discrimination, Discrimination against Other Groups, Policy Application: Determinants of the Black–White Wage Ratio, Policy Application: Determinants of the Fe- male–Male Wage Ratio.

Recommended readings

- GeorgeJ.Borjas,*LaborEconomics*,McGrawHill(7thEdition)
- P.Cahuch,StéphaneCarcillo,andAndréZylberberg.*LaborEconomics*,SecondEdition. MIT Press,2014
- Lectures in Labor Economics By Daron Acemoglu and DavidAutor
- Acemoglu, D., D. Autor and D. Lyle, "Women, Warand Wages: The Effect of Female Labor Supply on the Wage Structure at Mid-century," *Journal of Political Economy* (2004) 112:497-551.
- Angrist, J. D., & Pischke, J. S. (2008). *Mostly harmless econometrics*. Princeton universitypress.
- Angrist, J. D., Caldwell, S., & Hall, J. V. (2021). Uber versus taxi: A driver's eye view. *American Economic Journal: Applied Economics*, 13(3),272-308.
- Ashenfelter, O., K. Doran, and B. Schaller, "A Shred of Credible Evidence on the Long-runElasticityofLabourSupply,"*Economica*(2010),77:637
- Bertrand, M. and S. Mullainathan, "AreEmily and Greg More Employable Than Lakisha and Jamal? A Field Experiment on Labor Market Discrimination," *AmericanEconomicReview*94(2004):991-1013(PrimaryReading)
- Cappelli, Peter and Keith Chauvin (1991) "An Interplant Test of the Efficiency Wage Hypothesis." *Quarterly Journal of Economics*, 106(3), 769 – 787.
- Card, David and A. B. Krueger, "Minimum Wages and Employment: A Case Study of the Fast-Food Industry in New Jersey and Pennsylvania," *American Economic Review*(1994)84:772-793.
- Carl Shapiro and Joseph Stiglitz (1984) "Equilibrium Unemployment as Worker DisciplineDevice,"*AmericanEconomicReview*,vol.74(3),pages433-44,June.
- Cesarini,D.,Lindqvist,E.,Notowidigdo,M.J.,&Östling,R.(2017).Theeffectof wealth on individual and household labor supply: evidence from Swedish lotteries. *American Economic Review*, 107(12),3917-46.
- Charles, K.K. and J. Guryan, "Prejudice and Wages: An Empirical Assessment of Becker's The Economics of Discrimination," *Journal of Political Economy* (2008), 16(5):773-809.
- D. Acemoglu, and J-S. Pischke (1999). "Beyond Becker: Training in Imperfect LaborMarkets,"*EconomicJournal*vol109February1999,ppF112-142.
- D. Autor, (2001) "Why Do Temporary Help Firms Provide Free General Skills Training?",*QuarterlyJournalofEconomics*,Vol.116,No.3,pp.1409-1448.(M)

- D. Card, ”UsingRegional Variation to Measure the Effect of the Federal Minimum Wage,” *Industrial and Labor Relations Review*, October1992.
- D. Card, “Estimating the Return to Schooling: Progress on Some Persistent Econometric Problems.” *Econometrica*69 (September2001).
- Fehr, E. and L. Goette, ”DoWorkers Work More if Wages are High? Evidence from aRandomizedFieldExperiment,”*AmericanEconomicReview*(2007),1:298-317.
- Goldin, C., and C.Rouse, ”Orchestrating Impartiality: The Impact of ”Blind” Auditions on Female Musicians,” *American Economic Review* (2000), 90 (4):715-741.
- Imbens, D. Rubin, and B. Sacerdote, “Estimating the Effect of Unearned Income on Labor Supply: Evidence from a Survey of Lottery Players,” *American Economic Review* 91(2001).
- J. Tyler, Richard J. Murnane and John Willett, “Estimating the Labor Market SignalingvalueoftheGED,”*QuarterlyJournalofEconomics*,May2000.(M)
- J.D. Angrist and A. Krueger, ”DoesCompulsory Schooling Attendance Affect SchoolingandEarnings?”*QuarterlyJournalofEconomics*,106[4],Nov1991,979- 1014.
- Krueger, Alan B, and Lawrence H. Summers (1988) “Efficiency Wages and the Inter-IndustryWageStructure,”*Econometrica*,56(2)259-93.
- Maiti, D., & Mukherjee, A. (2013). Trade cost reduction, subcontracting and unionised wage. *Labour Economics*, 21,103-110.
- P. Martorell and D. Clark, “The SignalingValue of a High School Diploma,” *Journal ofPoliticalEconomy*,122[2],April2014.
- Saha, B., Sen, K., & Maiti, D. (2013). Trade openness, labour institutions and flexibilisation:TheoryandevidencefromIndia.*Laboureconomics*,24,180-195.
- T. MaCurdy, ”AnEmpirical Model of Labor Supply in a Life-Cycle Setting,” *Journal of Political Economy*, 89[6], December 1981, 1059-1085.
- Weber, A. and E. Del Bono “Do Wages Compensate for Anticipated Working Time Restrictions? Evidence from Seasonal Employment in Austria”, *Journal of Labor Economics*, 26(1), 181-221,2008.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Discipline Specific Elective 29 (DSE-29): Sectoral Issues in Indian Economy

Semester	Course title & Code	Credits	Duration (per week)			Eligibility Criteria	Prerequisite
			Lecture	Tutorial	Practical/ Practice		
VI/VIII	Sectoral Issue in Indian Economy – ECON059	4	3	1	0	Class 12th Pass	NIL

Learning Objectives

The Learning Objectives of this course are as follows:
The course imparts in-depth knowledge on the issues relating to the agricultural and industrial economy of India, with the focus on the evolutionary path undertaken and the resultant concerns. This will cover issues of MSMEs and small farms to in form the problems industrialisation as well asincreasedproductivityofagriculture.

Learning outcomes

The Learning outcomes of this course are as follows:
This course will familiarize students with the problems, issues,currentdebates,andpolicyinterventionsforlong-termsustainability,efficiency,and resilience. The students will be able to understand, comprehend and critically analyse the issues and policies and would be able to form a well-informed and well- articulated opinionoftheirown.

Syllabus

UNIT I: Agricultural Performance since Independence: (6 hours)
Output and productivity growth Agricultural Performance since Independence in the context of land andlabour

UNIT II: The Policy Environment: Food security and nutritional concerns, MSPs, Agricultural price policy, subsidies/cash transfers, The public distribution system; Capital formation (9 hours)

UNIT III: Current Issues in Indian Agriculture (selected topics) (15 hours)
Resource Use Efficiency-Fertiliser, Water, Other inputs; Diversification for future Growth and enhanced farm income; Sustainable agricultural growth—concepts and constraints; Prospects for dryland/organic/zero budget farming; trade and competitiveness;useofnewtechnologyandartificialintelligence;Marketing/infrastructure; Crop insurance/agriculturalfinance

UNIT IV: Industry (15 hours)
Overview of the Industrial Scene in India- Trends in growth and productivity; Competitiveness and changes in Policy Regimes- domestic competitiveness and export; Issues relating to Indian Industry (selected topics); Scale and ownership, MSMEs and large industries, Public and Private Sector, Employment growth, labour and capital (domestic and foreign), formal and informal sectors, Infrastructural bottle- necks, research and development.

Recommended readings

- SukhamoyChakravarty (1984) Aspects of India's Development Strategy for 1980s? EPW vol 19 no20-21
- J. Bhagwati (1993), India in Transition: Freeing the Economy, Clarendon Oxford 1993
- K. V. Ramaswamy (2015) Labour, Employment and Economic Growth in India CambridgeUniversityPress
- Isher Judge Ahluwalia (1985) Industrial Growth in India: Stagnation Since the Mid-sixties,OxfordUniversityPress
- R. Nagaraj (2015) Can the Public Sector Revive the Economy? Review of the Evidence and a Policy Suggestion EPW vol 50 no5
- S N Rajesh Raj, Kunal Sen (2020) The 'Missing Middle' Problem in Indian Manufacturing. What Role Do Institutions Play? EPW April 18, 2020 vol 55 no16
- Indian Industrialisation, ICSSR Research and Surveys and Explorations in Eco- nomics vol.1 (2015)-C P Chandrasekhar (ed), Oxford University Press,Delhi
- Sabyasachi Mitra, Abhijit Sen Gupta, and Atul Sanganeria (2020) Drivers and Benefits of Enhancing Participation in Global Value Chains: Lessons for India, ADB South Asia Working Paper No. 79
- Raghuram Rajan (2015) Make in India, largely for India, Indian Journal of Indus- trial Relations, Vol. 50, No. 3 (January 2015), pp.361-372
- Vaidyanathan, A. (1994), "Performance of Indian Agriculture since Independence" in Kaushik Basu (ed.), Agrarian Questions Oxford UniversityPress.
- Mahendra Dev (2016) Water Management and Resilience in Agriculture vol 51, No 8 EPW Economic & Political Weekly
- Ramesh Chand (2012) Development Policies and Agricultural Markets EPW DE- CEMBER 29, 2012 vol 47 no52
- Yoginder K Alagh (2021) Globalisation and the Indian Farmer EPW vol 56 no 28
- Chatterjee, S., Kapur, D. (2017). Six puzzles in Indian agriculture. India Policy Forum 2016, Vol. 17.
- NABARD Foundation Day, Paper on enhancing Farmers' income by K J S Satyasai and Nirupam Mehrotra. 12 July 2016
- Acharya, S.S. (2007) "Agribusiness in India: Facts and Emerging Issues", AgriculturalEconomicsResearchReview,Vol. 20,ConferenceIssue,pp.409-424
- Mohan, R., (2006) Agricultural Credit in India: Status, Issues and Future Agenda, EconomicandPoliticalWeekly,March18,2006,pp1013-1021.
- Mishra S.N. and Chand, R., (1995) Public and Private Capital Formation in Indian Agriculture: Comments on Complementarily Hypothesis, Economic and Political Weekly, June 24th,1995
- GOI (2007), Report of The Working Group on Risk Management in Agriculture for the Eleventh Five Year Plan (2007-2012), GOI, NewDelhi
- Indian Agriculture Towards 2030-Pathways for Enhancing Farmers' Income, Nutritional Security and Sustainable Food and Farm Systems (2021) An open-access Springerpublication.
- Government of India (2017) "Report of the Committee on Doubling Farmers' In- come". Ministry of Agriculture and Farmers' Welfare, Government ofIndia
- PRS Legislative Research (2017), Swaminathan Report: National Commission on Farmers, at Swaminathan Report: National Commission on Farmers, PRSIndia
- Acharya SS and NL Agarwal (2016), Agricultural Marketing in India, New Delhi: CBS Publishers andDistributors
- Expert Committee Report on Marketing Infrastructure & Agricultural Marketing Reforms (2000) Government of India, Department of Agricultural & Cooperation Krishi Bhavan, NewDelhi

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Discipline Specific Elective 30 (DSE-30): Topics in Game Theory

Semester	Course title & Code	Credits	Duration (per week)			Eligibility Criteria	Prerequisite
			Lecture	Tutorial	Practical/ Practice		
VI/VIII	Topics in Game Theory – ECON060	4	3	1	0	Class 12th with Mathematics	Game Theory and Strategic Interactions (ECON013)

Learning Objectives

The Learning Objectives of this course are as follows:

- This course deals with extensive form games. Students learn the concepts of subgame- perfect equilibrium, Bayesian and Perfect Bayesian equilibrium in static and dynamic forms.

Learning outcomes

The Learning outcomes of this course are as follows:

- The students will learn how to model multi-person decision making in an interactive setting.
- They will understand how to formulate different real-life situations as games and learn to predict the optimal strategies of players and how the players can exploit strategicsituationsfortheirownbenefit.

Syllabus

UNIT I: Extensive form games with perfect information (9 hours)
Extensive games with perfect information; strategies and outcomes; Nash equilibrium; subgame perfect equilibrium; backward induction in finite games; commitment; bargaining; Stackelberg's model of duopoly; a race; other illustrations

UNIT II: Simultaneous move games (9 hours)
Entry into a monopolized industry; electoral competition with strategic voters; committee decision-making; exit from a declining industry

UNIT III: Bayesian games (9 hours)
Strategies; Bayesian Nash equilibrium; Cournot's duopoly game with imperfect information; providing a public good; auctions; juries; other applications.

UNIT IV: Extensive form games with imperfect information (9 hours)
Strategies; Nash equilibrium; beliefs and sequential equilibrium; perfect Bayesian equilibrium; signaling games; applications.

UNIT V: Repeated Games (9 hours)
Payoffs, strategies, Nash equilibrium and subgame perfect equilibrium of repeated games

Recommended readings

- Martin J. Osborne, *An Introduction to Game Theory*, Oxford University Press, New Delhi,2004.

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DISCIPLINE SPECIFIC ELECTIVE COURSE 31(DSE-31) : FINANCIAL DERIVATIVES

Credit distribution, Eligibility and Pre-requisites of the Course

Semester	Course title & Code	Credits	Duration (per week)			Eligibility Criteria	Prerequisite
			Lecture	Tutorial	Practical / Practice		
VI/VIII	Financial Derivatives ECON077	4	3	1	0	Class XII with Mathematics	Introductory Mathematical Methods for Economics ECON002

Learning Objectives

- To equip students with essentials tools for understanding Finance at undergraduate level.
- To provide analytical knowledge to understand complex financial Derivatives.
- To provide advance skills for pricing and formulating trading strategies using Derivative products

Learning outcomes

- After studying this course, students would be able to understand the core concepts of financial derivates. The course would develop an analytical knowledge for understanding the mechanics and characteristics of derivative products such as Future, Options and SWAP agreements.
- After studying this course, students would be able to understand and formulate complex trading strategies adopted using financial derivate products.

SYLLABUS OF DSE: FINANCIAL DERIVATIVES

Unit 1: Futures Contract & SWAP (15 Hours)
Part I: Futures/Forward Contracts: Properties, Pricing and Hedging
a) Introduction to derivatives and options; forward and futures contracts; options; other derivatives
Hull Chapter - 2: Mechanics of Futures Markets (Sections 2.1 - 2.4 & 2.11)

b) Forward and future prices
Hull Chapter-5: Determination of Forward & Futures Prices (Sections 5.1 - 5.5, 5.9, 5.11 & 5.12)

c) Stock index futures & the use of futures for hedging
Hull Chapter - 3: Hedging Strategies using Futures

Part II: Interest Rate Futures
d) Interest rate futures & duration-based hedging strategies
Hull Chapter - 6: Interest rate futures (6.1 to 6.4) [exclude page-158 & 159]

Part III: SWAP & FRA
e) Forward Rate, Forward Rate Agreement and SWAP
Hull Chapter - 4: Interest rate (4.1 to 4.3, 4.6 and 4.7)
Kolb Chapter – 37: Forward Rate Agreements (Page 575- 577)
Hull Chapter - 7: Swaps (7.1 to 7.4)

Kolb Chapter – 1: Swap Contracts (Page 11-13); Chapter - 28: Pricing and Valuation of SWAP (page 407-410)

Unit 2: Options Contract (30 Hours)
Part I: Introduction and Properties of Option Contracts
f) Option markets; call and put options; factors affecting option prices; put-call parity
Hull Chapter - 10: Mechanics of options markets (10.1 to 10.7);
Hull Chapter -11: Properties of stock options (Full Chapter)

Part II: Option Strategies
g) Option trading strategies: spreads; straddles; strips and straps; strangles
Hull Chapter -12: Trading strategies involving options (Full Chapter)

Part III: Pricing of Options, BSM and Greek letters
h) The principle of arbitrage; discrete processes and the binomial tree model; risk neutral valuation, Black Scholes Merton (BSM) Model, Greek letters
Hull Chapter - 13: Binomial trees. Sections 13.1-13.4, 13.6 - 13.9 & Appendix (Derivation of BSM)
Hull Chapter - 14: Section 14.6 ITOˆ ’S Lemma
Hull Chapter - 15: The Black–Scholes–Merton Model: Sections 15.3, 15.4, 15.5, 15.6, 15.8,15.11
Hull Chapter - 19: The Greek Letters

Recommended readings

Hull, John C.,Options, Futures and Other Derivatives, Pearson Education, Inc, 9th Edition (Global Edition), 2018.

Robert W. Kolb, James A. Overdahl, Financial Derivatives: Pricing and Risk Management, John Wiley & Sons, 2010

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Discipline Specific Elective 32 (DSE-32): Political Economy and Globalisation

Semester	Course title & Code	Credits	Duration (per week)			Eligibility Criteria	Prerequisite
			Lecture	Tutorial	Practical/ Practice		
IV/VI/VIII	Political Economy and Globalisation – ECON078	4	3	1	0	Class 12th Pass	NIL

Learning Objectives

The Learning Objectives of this course are as follows:

- To explore some of the fundamental structural changes and dynamics of the advanced capitalist system since the early twentieth century to the contemporary period.
- To analyse the changes in the organization of production, labour market institutions as well as shifts in corporate, managerial, fiscal, financial and inter-firm governance structures.
- To analyse the role of state in the era of globalization. It also integrates contemporary issues of gender and environment in a political economy framework.

Learning outcomes

After completion of the course the learners will be able to:

- Do critical analysis in an integrated and broader political economy framework.
- Analyze some of the most contemporary trends and developments at the global level and evaluate them.
- Analyze the issues studied in the compulsory courses on the Indian Economy and Development Economics.

Syllabus

UNIT I: Changing Dynamics of Capitalist Production, Organisational Form and Labour Process (9 hours)
Historical Overview; changing dynamics of the organisation of production, markets and labour process; Evolution of the multinational corporations and their economic logic; changing nature of employment, job security and labour rights.

UNIT II: The State and the Economy (9 hours)
State and the economy; political economy of macroeconomic policy; state in the international political economy - globalisation and imperialism.

UNIT III: Neoclassical political economy (9 hours)
State and rent seeking; market failure; government failure and decentralized development; institutions and economic development; theory of political transitions.

UNIT IV: Political economy of fiscal consolidation and financialization (9 hours)
Principles of Political economy of Taxation; changing role of finance and the shifts in corporate governance structures: financialization – its nature and consequences.

UNIT V: Broader Perspectives (Gender and Environment) (9 hours)
Dimensions of Gender in work, accumulation and globalization; political economic issues in environment, sustainability and inequality.

Recommended readings

- Acemoglu, D and J. A. Robinson (2001). "A Theory of Political Transitions", *The AmericanEconomicReview*,Vol. 91,No. 4(September),pp. 938-963
- Acemoglu, D., & Robinson, J. A. (1999). On the political economy of institutions and development. *American Economic Review*, 91(4), 938-63.
- Acemoglu, D., Golosov, M., &Tsyvinski, A. (2007). Political economy and the structure of taxation. MIT mimeo.
- Bardhan, Pranab (1996)Decentraliseddevelopment. *Indian EconomicReview,* 1996.
- Beaud, Michel (2001). A History of Capitalism, 1500-2000, translated by Tom Dickman and Anny Lefebvre, New York: Monthly Review Press.
- Boyce, J. K. (2002). *The Political Economy of the Environment*, Edward Elgar.
- Chang, D. (2009). "Informalising Labour in Asia's Global Factory" *Journal of Contemporary Asia*, 39:2, 161-179.
- Datta-chaudhuri, Mrinal (1990) Market failure and Government Failure. *JournalofEconomicPerspectives*.Volume4,Number3—Summer1990—Pages25–39.
- Di John, J. (2006). The political economy of taxation and tax reform in developing countries (No. 2006/74). WIDER research paper.
- Dore, Ronald (2008). "Financialization of the Global Economy", *Industrial and Corporate Change*, Volume 17, Number 6, pp. 1097-1112.
- Gandini, Alessandro (2019). "Labour Process Theory and the Gig Economy",*Human Relations*, Vol. 72(6). [Particularly pages 1044-1051. The sections of"The point of production in the gig economy", "Emotional labour and gig work",and "Control"].
- Gereffi, G, J. Humphrey and T. Sturgeon (2005): "The Governance of Global Value Chains", *Review of International Political Economy*, Volume 12, pp. 78-104.
- Gottfried, Heidi (2013). *Gender, Work and Economy - Unpacking the Global Economy, Polity*. [Chapter 10 "Gender, Global Labor Markets, Commodity Chains and Mobilities"]
- Hall, P. A. and D. Soskice (2001) 'An Introduction to Varieties of Capitalism' in Hall, P. A. and D. Soskice Varieties of Capitalism: the institutional foundation of comparative advantage, Oxford University Press, pp 1-68
- Huws, Ursula (2016). "A New Paradigm for work Organisation?", *Work Organisation, Labour & Globalisation*, Vol 10 No. 1 pp 7-26, Pluto Journals.
- Hymer, Stephen (1975). "The Multinational Corporation and the Law of Un-even Development", in H. Radice (ed.) *International Firms and Modern Imperialism*, Penguin Books.
- Kim, S. Y., & Spilker, G. (2019). Global value chains and the political economy of WTO disputes. *The Review of International Organizations*, 14(2), 239-260.
- Kiser, E., &Karceski, S. M. (2017). Political economy of taxation. *Annual review of political science*, 20, 75-92.
- Sen, Amartya K. (1990): "Gender and Cooperative Conflicts" in Irene Tinker (ed.)*Persistent Inequalities - Women and World Development*, OUP.
- Srinivasan T N (1985) Neoclassical political economy, the state and economic development. *Asian Development Review* Vol. 3.1985, 2, p. 38-58

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COMMON POOL OF GENERIC ELECTIVES (GE) COURSES

GENERIC ELECTIVES (GE-1): PRINCIPLES OF MICROECONOMICS I

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Semester	Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
			Lecture	Tutorial	Practical/ Practice		
I/III/V/VII	Principles of MicroeconomicsI ECON025	4	3	1	0	Class XII pass	NIL

Learning Objectives

The Learning Objectives of this course are as follows:

- This course discusses the basic principles in Microeconomics and their applications. It includes consumer's problem, demand estimation, production function, cost functions and market analysis. It illustrates how the concepts of microeconomics can be applied toanalyzereal-lifeeconomicsituations.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Thestudentslearnsomebasicprinciplesofmicroeconomicsofconsumerandproducers,andinteractions of supply and demand, characteristics of perfect competition, efficiency and welfareoutcomes.

SYLLABUS OF GE-1

UNIT – I: Introduction (12 hours)
Problem of scarcity and choice: scarcity, choice and opportunity cost; production possibility frontier; economic systems. Demand and supply: law of demand, determinants of demand, shifts of demand versus movements along a demand curve, market demand, law of supply, determinants of supply, shifts of supply versus movements along a supply curve, market supply, market equilibrium. Applications of demand and supply: price rationing, price floors, consumer sur- plus, producer surplus. Elasticity: price elasticity of demand, calculating elasticity, determinants of price elasticity, other elasticities

UNIT – II: Consumer Theory (12 hours)
Budget constraint, concept of utility, diminishing marginal utility, Diamond-water paradox, income and substitution effects; consumer choice: indifference curves, derivation of demand curve from indifference curve and budget constraint

UNIT – III: Production and Costs (12 hours)

Production: behaviour of profit maximising firms, production process, production functions, law of variable proportions, choice of technology, isoquant and isocostlines, cost minimizing equilibrium condition
Costs: costs in the short run, costs in the long run, revenue and profit maximization, minimizing losses, short run industry supply curve, economies and dis- economies of scale, long run adjustments

UNIT – IV: Perfect Competition (09 hours)

Assumptions: theory of a firm under perfect competition, demand and revenue; equilibrium of the firm in the short run and long run; Long run industry supply curve: increasing, decreasing and constant cost industries.
Welfare: allocative efficiency under perfect competition.

Practical component (if any) - NIL

Essential/recommended readings

- Mankiw,N.G.(2018).*PrinciplesofMicroeconomics*8thed.
- Frank, R. H., & Cartwright, E. (2010). *Microeconomics and behavior*. New York: McGraw-Hill.
- Bernheim,B.,Whinston,M.(2009).*Microeconomics*.TataMcGraw-Hill.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

GENERIC ELECTIVES (GE-2): BASIC DEVELOPMENT ECONOMICS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Semester	Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
			Lecture	Tutorial	Practical/ Practice		
I/III/V/VII	**Basic DevelopmentEconomics ECON029**	**4**	**3**	**1**	**0**	**Class XII Pass**	**NIL**

Learning Objectives

The Learning Objectives of this course are as follows:

- This course exposes students to some of the key ideas and concepts in the areas of economic growth, human development and globalisation building on the concept of growth and further links it up with alternative conceptions of development.

Learning outcomes

The Learning Outcomes of this course are as follows:

- Students will develop a critical understanding of the contemporary issues in economic growth and development and their paths. Students will thus be better prepared to face the professional world and can use this knowledge base in a variety of jobs, including in the corporate, civil service and NGOsectors.

SYLLABUS OF GE-2

UNIT – I: Development and underdevelopment (12 hours)
Growth vs Development; Classic Approaches of Development; Contemporary theories of Development and Underdevelopment

UNIT – II: Development goals and indicators, measures of underdevelopment
Various concepts and measures of poverty and inequality, poverty lines using various national and international criteria. (12 hours)

UNIT – III: Capabilities, human development and sustainable development (12 hours)

UNIT – IV: Globalisation and development (9 hours)

Practical component (if any) - NIL

Essential/recommended readings

- DebrajRay,*DevelopmentEconomics*,(DE),PrincetonUniversityPress,1998.
- Robinson, J. A., & Acemoglu, D. (2012). *Why nations fail: The origins of power, prosperity and poverty* (pp. 45-47). London: Profile.
- Abhijit Banerjee, Roland Benabou and Dilip Mookerjee (eds), *UnderstandingPoverty* (UP), Oxford University Press, 2006.

- Angus Deaton, *The Great Escape: Health, Wealth and the Origins of Inequality*, PrincetonUniversityPress,2013.
- Gustav Ranis et.al, Economic Growth and Human Development, *World Development* Vol. 28, No. 2, Elsevier Science Ltd.,2000
- Amartya Sen, *Development as Freedom*, OUP,2000
- Thomas Piketty and Emmanuel Saez, 'Inequality in the Long Run', Science, 344 (838),2014
- Piketty,Thomas,2019,*CapitalandIdeology*,HarvardUniversityPress,
- SéverineDeneulinwithLilaShahani(ed.),*AnIntroductiontotheHuman DevelopmentandCapabilityApproach:FreedomandAgency*,Roultedge,2009

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

GENERIC ELECTIVES (GE-3): ESSENTIALS OF ECONOMICS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Semester	Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
			Lecture	Tutorial	Practical/ Practice		
I/III/V/VII	**Essentials of Economics ECON076**	**4**	**3**	**1**	**0**	**Class XII pass**	**NIL**

Learning Objectives

The Learning Objectives of this course are as follows:

- This course will introduce the fundamental concepts of economics, the study of how people manage resources. It contains basic principles of microeconomics (the behaviour of consumers, firms and companies), macroeconomics (national production, employment, inflation and interest rates) and international economics (balance of payment, exchange rate and trade) with graphical illustration and contemporary examples.

Learning outcomes

The Learning Outcomes of this course are as follows:

- By studying this course, the students will learn to think like an economist and understand how a modern market economy function. They will learn about the factors that determine long-run growth and short-term fluctuations and role of government and financial institutions, so they can better understand how economics applies to the everyday life.

SYLLABUS OF GE-3

UNIT – I: Microeconomic Foundations (15 hours)
Foundations of economics, how market works, firms and market structures, markets for factor of production, role of government

UNIT – II: Macroeconomic Foundations (15 hours)
GDP (measuring total production, income and economic growth), unemployment and inflation; aggregate demand and aggregate supply analysis; monetary and fiscal policies

UNIT – III: Foundation of International Economics (15 hours)
Comparative advantage and the gains from trade, macroeconomics in an open economy

Practical component (if any) - NIL

Essential/recommended readings

– Hubbard, G., Garnett, A., & Lewis, P. (2019). Essentials of economics. 5th edition, Pearson Higher Education AU.

– Sloman, J., & Garratt, D. (2016). Essentials of Economics, 7th edition, Pearson

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GENERIC ELECTIVES (GE-4): PRINCIPLES OF MACROECONOMICS I

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Semester	Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
			Lecture	Tutorial	Practical/ Practice		
II/IV/VI/VIII	**Principles of MacroeconomicsI ECON026**	**4**	**3**	**1**	**0**	**Class XII pass**	**NIL**

Learning Objectives

The Learning Objectives of this course are as follows:

- This course introduces the basic concepts in Macroeconomics both in closed and open economy. It deals with the behaviour and characteristics of aggregate economy.
- This course introduces the definition, measurement of the macroeconomic variables like GDP, consumption, savings, investment and balance of payments.
- The course also discusses various theories and approaches of determining GDP.

Learning outcomes

The Learning Outcomes of this course are as follows:

- The students will learn the broad understanding of macroeconomic variables and their measurement issues like GDP, inflation, money supply, interest rate and their inter- linkages.
- It will also allow them to critically evaluate various macroeconomic policies and their effects on output and interest rate in theeconomy.

SYLLABUS OF GE-4

UNIT – I: Introduction (9 hours)
What is macroeconomics? Macroeconomic issues in an economy

UNIT – II: National Income Accounting (9 hours)
Concepts of GDP and National Income; measurement of national income and re-
lated aggregates; nominal and real income; limitations of the GDP concept

UNIT – III: Determination of GDP (9 hours)
Actual and potential GDP; aggregate expenditure; consumption function; invest-
ment function; equilibrium GDP; concepts of MPS, APS, MPC, APC; autonomous expenditure; Concept of multiplier

UNIT – IV: National Income Determination in an Open Economy with Government (9 hours)
Income determination; Fiscal Policy: impact of changes in government expenditure and taxes; net exports function; net exports and equilibrium national income.

UNIT – V: Money in a Modern Economy (9 hours)

Concept of money in a modern economy; monetary aggregates; demand for money; quantity theory of money; liquidity preference and rate of interest; money supply and credit creation; monetary policy.

Practical component (if any) - NIL

Recommendedreadings

- Andrew Abel, Ben Bernanke and Dean Croushore (2011). *Macroeconomics* (7th edition). Pearson
- Richard T. Froyen(2013). *Macroeconomics: Theories and Policies* (10th ed.), Pearson.
- Blanchard,O.(2018).*Macroeconomics*(7thedition).Pearson
- Blanchard,O.(2006).*Macroeconomics*(6thedition).Pearson
- Dornbusch, R., and S. Fischer. (1994). *Macroeconomics* (6th edition). McGraw- Hill
- R. Dornbusch, S. Fischer and R. Startz. (2018). *Macroeconomics* (12th edition). McGraw-Hill

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

GENERIC ELECTIVES (GE-5): BASIC STATISTICS FOR ECONOMICS

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Semester	Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
			Lecture	Tutorial	Practical/ Practice		
II/IV/VI/VIII	**Basic Statistics forEconomics ECON022**	**4**	**3**	**1**	**0**	**Class XII pass**	**Knowledge of Class XII standard Mathematics**

Learning Objectives

The Learning Objectives of this course are as follows:

- The course teaches students the basics of probability theory and statistical inference based on simple technical rigor.
- It includes introductory probability theories, sample distribution and hypothesis testing that set a necessary foundation for the econometrics course taught as a General Elective.

Learning outcomes

The Learning Outcomes of this course are as follows:

- The student will be able to analyse the data using basic statistical concepts.
- They will understand sampling characteristics, estimation as well as examining the hypotheses using discrete and continuous distributions.

SYLLABUS OF GE- 5

UNIT – I: Introduction and overview (12 hours)

Populations and samples; sample statistics; Descriptive Statistics.

UNIT – II: Basic concepts of probability(12 hours)

Spaces and events; probability concepts, conditional probabilities

UNIT – III: Probability distributions and Sampling (12 hours)

Random variables – discrete and continuous, various probability distributions - functions and characteristics; Commonly used distributions - uniform, binomial, exponential, Poisson, hypergeometric and Normal random variables. Jointly distributions- conditional distributions and expectations, covariance and correlation

Unit – IV: Estimation and Hypothesis testing (9 hours)

Estimation of population parameters - methods of moments and maximum likelihood procedures; properties of estimators; confidence intervals; Defining statistical hypotheses; distributions of test statistics; testing hypotheses related to population parameters; Type I and Type II errors; power of a test

Practical component (if any) - NIL

Recommendedreadings

- Larsen, R., Marx, M. (2011). *An Introduction to Mathematical Statistics and its Applications*, PrenticeHall.
- James McClave, P. George Benson, Terry Sincich (2017), *Statistics for Business and Economics*, PearsonsPublication.
- Anderson D. R, Sweeney D.J. et. al (2019), Statistics for Business & Economics, 13th ed. CengageLearning.
- SheldonRoss(2017),IntroductoryStatistics,4thEdition,AcademicPress

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

GENERIC ELECTIVES (GE-6):INDIAN ECONOMY

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Semester	Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course
			Lecture	Tutorial	Practical/ Practice		
II/IV/VI/VIII	**IndianEconomy ECON030**	**4**	**3**	**1**	**0**	**Class XII pass**	**NIL**

Learning Objectives

The Learning Objectives of this course are as follows:

- This course introduces the economic problems related to the Indian economy by familiarizing them with the research studies on areas relating to economic development and policy in India with an emphasis on contemporary debates.

Learning outcomes

The Learning Outcomes of this course are as follows:

- The students will be able to learn the development paradigm adopted in India since independenceandevaluateitsimpactoneconomicaswellassocialindicatorsofprogress.
- Students will have the ability to explore current policy debates and contribute to policy making in an informed way using relevant databases.
- They will also learn how to conductindependentresearchinthesareas

SYLLABUS OF GE-3

Unit 1 : Historical and general overview of Indian economy since Independence (9 hours)

Unit 2 : Growth and structural change (9 hours)

Unit 3 : The Indian economy in a comparative perspective (9 hours)
Unit 4 : Key issues: poverty, inequality, education, health and gender (9 hours)
Unit 5 : Agriculture, industry, services and international trade (9 hours)

Practical component (if any) - NIL

Recommendedreadings

- Kumar, Dharma (2005) ed the article on The Indian Economy 1970 to 2003 in revised version of CEHI VolII
- Balakrishnan, Pulapre(2010) *Economic Growth in India: History and Prospect*. OUP.
- Rakshit, Mihir (2011) *Macroeconomics of Post-reformIndia*. OUP
- Rakshit, Mihir (2010) *Money and Finance in the Indian Economy*.OUP
- Goyal, Ashima(ed) (2015)*A Concise handbook of Indian Economy in the 21st Century*.OUP
- Ghate,Chetan(ed)(2012)*TheOxfordHandbookofIndianEconomy*.OUP.
- Bosworth, B., Collins, S. M., & Virmani, A. (2007). *Sources of growth in the Indian economy*.
- Goyal, A. (Ed.). (2019). *A Concise Handbook of the Indian Economy in the 21st*

Century.OxfordUniversityPress.

- Pulapre Balakrishnan, 2007, "The Recovery of India: Economic Growth in the Nehru Era", *Economic and Political Weekly*, November.
- RakeshMohan,2019,*MovingIndiatoanewGrowthTrajectory:NeedforaComprehensiveBigPush*,BrookingsIndia,Section1and2,9-30.
- Ahluwalia,M.S.,2019,"India'seconomicreforms: AchievementsandNextSteps", *Asian Economic Policy Review*, 14(1), 46-62.
  James, K.S., & Srinivas Goli, 2016, "Demographic Changes in India: Is the Country Prepared for the Challenge?" *Brown Journal of World Affairs*, Fall/Winter 2016, Volume XXIII, IssueI.
  Desai, S., 2015, "Demographic deposit, dividend and debt", *The Indian Journal of Labour Economics*, 58,217-232
  Arvind Subramanian and Josh Felman (2021) India's Stalled Rise-How the State Has Stifled Growth, *Foreign Affairs*on 14.12. 2021
  Executive Summary, 2014, Report of the Expert Group to Review the Methodology for Measurement of Poverty (Rangarajan Committee report), GOI,1-5
- Thomas, J. J. (2020). 'Labour Market Changes in India, 2005–18', *Economic and Political Weekly*, 55(34),57

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Generic Elective (GE-7): Theory of Public Finance

Semester	Course title & Code	Credits	Duration (per week)			Eligibility Criteria	Prerequisite
			Lecture	Tutorial	Practical/ Practice		
III/V/VII	Theory of Public Finance – ECON061	4	3	1	0	Class 12th Pass	Introductory /Principles of Microeconomics

Learning Objectives

The Learning Objectives of this course are as follows:

- This course will look into the efficiency and equity aspect of market mechanism of allocating resources and also the design and implications of public sector policies including taxation and monetary policies.
- It will deal with efficiency, equity, public goods, externalities, taxation, subsidies, fiscal multiplier, money supply, interest rate and their interlinkages.

Learning outcomes

The Learning Outcomes of this course are as follows:

- This course aims to develop the broad conceptual frameworks which will enable students to learn economic issues efficiency, equity, public goods, externalities, taxation, subsidies, fiscal multiplier, money supply, interest rate and their interlinkages.
- It will also allow them to critically evaluate various micro and macro aspects of government policies and their effects on output, distribution, and welfare in the economy.
- The course will be useful for students aiming towards careers in the government sector, policy analysis, business and journalism.

Syllabus

UNIT I: Theories of Public Sector and Market Mechanism (12 hours)
Overview of Fiscal Functions; Tools of Normative Analysis; Pareto Efficiency; General Equilibrium Framework; Equity and the Social Welfare

UNIT II: Market Failure (12 hours)
Sources of Market failures; Public Goods; and Externalities.

UNIT III: Theories of Taxation (12 hours)
Product and Factor tax; Tax Burden; Tax Distortions; Tax Design

UNIT IV: Working of Fiscal and Monetary Policies (9 hours)
Fiscal policy; Banking system and creation of Money; Monetary Instruments and Policies; Fiscal and Monetary Management in Indian Context.

Recommended readings

- R.A. Musgrave and P.B. Musgrave ,*Public Finance in Theory and Practice*, 5th Edition.
- Rosen,H.&Gayer,T.(2014).*Publicfinance*(10thed.).NewYork:McGraw-Hill.
- Stiglitz, J E & Rosengard J K (2015), *Economics of the Public Sector*, 4th ed, W.W. Norton.

- Jonathan Gruber, (2011), Public Finance and Public Policy, 3rd edition, Worth Publishers. (MainTextbook)
- Cullis, J., Jones, P. (1998). Public finance and public choice, 2nd ed. Oxford UniversityPress.
- Hindriks,J.,Myles,G.(2013).Intermediatepubliceconomics,2nded.MITPress.
- A. Bagchi (ed.): Readings in public finance. Oxford UniversityPress.
- Stiglitz, J. (2009). Economics of the public sector, 3rd ed. W. W.Norton.

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Generic Elective (GE-8): Money and Banking

Semester	Course title & Code	Credits	Duration (per week)			Eligibility Criteria	Prerequisite
			Lecture	Tutorial	Practical/ Practice		
III/V/VII	**Money and Banking – ECON062**	**4**	**3**	**1**	**0**	**Class 12th Pass**	**Introductory / Principles of Macroeconomics**

Learning Objectives

The Learning Objectives of this course are as follows:

- This course exposes students to the theory and functioning of the monetary and financial sectors of the economy.
- It highlights the organization, structure, and role of financial markets and institutions. It also discusses interest rates, monetary management, and instruments of monetary control.
- Financial and banking sector reforms and monetary policy with special reference to India are also covered.

Learning outcomes

The Learning Outcomes of this course are as follows:
This allows students to understand current monetary policies and financial market out- comes. It also enables them to critically evaluate policies.

Syllabus

UNIT I: Money (9 hours)
Understanding concept and functions of money, Measurement of money supply, Analytics and Methodology of computation of money supply, Theories of money supply determination

UNIT II: Financial markets: an Introduction (12 hours)
Role of financial markets and institutions; Problems of Asymmetric information, Financial Crises; Financial derivatives: Futures, Options and Swaps; Financial markets and Institutions in India: Organization, Structure and Reforms in India

UNIT III: Interest Rates (12 hours)
Determination of interest rates; Sources of interest rates differentials and risk; Theories of term structure of interest rates; Interest rates in India

UNIT IV: Central Banking and Monetary policy (12 hours)
Central Bank: Functions and Balance Sheet
Monetary Policy: Targets and instruments, Monetary management in an open economy
Monetary Policy Framework in India: Evolution and current scenario, critical evaluation
Digital currency: implications and emerging issues in Indian economy

Recommended readings

- F J Fabozzi et al: Foundations of Financial Markets and Institutions, Pearson
- F S Mishkin , S G Eakins, T Jayakumar, R K Pattnaik : Financial Markets and Institutions Pearson
- N Jadhav: Monetary Policy, Financial stability and Central Banking in IndiaMacmilla

- M.R. Baye and D.W. Jansen Money, Banking and Financial Markets AITBS, 1996
- Report of the Working Group: Money Supply Analytics and Methodology of Compilation, 1998 Annual Report; Master Circular - Prudential Norms on Capital Adequacy - Basel I Framework - 2011; RBI Bulletin; Report of Currency and Finance (latest).
- Dua, P., "Monetary Policy Framework in India", Indian Economic Review, Vol. 55, Issue 1, June 2020
- Ghate, C., &Kletzer, K. M. (Eds.). (2016). Monetary policy in India: A modern macroeconomic perspective. Springer.
- Various publications of RBI and other agencies / institutions

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Generic Elective (GE-9): Digitalisation and Development

Semester	Course title & Code	Credits	Duration (per week)			Eligibility Criteria	Prerequisite
			Lecture	Tutorial	Practical/ Practice		
III/V/VII	**Digitalisation and Development – ECON063**	**4**	**3**	**1**	**0**	**Class 12th Pass**	**NIL**

Learning Objectives

The Learning Objectives of this course are as follows:

- The analysis of the impact of information and communication technologies (ICTs) on economies and societies is a growing field. Technology is an enabling factor. Technological developments become relevant to the extent that they are economically and socially meaningful.
- This course aims to offers an overview of the understanding of economics of digitalisation and its impact on the life and livelihood with an interdisciplinary approach.

Learning outcomes

The Learning Outcomes of this course are as follows:
The students would understand the functions information technology and its socio- economic impact, wellbeing and progress on the contemporary world.

Syllabus

UNIT I: Digital development - India and the World (12 hours)

UNIT II: The transformation of management practices; work and employment; social net- works, trust and social capital in the digital economy; cultural and motivational aspects (12 hours)

UNIT III: Unit ICTs, Digital Divide and the political economy of inequality (12 hours)

UNIT IV: Access to ICT and poverty and wellbeing, work-life balance (9 hours)

Recommended readings

- Goldfarb, A., Gans, J.,& Agrawal, A. (2019). The Economics of Artificial Intelligence: An Agenda. University of Chicago Press.
- Agrawal, A., Gans, J., & Goldfarb, A. (2018). Prediction machines: the simple economics of artificial intelligence. Harvard Business Press.
- Goldfarb, A., & Tucker, C. (2019). Digital economics. Journal of Economic Literature, 57(1), 3-43.
- Goldfarb, A., Greenstein, S. M., & Tucker, C. E. (Eds.). (2015). Economic analysis of the digital economy. University of Chicago Press.
- Maiti, D., & Awasthi, A. (2020). ICT exposure and the level of wellbeing and progress: A cross country analysis. Social Indicators Research, 147(1), 311-343.
- Acemoglu, D., & Restrepo, P. (2018). Artificial intelligence, automation, and work. In The economics of artificial intelligence: An agenda (pp. 197-236). University of Chicago Press.
- Acemoglu, D., & Restrepo, P. (2018). The race between man and machine: Im- plications of technology for growth, factor shares, and employment. American Economic Review, 108(6), 1488-1542.

- Varian, H. R. (2001). Economics of information technology. University of California, Berkeley.
- Maiti, D., Castellacci, F., & Melchior, A. (2020). Digitalisation and development: issues for India and beyond. In Digitalisation and Development (pp. 3-29). Springer, Singapore.
- Singh, N. (2016). Information technology and its role in India's economic development: A review. Development in India, 283-312.
- Castellacci, F., & Tveito, V. (2016). The Effects of ICTs on Well-being: A Survey and a Theoretical Framework (No. 20161004). Centre for Technology, Innovation and Culture, University of Oslo.
- Huyer, S., & Mitter, S. (2003). ICTs, globalisation and poverty reduction: Gender dimensions of the knowledge society. Kampala (Uganda): http://gab. wigsat. org/policy. htm.

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Generic Elective (GE-10): Introduction to Comparative Economic Development

Semester	Course title & Code	Credits	Duration (per week)			Eligibility Criteria	Prerequisite
			Lecture	Tutorial	Practical/ Practice		
III/V/VII	**Introduction to Comparative Economic Development – ECON064**	**4**	**3**	**1**	**0**	**Class 12th Pass**	**NIL**

Learning Objectives

The Learning Objectives of this course are as follows:

- This course investigates selected issues in industrialization and development in comparative historical perspective.
- The course focuses on a set of countries which followed diverse trajectories and patterns of growth to achieve their industrial transition and compares the outcomes of these diverse trajectories on sectoral change, intersectoral relations, labour processes and industrial relations and compares the role of the state in facilitating the respective trajectories.

Learning outcomes

The Learning Outcomes of this course are as follows:

- The students will be able to visualise economic development in a historical perspective and assimilate material from diverse narratives.
- It will help them to understand the diverse paths of economic development in the advanced economies.

Syllabus

UNIT I: Introduction (9 hours)
Theoretical issues and comparative historical background.

UNIT II: Agricultural transformation and its role in industrialization (9 hours)
Agrarian and land relations, production and productivity, agrarian surplus in industrial development. Case studies: Britain, Japan and U.S.S.R.

UNIT III: The industrialization process of Britain, Japan and U.S.S.R. (9 hours)

UNIT IV: The factory system and making of the industrial working class. Case studies: Britain and Japan (9 hours)

UNIT V: The role of the state in industrial and developmental transitions. Case studies: Britain, Japan and U.S.S.R. (9 hours)

Recommended readings

- Davies, R. (1998). Soviet economic development from Lenin to Khrushchev. Cam- bridge University Press.
- Dobb, M. (1966). Soviet economic development since 1917. Routledge.

- Hughes, J., Cain, L. (1994). American economic history, 4th ed. Harper Collins College Publishers.
- Hayami, Y. (1975). A century of agricultural growth in pre-war Japan: Its relevance to Asian development. University of Minnesota Press.
- Hobsbawm, E. (1968). Industry and empire: An economic history of Britain since 1750. Weidenfeld & Nicholson.
- Hobsbawm, E. (1984). Worlds of labour: Further studies in the history of labour. Weidenfeld & Nicolson.
- Johnson, C. (1982). MITI and the Japanese miracle: The growth of industrial policy 1925-1975. Stanford University Press.
- Macpherson, W. (1995). The economic development of Japan 1868-1941. Cam- bridge University Press.
- Norman, E. (2007). Japan's emergence as a modern state: Political and economic problems of the Meiji period. University of British Columbia Press.
- Okochi, K., Karsh, B., Levine, S. (1974). Workers and employees in Japan: The Japanese employment relations system. Princeton University Press.
- Paul, G., Robert, C. (1990). Soviet economic structure and performance, 3rd ed. Harper and Row.
- Tauger, M. (2004). Soviet peasants and collectivization 1930-39: resistance and adaptation. Journal of Peasant Studies, 31: 3-4. 427-456.
- Angus Maddison (2001). The World Economy, Vol. 1: A Millennial Perspective. OECD.

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Generic Elective (GE-11): Education and Development

Semester	Course title & Code	Credits	Duration (per week)			Eligibility Criteria	Prerequisite
			Lecture	Tutorial	Practical/ Practice		
III/V/VII	**Education and Development – ECON065**	**4**	**3**	**1**	**0**	**Class 12th Pass**	**NIL**

Learning Objectives

The Learning Objectives of this course are as follows:
This course discusses the role of education in development and policy analysis and formulation in the context of development; the impact of the globalisation on, and the role of international agencies in, education for development; human capital theory and human resource development; education and aid; research and consultancy strategies and ethics. he emphasis in this course is laid on understanding the theoretical aspects of education and linking it with the issues of education in a developing country like India.

Learning outcomes

The Learning Outcomes of this course are as follows:
This course will develop skills amongst the students to role of education and strategies to expand education in highly unequal societies. This will further help to conduct research and analysis the role of institutions for the outcome of education.

Syllabus

UNIT I: Introduction (9 hours)
Defining the educational problem

UNIT II: Human capital theory (6 hours)
The basic economic perspective on education

UNIT III: Early childhood education: How important? When did earnings become so dependent on education? Do our regression estimates overestimate the impact of education on earnings? The case of ability bias. (9 hours)

UNIT IV: Education as a signal of skill (9 hours)
If the return to education is real, does it reflect skills learned or is it a signal? Why has the rate of return to education increased? What skills are now rewarded in the workplace?

UNIT V: Schooling and Achievement (6 hours)
Do smaller classes raise achievement? School vouchers and parental choice; School accountability, standards and testing; Teacher quality and teacher training; Can technology complement what teachers do?

UNIT VI: Higher Education (6 hours)
Basic issues and structure; Higher education policy

Recommended readings

- Borjas, George. Labor Economics. Boston, MA: McGraw-Hill, 2005
- Lovenheim, M., & Turner, S. E. (2017). Economics of education. Macmillan Higher Education.

- Feinstein, Leon. "Inequality in the Early Cognitive Development of British Children in the 1970 Cohort." Economica 70, no. 277 (2003): 73-97.
- Duflo, Esther. "Schooling and Labor Market Consequences of School Construction in Indonesia: Evidence from an Unusual Policy Experiment." American Economic Review 91, no. 4 (2001): 795-800.
- Levy, Frank, and Richard J. Murnane. "Computers, Offshoring, and Skills." Working Paper. September 18, 2005..
- Hanushek, E. A., Machin, S. J., &Woessmann, L. (Eds.). (2016). Handbook of the economics of education. Elsevier.
- Bradley, S., & Green, C. (Eds.). (2020). The Economics of Education: A Com- prehensive Overview.
- Hanushek, Eric A., 2005, Economic Outcomes and School Quality, International Academy of Education and International Institute for Educational Planning.
- Goldin, C., & Katz, L. F. (2010). The race between education and technology. harvard university press.
- Haveman, R., & Smeeding, T. (2006). The role of higher education in social mobility. The Future of children, 125-150.
- Singh, A., Park, A., &Dercon, S. (2014). School meals as a safety net: an evaluation of the midday meal scheme in India. Economic Development and Cultural Change, 62(2), 275-306.
- Krueger, Alan B. "Experimental Estimates of Education Production Functions." Quarterly Journal of Economics 114, no. 2 (1999): 497-532.
- Loeb, Susanna, and Marianne E. Page. "Final Examinationining the Link between Teacher Wages and Student Outcomes: The Importance of Alternative Labor Market Opportunities and Non-pecuniary Variation." Review of Economics and Statis- tics 82, no. 3 (2000): 393-408.
- Winston, Gordon. "Subsidies, Hierarchy and Peers: The Awkward Economics of Higher Education." Journal of Economic Perspectives 13, no. 1 (1999): 13-36.
- Azam, M., & Kingdon, G. G. (2015). Assessing teacher quality in India. Journal of Development Economics, 117, 74-83.

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Generic Elective (GE-12): Basic Resource and Energy Economics

Semester	Course title & Code	Credits	Duration (per week)			Eligibility Criteria	Prerequisite
			Lecture	Tutorial	Practical/ Practice		
III/V/VII	**Basic Resource and Energy Economics – ECON066**	**4**	**3**	**2**	**0**	**Class 12th with Mathematics**	**Introductory /Principles of Microeconomics**

Learning Objectives

The Learning Objectives of this course are as follows:
ThiscoursewillintroducethebasicsofResourceandEnergyeconomics.Theobjectiveofthis course is to provide theoretical and empirical topics on Resource economics, energy economics, energy transition, and energy security. This course introduces the conceptual and theoretical foundations of Resource Economics. In particular, the policies and potential sources are both renewable and non-renewable. The objective of thiscourseistoprovideknowledgeontheprinciplesofgoverningandmanagingnaturalresources.

Learning outcomes

The Learning outcomes of this course are as follows:
The students will learn some issues of resource economics relating to the basics of supply, demand, and prices, income elasticities, world oil markets, and depletable resources, pathways of energy transition from conventional to renewable energysources.

Syllabus

UNIT I: Resource Economics (Renewable and non-renewable sources) (15 hours)
Optimal extraction of a non-renewable resource, Optimal management of renewable resources -Fishery and Forestry, Tom Tietenberg and Lynne Lewis, Environment and Natural Resource Economics, 9th edition, Chapter 5,6,12 and13

UNIT II: Energy Economics (15 hours)
Types of energy sources, Introduction to Basics of supply, demand, and prices, energy supply and economics of depletable resources, world oil markets

UNIT III: Energy transition and energy security Pathways of energy transition from conventional to renewable energy sources, Policy instruments, Energy security, accessibility and 4 A definition, and Energy poverty (15 hours)

Recommended readings

- Tom Tietenberg and Lynne Lewis, Environment and Natural Resource Economics, 9thedition
- Review of the Basics of Supply, Demand and Price Formationin Competitive MarketsPindyckandRubinfeld.2005
- Fouquet, R. Historical energy transitions: speed, prices and system transformation. Energy Res. Soc. Sci. 22, 7–12 (2016).
- McGowan, J., and S. Conners. ”Windpower: A Turn of the Century Review.” AnnualReviewofEnergyandtheEnvironment25(2000):147-197.

- Chen, B., Xiong, R., Li, H., Sun, Q., &Yang, J. (2019). Pathways for sustainable energytransition.JournalofCleanerProduction,228,1564-1571.
- Palmer, K., and D. Bullaw. ”Cost-Effectiveness of Renewable Electricity Policies.” Energy Economics 27 (2005):873-894
- Deffeyes, K. Hubbert’s Peak: The Impending World of Oil Shortage. Princeton, NJ:PrincetonUniversityPress,2001,chapter1.ISBN:0691116253.
- Lynch M. ”ThePessimism About Petroleum Resources: Debunking the Hubbert Model (and Hubbert Modelers).” Minerals and Energy - Raw Materials Report 18, no. 1 (2003):1-18.
- Watkins, G. ”OilScarcity: What Have the Past Three Decades Revealed?” Energy Policy 34 (2006):508-514.
- Cherp, A., & Jewell, J. (2014). The concept of energy security: Beyond the four As. Energy policy, 75,415-421.
- Carley, S., &Konisky, D. M. (2020). The justice and equity implications of the cleanenergytransition.NatureEnergy,5(8),569-577.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Generic Elective (GE-13): Principles of Microeconomics II

Semester	Course title & Code	Credits	Duration (per week)			Eligibility Criteria	Prerequisite
			Lecture	Tutorial	Practical/ Practice		
III/V/VII	Principles of Microeconomics II – ECON027	4	3	1	0	Class 12th with Mathematics	Introductory Microeconomics (ECON001)/ Principles of Microeconomics I (ECON025)

Learning Objectives

The Learning Objectives of this course are as follows:

- This course covers imperfect markets and equilibrium analysis, consumer and producer theories under various markets and its failure, and international trade.

Learning outcomes

The Learning outcomes of this course are as follows:

- This course helps the students to understand different forms of market imperfections and market failures observed in real life situations.
- The students learn about the environment where the standard market mechanism fails to generate the desirable outcomes.
- They develop a sense of how the production is distributed among the different factors of production and the demand for inputs.
- Some preliminary concepts of international tradearealsocoveredinthiscourse.

Syllabus

UNIT I: Market Structures (12 hours)
Theory of a Monopoly Firm: Concept of imperfect competition; short run and long run price and output decisions of a monopoly firm; concept of a supply curve under monopoly; comparison of perfect competition and monopoly, social cost of monopoly, price discrimination; remedies for monopoly: Antitrust laws, natural monopoly
Imperfect Competition: Monopolistic competition: Assumptions, SR and LR price and output determinations under monopolistic competition, economic efficiency and resource allocation; oligopoly: assumptions, oligopoly models, game theory, contestable markets, role of government

UNIT II: Consumer and Producer Theory (12 hours)
Consumer and Producer Theory in Action: Externalities, marginal cost pricing, internalising externalities, public goods; imperfect information: adverse selection, moral hazard, social choice, government inefficiency.
Markets and Market Failure: Market adjustment to changes in demand, efficiency of perfect competition; sources of market failure: imperfect markets, public goods, externalities, imperfect information; evaluating the market mechanism.

UNIT III: Income Distribution and Factor pricing (12 hours)
Input markets: demand for inputs; labour markets, land markets, profit maximisation condition in input markets, input demand curves, distribution of Income.

UNIT IV: International Trade (9 hours)
Absolute advantage, comparative advantage, terms of trade, sources of comparative advantage, trade barriers, free trade/ protectionism.

Recommended readings

- Mankiw,N.G.(2018).*PrinciplesofMicroeconomics*8thed.
- Bernheim,B.,Whinston,M.(2009).*Microeconomics*.TataMcGraw-Hill.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Generic Elective (GE-14): Corporate Finance, Governance and Development

Semester	Course title & Code	Credits	Duration (per week)			Eligibility Criteria	Prerequisite
			Lecture	Tutorial	Practical/ Practice		
V/VII	Corporate Finance, Governance and Development – ECON067	4	3	2	0	Class 12th with Mathematics	Basic Statistics

Learning Objectives

The Learning Objectives of this course are as follows:

- This course covers the important financial decisions that face companies and corporate world in the modern economies.
- This will cover investment, financing and dividend decisions, together with the management of risk.

Learning outcomes

The Learning outcomes of this course are as follows:

- The students will be able to under the risk and decisions taken by the corporate world in the present-daysituations.
- The student will learn the practical issues of assets formation in the share and equity markets.
- They will also learn the role of institution in regulating uncertain and risky behaviours of the corporate firms.

Syllabus

UNIT I: Investment decisions (12 hours)
Traditional methods of investment appraisal, Investment–consumption decision model, The discounted cash flow approach, Net present value and internal rate of return, Project cash flows, Capitalrationing

UNIT II: Risk analysis (12 hours)
Simple risk techniques, Risk and return, Portfolio theory, The capital asset pricing model, Option valuation, Interest rate risk

UNIT III: Financing decisions (12 hours)
Financial markets, the cost of capital, Weighted average cost of capital, Capital structure in a simple world, Capital structure in a complex world, Investment and financing interactions, The dividend decision

UNIT IV: International issues (9 hours)
Foreign exchange, Foreign exchange hedging, Foreign direct investment

Recommended readings

- Quiry, P., LeFur, Y., Vernimmen, P. (2022). Corporate finance:theoryandpractice. John Wiley &Sons.
- Lumby, S., & Jones, C. (2003). Corporate finance: Theory & practice. Cengage LearningEMEA.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Generic Elective (GE-15): Principles of Macroeconomics II

Semester	Course title & Code	Credits	Duration (per week)			Eligibility Criteria	Prerequisite
			Lecture	Tutorial	Practical/ Practice		
IV/VI/VIII	Principles of Macroeconomics II – ECON028	4	3	1	0	Class 12th with Mathematics	Introductory Macroeconomics/ Principles of Macroeconomics I

Learning Objectives

The Learning Objectives of this course are as follows:

- This course introduces labour markets and derives the aggregate supply (AS) curve.
- Then, it integrates with Aggregate Demand (AD) to determine equilibrium prices and output.
- The course discusses Phillips curve and the alleged trade-off between inflation andunemployment.
- Both adaptive and rational expectations are introduced.

Learning outcomes

The Learning outcomes of this course are as follows:

- The students would learn an analytical framework to analyse the basic functioning of the aggregate macroeconomy under closed and open economy.
- It also enables them to analyse the functioning of the economies in term of the effects of fiscal and monetary policy and trade-off between inflation and unemployment.

Syllabus

UNIT I: IS-LM Analysis for income determination (12 hours)
Derivations of the IS and LM functions; IS-LM and aggregate demand; shifts in the ADcurve

UNIT II: GDP and Price Level in Short Run and Long Run (12 hours)
Aggregate demand and aggregate supply; multiplier analysis with AD curve and changes in price levels; aggregate supply in the SR and LR

UNIT III: Inflation and Unemployment (12 hours)
Concept of inflation; determinants of inflation; relationship between inflation and unemployment: Phillips Curve in short-run and long-run

UNIT IV: Balance of Payments and Exchange Rate (9 hours)
Balance of payments: current account and capital account; market for foreign exchange; determination of exchange rate

Recommended readings

- Blanchard,O.(2006).*Macroeconomics*,4thed.PearsonEducation.
- C.L.F. Attfield, D. Demery and N.W. Duck, *Rational Expectations in Macroeconomics:anintroductiontotheoryandevidence*(1991,2ndEd.).
- Sheffrin,Steve Rational Expectations. Cambridge University Press (1996, 2nd ed.).
- Dornbusch,R.,Fischer,S.(1994).*Macroeconomics*,6thed.McGraw-Hill.
- R. Dornbusch, S. Fischer and R. Startz. (2018). *Macroeconomics* (12th edition). McGraw-Hill.
- Branson,W.(2013).*Macroeconomics:Theoryandpolicy*,3rded,EastWestPress.

- Carlin, W and D Soskice (2007), *Macroeconomics: Imperfections, Institutions and Policies*, Indian Edition,OUP.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Generic Elective (GE-16): Basic Econometrics

Semester	Course title & Code	Credits	Duration (per week)			Eligibility Criteria	Prerequisite
			Lecture	Tutorial	Practical/ Practice		
IV/VI/VIII	Basic Econometrics – ECON024	4	3	2	0	Class 12th Pass	Knowledge of Class XII standard Mathematics AND Basic Statistics

Learning Objectives

The Learning Objectives of this course are as follows:

- This course introduces students to the econometric methods used to conduct empirical analysis based on the basic statistics.
- It offers the basic quantitative techniques needed to undertake applied research projects to establish the relationship between variables of interestsacrosswidevarietyofdisciplines.

Learning outcomes

The Learning outcomes of this course are as follows:

- Students will learn to estimate simple estimation and inferences about population parameters, to formulate empirical models and analyze data.
- An expertise in econometrics increases the job prospect of the students significantly.

Syllabus

UNIT I: Regression Models (15 hours)
OLS estimators, hypothesis Testing using software and practical application; multi- ple Regression Model - estimation, Testing and practical application using software like GRETL/EViews/ R/Stata/EXCEL etc.

UNIT II: Qualitative variables and Estimation (15 hours)
Application of qualitative variables, Nonlinear Models, Applications of dummy variables

UNIT III: Issues with Classical Assumptions (15 hours)
Violation of normal distribution, Collinearity with independent variables, heteroscedasticity, autocorrelation, practical application

Recommended readings

- Christopher Dougherty, *Introduction to Econometrics*, 4th edition, OUP, Indian edition.
- Damodar Gujarati, *Econometrics by Example*, 2nd edition, Palgrave Macmillan, 2014.
- Gujarati,D.,Porter,D.(2010).*EssentialsofEconometrics*,4thed.McGraw-Hill.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Generic Elective (GE-17): Sectoral Issues in Indian Economy

Semester	Course title & Code	Credits	Duration (per week)			Eligibility Criteria	Prerequisite
			Lecture	Tutorial	Practical/ Practice		
IV/VI/VIII	Sectoral Issue in Indian Economy – ECON059	4	3	1	0	Class 12th Pass	NIL

Learning Objectives

The Learning Objectives of this course are as follows:

- The course imparts in-depth knowledge on the issues relating to the agricultural and industrial economy of India, with the focus on the evolutionary path undertaken and the resultant concerns.
- This will cover issues of MSMEs and small farms toinformtheproblemsindustrialisationaswellasincreasedproductivityofagriculture.

Learning outcomes

The Learning outcomes of this course are as follows:

- This course will familiarize students with the problems, issues,currentdebates,andpolicyinterventionsforlong-termsustainability,efficiency,and resilience.
- The students will be able to understand, comprehend and critically analyse the issues and policies and would be able to form a well-informed and well- articulated opinionoftheirown.

Syllabus

UNIT I: Agricultural Performance since Independence: (9 hours)
Output and productivity growth Agricultural Performance since Independence in the context of land andlabour

UNIT II: The Policy Environment: Food security and nutritional concerns, MSPs, Agricultural price policy, subsidies/cash transfers, The public distribution system; Capital formation (12 hours)

UNIT III: Current Issues in Indian Agriculture (selected topics) (12 hours)
Resource Use Efficiency-Fertiliser, Water, Other inputs; Diversification for future Growth and enhanced farm income; Sustainable agricultural growth—concepts and constraints; Prospects for dryland/organic/zero budget farming; trade and competitiveness;useofnewtechnologyandartificialintelligence;Marketing/infrastructure; Crop insurance/agriculturalfinance

UNIT IV: Industry (12 hours)
Overview of the Industrial Scene in India- Trends in growth and productivity; Competitiveness and changes in Policy Regimes- domestic competitiveness and export; Issues relating to Indian Industry (selected topics); Scale and ownership, MSMEs and large industries, Public and Private Sector, Employment growth, labour and capital (domestic and foreign), formal and informal sectors, Infrastructural bottle- necks, research and development.

Recommended readings

- SukhamoyChakravarty (1984) Aspects of India's Development Strategy for 1980s? EPW vol 19 no20-21

- J. Bhagwati (1993), India in Transition: Freeing the Economy, Clarendon Oxford 1993
- K. V. Ramaswamy (2015) Labour, Employment and Economic Growth in India CambridgeUniversityPress
- Isher Judge Ahluwalia (1985) Industrial Growth in India: Stagnation Since the Mid-sixties,OxfordUniversityPress
- R. Nagaraj (2015) Can the Public Sector Revive the Economy? Review of the Evidence and a Policy Suggestion EPW vol 50 no5
- S N Rajesh Raj, Kunal Sen (2020) The 'Missing Middle' Problem in Indian Manufacturing. What Role Do Institutions Play? EPW April 18, 2020 vol 55 no16
- Indian Industrialisation, ICSSR Research and Surveys and Explorations in Eco- nomics vol.1 (2015)-C P Chandrasekhar (ed), Oxford University Press,Delhi
- Sabyasachi Mitra, Abhijit Sen Gupta, and Atul Sanganeria (2020) Drivers and Benefits of Enhancing Participation in Global Value Chains: Lessons for India, ADB South Asia Working Paper No. 79
- Raghuram Rajan (2015) Make in India, largely for India, Indian Journal of Indus- trial Relations, Vol. 50, No. 3 (January 2015), pp.361-372
- Vaidyanathan, A. (1994), "Performance of Indian Agriculture since Independence" in Kaushik Basu (ed.), Agrarian Questions Oxford UniversityPress.
- Mahendra Dev (2016) Water Management and Resilience in Agriculture vol 51, No 8 EPW Economic & Political Weekly
- Ramesh Chand (2012) Development Policies and Agricultural Markets EPW DE- CEMBER 29, 2012 vol 47 no52
- Yoginder K Alagh (2021) Globalisation and the Indian Farmer EPW vol 56 no 28
- Chatterjee, S., Kapur, D. (2017). Six puzzles in Indian agriculture. India Policy Forum 2016, Vol. 17.
- NABARD Foundation Day, Paper on enhancing Farmers' income by K J S Satyasai and Nirupam Mehrotra. 12 July 2016
- Acharya, S.S. (2007) "Agribusiness in India: Facts and Emerging Issues", AgriculturalEconomicsResearchReview,Vol. 20,ConferenceIssue,pp.409-424
- Mohan, R., (2006) Agricultural Credit in India: Status, Issues and Future Agenda, EconomicandPoliticalWeekly,March18,2006,pp1013-1021.
- Mishra S.N. and Chand, R., (1995) Public and Private Capital Formation in Indian Agriculture: Comments on Complementarily Hypothesis, Economic and Political Weekly, June 24th,1995
- GOI (2007), Report of The Working Group on Risk Management in Agriculture for the Eleventh Five Year Plan (2007-2012), GOI, NewDelhi
- Indian Agriculture Towards 2030-Pathways for Enhancing Farmers' Income, Nutritional Security and Sustainable Food and Farm Systems (2021) An open-access Springerpublication.
- Government of India (2017) "Report of the Committee on Doubling Farmers' In- come". Ministry of Agriculture and Farmers' Welfare, Government ofIndia
- PRS Legislative Research (2017), Swaminathan Report: National Commission on Farmers, at Swaminathan Report: National Commission on Farmers, PRSIndia
- Acharya SS and NL Agarwal (2016), Agricultural Marketing in India, New Delhi: CBS Publishers andDistributors
- Expert Committee Report on Marketing Infrastructure & Agricultural Marketing Reforms (2000) Government of India, Department of Agricultural & Cooperation Krishi Bhavan, NewDelhi

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Generic Elective (GE-18): Game Theory and Social Sciences

Semester	Course title & Code	Credits	Duration (per week)			Eligibility Criteria	Prerequisite
			Lecture	Tutorial	Practical/ Practice		
IV/VI/VIII	**Game Theory and Social Sciences – ECON068**	**4**	**3**	**1**	**0**	**Class 12th Pass**	**Knowledge of Class XII Standard Mathematics**

Learning Objectives

The Learning Objectives of this course are as follows:

- This course will teach the basic elements of game theory with applications to political science and other social sciences.
- It will coversimultaneous games, extensive-form games, repeated games, and spatial models of elections.
- The course will also focus on using the logic of games to make inferences and arguments about political and social behavior, with readings on collective action, voting, bargaining, repeated interaction, war, and other FinalExamples.

Learning outcomes

The Learning outcomes of this course are as follows:

- The students will learn how to apply multi-person decision making in an interactive setting.
- They will understand how to formulate different real-life situations as games and learn to predict the optimal strategies of players and how the players can exploit strategic situations for their own benefit.
- They will solve basic and intermediate games, including simultaneous-move and extensive-form games, as well as basic games of asymmetric information.
- The students can create and solve an original model designed to understand a social or political problem of interest.

Syllabus

UNIT I: Rational choice; interacting decision-makers; the normal/strategic form (9 hours)

UNIT II: Dominant and dominated strategies; rationalizability; iterated elimination of dominated strategies; dominance solvability; best response functions; Nash equilibrium. (12 hours)

UNIT III: Extensive-form and simultaneous game, Strategic game and its application in social sciences, electoral competition; the war of attrition, auctions; accident law; mixed strategies; finding mixed strategy equilibria;symmetricgamesandsymmetricequilibria;illustrations:reportingacrime;expertdiagnosis (12 hours)

UNIT IV: Strictly competitive equilibrium and maximization (12 hours)

Recommended readings

- Martin J. Osborne, *An Introduction to Game Theory*, Oxford University Press, New Delhi,2004.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Generic Elective (GE-19): Economy of Colonial India

Semester	Course title & Code	Credits	Duration (per week)			Eligibility Criteria	Prerequisite
			Lecture	Tutorial	Practical/ Practice		
IV/VI/VIII	**Economy of Colonial India – ECON069**	**4**	**3**	**1**	**0**	**Class 12th Pass**	**NIL**

Learning Objectives

The Learning Objectives of this course are as follows:

- This course Final Examples some key spheres and trends of India's economy under colonial rule and situates them in the realms of land, labour, capital and state policy as they emerged from the shadows of the Mughal decline and moved into the colonial era.
- A special focus will be given on the peasants, artisans, migrants and their changing relationships with state power.
- The course will revisit some influential debates of Indian economic history: deindustrialisation, the nature of growth under colonial conditions, forced commercialization, the modernity of its industrialisation, working classes, drain of wealth and the role of the colonialstate.

Learning outcomes

The Learning outcomes of this course are as follows:

- The students will be able to learn economic transformation from pre-colonial period to the British colonial regime that paved the way of distorted path of growth and development.
- They will understand the nature of colonial economy and how resources of colonies were exploited by the colonial power.
- They will acquire skill to critically engagewithideasofeconomicchangesinthelasttwocenturies.

Syllabus

UNIT I: Economic transformation from pre-colonial to colonial regime (12 hours)
Economic transition, Colonial exploitation and resultant tyranny affected the trend of population, national income; occupational structure, merchandise trade, emergence of state with the East India Company and nature of its rule.

UNIT II: Agrarian Transformation (12 hours)
Colonial Rule on Indian Soil affected land revenue settlements, commercialization of agriculture, changing cropping pattern, land market, rural credit and indebtedness. It further influenced agrarian relations that includes agricultural labour, regional variations, peasant commodity production and generated debates on the 'mode of production in Indian agriculture', the 'invisible' women of India's agrarian history.

UNIT III: The de-industrialisation debate (12 hours)
Role of infrastructure for merchandise trade, evolution of entrepreneurial and industrial structure; constraints on industrial growth; labourrelations; drain of wealth; international trade and Balance of Payments

UNIT IV: Evolution of State and Financial Market (9 hours)
Evolution of state and its function for social welfare and relief under famine and starvation; Public Finance, Government revenue, expenditure and investment over the years; Emergence of Modern Banking in India and its role in economy; Overall assessment of colonial economy: stagnation and decline with regional variations.

Recommended readings

- Guha, S., 1991, Mortality decline in early 20th century India, Indian Economic and Social History Review, vol. 28
- Roy,T,2011,*TheEconomicHistoryofIndia1857-1947*,3rdedn,OrientLongman, Delhi.
- Irfan Habib, 2006, Indian Economy 1858-1914, A People's History of India, vol. 28, Tulika,Delhi
- Chaudhary, L., B. Gupta, T Roy and A. V. Swami (eds.), A New Economic History of Colonial India, Routledge, London and NewYork.
- Parthasarathi, P. 2009, Historical Issues of Deindustrialization in Nineteenth Cen- tury South India, in T Roy and Giorgio Riello (eds) How India Clothed the World: The World of South Asian Textiles, 1500-1850 , Brill,Leiden
- Morris, M.D , 1965, Summary and Conclusions in Emergence of an Industrial Labour Force in India, OUP,Delhi
- Roy, T., 2018, Capital and Empire (1850-1930): Trade and Finance in A Business History of India: Enterprise and the Emergence of Capitalism from 1700, CambridgeUniversityPress,Delhi
- Chatterjee, B., 1992, Trade, Tariffs and Empire, Oxford University Press, Delhi, Epilogue.
- Washbrook, D. , 2012, The Indian Economy and the British Empire in Douglas M Peers and Nandini Gooptu (ed.) India and the British Empire, OUP, Delhi.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Generic Elective (GE-20): Basic Environmental Economics

Semester	Course title & Code	Credits	Duration (per week)			Eligibility Criteria	Prerequisite
			Lecture	Tutorial	Practical/ Practice		
IV/VI/VIII	**Basic Environmental Economics – ECON070**	**4**	**3**	**1**	**0**	**Class 12th Pass**	**Introductory /Principles of Microeconomics**

CourseObjectives:

- The objective of this course is to provide basic knowledge of environmental economics, and its relationship between microeconomics and welfare economics.
- It covers the sig- nificance and application of Environmental Economics in the present environmental challenges in India. It describes and comprehends various environmental policies by de- ployingvarious policy instruments as well as measure the various market and non-market benefits of environmental policies.
- Finally, the course addresses the transboundary en- vironmental problems, and challenges related to trade and the environment.

Course LearningOutcomes

- The students will be able to learn the basic factors influencing the environmental chal- lenges faced by the present world.
- They will comprehend the functions of state and institution in mitigating such challenges.

Content (Unit-wise):

Unit 1 : Introduction to Environment Economics (9 hours)

What is environmental economics, Overview of environmental problems in India Unit 2 :

Welfare economics and inefficiencies (9 hours)

Pareto efficiency in consumption (Edgeworth Box), Pareto efficiency in Production, Theorems of welfare economics

Unit 3 : Externalities, property rights and Environmental Policy (9 hours)

Market Failure, externalities in Production and consumption, Externalities in prop- erty rights. Types of environmental goods (use and non-use value)

Unit 4 : Bargaining Solutions and Environmental Policies (9 hours)

Coase Theorem and its implications, Overview of regulatory policies related to environment, implementation of environmental policy

Unit 5 : International Environmental Problems (9 hours)

Environment and World Trade Organization, GATT, Multilateral Environmental Agreements, Transboundary environmental problems

SuggestedReadings:

– Charles Kolstad. Intermediate Environmental Economics, Oxford University Press, 2ndedition(2012).[Indianreprintavailable.]

- Roger Perman, Yue Ma, James McGilvray and Michael Common. Natural Re- source and Environmental Economics, Pearson Education/Addison Wesley, 4th edition(2011).
- Robert N. Stavins (ed.). Economics of the Environment: Selected Readings, W.W. Norton,6thedition(2012).

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Generic Elective (GE-21): Law and Development

Semester	Course title & Code	Credits	Duration (per week)			Eligibility Criteria	Prerequisite
			Lecture	Tutorial	Practical/ Practice		
IV/VI/VIII	**Law and Development – ECON071**	**4**	**3**	**1**	**0**	**Class 12th Pass**	**Introductory /Principles of Microeconomics**

CourseObjectives:

- Law is widely thought of a prerequisite to economic development. The course focuses on how property rights play a central role in economic development and individuals investif they can reap the future benefits of their investments as well formation of assetswithcollateral.
- Thecoursedealswiththequestions,wherepropertyrightscome from, how they are made and evolve, why, by whom and in what manner attributes of property rights are grafted onto different objects, claims, or assets.
- More specifically, the course covers key areas such as property rights, business transactions, and industrial promotion,withguidanceforpro-developmentlegislationineach.

Course learning outcomes:

- The students will acquire understanding the efficacy of laws and institutions in the modern economies for property rights and debt that helped equity and transparency for economic development.
- The students will learn the facility incomparativelaw,approachestolegalinstitutionalism,andlawandpoliticaleconomy.

Content(unit-wise):

Unit 1 : Introduction (9 hours)

The Importance of Laws and institutions for EconomicDevelopment

Unit 2 : Property Rights and Economic Development (12 hours)

Property rights and their role in resource allocation (Market and non-market mechanism for land transfer); Intellectual Property Rights (IPRs) Patents, Copyright and Trademarks. Cost and benefits of private IPRs; Individual rights vs common good

Unit 3 : Legal Frameworks for Business Transactions and Economic Development (12 hours)

Economics of Contract Law Legal contract; Role of Contracts for functioning of markets; Incomplete contracts; Efficient contracts; Damages measures and theirefficiency properties.

Unit 4 : Law and Industrial Promotion as Tools for Economic Development (12 hours)

Anti-trust laws, Competition Policy; Legal Process: Litigation – its causes and consequences; Benefits of legal certainty

- SuggestedReadings:

– Lee, Yong-Shik (2017) ”GeneralTheory of Law and Development,” Cornell

Interna- tional Law Journal: Vol. 50 : No. 3 , Article 2. Available at: https://scholarship.law. cornell.edu/cilj/vol50/iss3/2

- Cooter, Robert and Thomas Ulen, Law and Economics, Sixth Edition, Addison Wesley 2013, ISBN 9780132540650. Free here Law and Economics, 6th edition (jku.at)
- Lee, Y.S., Call for a New Analytical Model for Law and Development (Septem- ber 16, 2016). Law and Development Review, Vol. 8, No. 2 (June 2015), 1-67, Available at SSRN: https://ssrn.com/abstract=2839943
- Lee, Y.S.; General Theory of Law and Development; https://ww3.lawschool.cornell.edu/research/I final.pdf
- Trubek, D. M., & Santos, A. (Eds.). (2006). The new law and economic develop- ment: a critical appraisal. Cambridge UniversityPress.
- Dam, K. W. (2007). The law-growth nexus: The rule of law and economic devel- opment.BrookingsInstitutionPress.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Generic Elective (GE-22): Public Finance inIndia

Semester	Course title & Code	Credits	Duration (per week)			Eligibility Criteria	Prerequisite
			Lecture	Tutorial	Practical/ Practice		
IV/VI/VIII	**Public Finance in India – ECON072**	**4**	**3**	**1**	**0**	**Class 12th Pass**	**NIL**

CourseObjectives:

- This course covers an overview of recent trends and issues in government finances of India.
- It will look into the recent trends in budget, deficits, reforms in taxes of the centre, states and the local governments and the issues of fiscal federalism and decentralisation in India.
- It also offers an overview of principles and finances of India's flagships welfare programs.

Course LearningOutcomes:

- The students will learn India's recent trends and issues in direct and indirect taxes, intergovernmental transfers and welfare policies.
- It will enable them to compare and contrast India's public sector performance with the conceptual standards and perfor- mances of other nations.
- It will also equip them to engage in empirical based public policy debates around taxation, fiscal federalism and welfare policies.
- The course will be useful for students aiming towards careers in the government sector, policy analysis, business andjournalism.

Content (Unit-wise):

Unit 1 : Current Issues of India's Tax system (12 hours)

Overview of India's tax system and performance; GST; Issues in Direct Taxes; other issues in indirect taxes (eg. taxes on petroleum products)

Unit 2 . Analysis of Budget and Deficits: (12 hours)

Union and State Budget analysis; Deficit and Debt Management; Unit

3 Fiscal Federalism in India (12 hours)

Theories of Fiscal Federalism; Overview of Fiscal Federalism Structure in India; Intergovernmental Transfers; Local Finances in India

Unit 4 : Development and Welfare Policies- (9 hours)

India's Flagship Programs- Public Distribution system, National Health Mission, Universal Health Insurance, Education, other Central and State sponsored schemes

SuggestedReadings:

- RelevantchaptersfromLatestFinanceCommissionReports
- Relevant chapters from the latest EconomicSurvey

- Latest BudgetDocument
- Rangarajan, Chakravarthy, and D. K. Srivastava. ”Fiscaldeficits and government debt: implications for growth and stabilisation.” Economic and Political Weekly (2005): 2919-2934
- Rao, M. Govinda. ”Centraltransfers to states in India: rewarding performance while ensuring equity.” Final report submitted to NITI Aayog(2017).
- Relevantarticlesfromreputedjournals

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Generic Elective (GE-23): Health andDevelopment

Semester	Course title & Code	Credits	Duration (per week)			Eligibility Criteria	Prerequisite
			Lecture	Tutorial	Practical/ Practice		
IV/VI/VIII	Health and Development – ECON073	4	3	1	0	Class 12th Pass	NIL

CourseObjectives:

- Thiscoursedealswiththeinterfacebetweenthehealthanddevelopment,bothmonetaryandnon-monetary terms.
- It identifies how health care markets differ from other goods and services, the unique role of health insurance for health equity.
- The course address how medical spending has evolved over time, role of state and institution for delivering health care services.
- It also covers the various strategies address by the nation and internationalorganisationsforensuringhealthcareandbetterlife.

Course LearningOutcomes:

- The students will be able to understand economic dimensions of health services, determinants of health care, role of state and institution, policies relating to health equity andstrategiestodealwithcommunicableandnon-communicablediseases

CourseOutline:

Unit 1 : Health, Wealth, and Welfare; Utility and Health; Causes and Consequences of Regional Variations in Health Care (9 hours)

Unit 2 : Health expenditure

Health Care Spending Growth; The Transformation of Medical Care to Health; TheDemandforMedicalCare;out-pocketexpenditure (9 hours)

Unit 3 : Health Insurance (9 hours)

Externalities in Health and Medical Care; The Demand for Health Insurance; Health Insurance Supply and Managed Care; Government Provision of Health Insurance; Universal Insurance Issues and International Comparisons of Health Care Systems; managing market (9 hours)

Unit 4 : Economics and mental health (9 hours)

Unit 5 : Health Systems (9 hours)

International health systems and Indian experiences, and health care financing.

Suggested Readings: Following is the suggested list of books/papers, which can be updated with more recent papers as ans when they becomeavailable.

Main Textbooks

- Deaton, A. (2007). Height, health, and development. Proceedings of the national academy of sciences, 104(33), 13232-13237.
- IMF (2004), Health and Development, https://www.imf.org/external/pubs/ft/health/eng/hdwi/h
- Satpathy SK, Bansal RD. Health economics–concepts and conceptual problems. HealthPopulPerspectIssues.1982Jan-Mar;5(1):23-33.PMID:10310083.
- Frank, R. G., & McGuire, T. G. (2000). Economics and mental health. Handbook ofhealtheconomics,1,893-954.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Generic Elective (GE-24): Global Political Economy

Semester	Course title & Code	Credits	Duration (per week)			Eligibility Criteria	Prerequisite
			Lecture	Tutorial	Practical/ Practice		
IV/VI/VIII	Global Political Economy – ECON074	4	3	1	0	Class 12th Pass	NIL

- CourseObjectives:
  - This course introduces students to the contemporary structures, trends and developments in the world economy from a political economy perspective.
  - The period covered is from the end of Second World War up to global economic crisis of 2008. Areas covered include the organization of production and corporate structure; changes in labour processes and labour regimes;
  - The financialization of the world economy; and the shift intheunderstandingofthenatureandroleofthestateunderglobalisation.
- Course LearningOutcomes:
  - This course enables students to develop a critical understanding of the contemporary global economy, changing dynamics of political economic relation and developments over the last five or six decades.

Content (Unit-wise):

Unit 1 : Introduction (6 hours)

The political economy of globalisation, a theoretical and historical overview.

Unit 2 : Changing dynamics of capitalist production. (9 hours)

Organisational forms and labour processes in the Fordist and Post-Fordist produc- tion regimes; multinational corporations – evolution, structural form and dynam- ics; global value chains and production networks; the nature of employment, job security and labour rights in a globalising world.

Unit 3 : Institutional setting of global trade. (6 hours)

Evolution of the role, structure and mechanisms of the international trade regime.

Unit 4 : The role of finance in the globalised economy. (9 hours)

Financialization– trends, instruments, features and consequences.

Unit 5 : The state in the era of globalisation: (6 hours)

Globalisation and the limits of the welfare and developmental states; the neoliberal state.

Unit 6 : Global economic instability and crisis: (9 hours)

The 2008 global economic crisis – prelude; proximate and long-term causes; and policy response.

- SuggestedReadings:

– Dore, R. (2008). Financialization of the global economy. Industrial and Corporate Change, 17,1097-1112.

– Harvey, D. (2005). A brief history of neoliberalism. Oxford UniversityPress.

- Hymer, S. (1975). The multinational corporation and the law of uneven develop- ment. In H. Radice (ed.): International firms and modern imperialism. Penguin Books.
- Nayyar, D. (2003). Globalisation and development. In H.-J. Chang (ed.): Re- thinking development economics. AnthemPress.
- Reddy, N. (2003). Economic globalisation, past and present: The challenges to labour. In K. Jomo, K.Jin (eds): Globalization and its discontents, revisited. TulikaBooks.
- Thun, E. (2011). The globalization of production. In J. Ravenhill (ed.): Global political economy. Oxford UniversityPress.
- Tonkiss, F. (2008). Contemporary economic sociology: Globalisation, production, inequality.Routledge.
- Vakulabharanam, V. (2009). The recent crisis in global capitalism: Towards a Marxianunderstanding.EconomicandPoliticalWeekly,44,144-150.
- Varoufakis, Y. (2011). The global Minotaur: America, the true origins of the financial crisis and the future of the world economy. ZedBooks.
- Winham, G. (2011). The evolution of the global trade regime. In J. Ravenhill (ed.): Global political economy. Oxford UniversityPress.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Generic Elective (GE-25): History of Indian Economic Thought

Semester	Course title & Code	Credits	Duration (per week)			Eligibility Criteria	Prerequisite
			Lecture	Tutorial	Practical/ Practice		
IV/VI/VIII	History of Indian Economic Thought – ECON075	4	3	1	0	Class 12th Pass	NIL

CourseObjectives:

- The purpose of this course is to develop understanding among the students about Indian Economic Thinking in ancient and pre-independence India.
- This course exposes students to prominent Indian economic thinkers from the ancient period till the early 20th century. The course will provide intellectual underpinning of ancient Indian economics, which will help them solve many ongoing economic problems.

Course LearningOutcomes:

- The students will be able to have idea about the ancient Indian economic system
- The course will help the students to understand the current economic system in view of the economic history of the country

- Content (Unit-wise):

Unit 1: Ancient and pre-colonial period (15 hours)

Postulates of Ancient Indian Economics; Buddhism and economics; Consumption, production, exchange and distribution in Ancient Indian Economy; Public finance and economic functions of government.

Unit 2 : Colonialism, Exploitation and Economic development (15 hours)

Classical & Neoclassical economics and Indian economic thought during colonial period; Theory of wealth drain and, famine and poverty; Industrialization, agrarian policy, infrastructure and structural changes.

Unit 3 : Economic thought: Indian Freedom Movement (15 hours)

Gandhian Economic model of swadeshi; Gokhle and Economics of Education; free trade to discriminating protection; Ranade and Economics of development; Ambedkar's thought on population, agriculture, banking and industrilisation.

- SuggestedReadings:

- Kangle, R. P. (1986). *KautiliyaArthasastra (vol. No. 1-3)* Motilal Banarsidass Publication.
- Bahadur, R. and Aiyanger, K.V.R. (1934). Aspects of Indian Economic Thought. The Madras Law Journal Press, Mylapore, Madras.
- Dasgupta, A. (1993). The history of Indian Economic Thought. Routledge, London and New York.
- Shah, K.T. (1954). Ancient Foundations of Economcis in India. Vora & Co. Publishers Ltd. Bombay.
- Mahadev Govind Ranade (2000). Indian political Economy. Indian economic association trust for research and development. Ch1.
- J. Krishnamurty (ed.; 2011). *Towards Development Economics: Indian Contribu- tions1900–1945*,OUP.
- Government of Maharashtra Education Department (1982). *On Measures for Birth Control' Dr. Babasaheb Ambedkar: Writings and Speeches, Volume.-2, Appendix-1* Government of

Maharashtra, page261.
- Waldauer, C., Zahka, W. J., & Pal, S. (1996). Kautilya's Arthashastra: A neglected precursor to classical economics. *Indian Economic Review*, 101-108.
- Tisdell, C. A. (2003). *A western perspective on Kautilya's' Arthasastra': Does it provide a basis for economic science?* (No. 1742-2016-140719, pp. 1-13).
- Adams, J. (2006). Economics, economists, and the Indian economy. *India Review*, *5*(1), 37-61.
- Skare, M. (2013). The missing link: From Kautilya's The Arthashastra to modern economics. *Journal of Philosophical Economics*, *6*(2), 2-31.
- Deodhar, S. Y. (2018). Indian antecedents to modern economic thought.
- Ambedkar, B. R. (1918). Small holdings in India and their remedies. *Journal of Indian Economic Society*, *1*, 1900-1945.

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.

Sd/-

REGISTRAR

UNIVERSITY OF DELHI

CNC-II/093/1(28)/2024-25/

Dated: 15.05.2024

NOTIFICATION

Sub: Amendment to Ordinance V

[E.C Resolution No. 14-1/-(14-1-6/-) dated 09.06.2023 and 27-1-1/ dated 25.08.2023]

Following addition be made to Appendix-II-A to the Ordinance V (2-A) of the Ordinances of the University;

Add the following:

Syllabi of Semester- V and VI in respect of Department of Physics & Astrophysics under Faculty of Science based on Under Graduate Curriculum Framework -2022 implemented from the Academic Year 2022-23:

(i) **SEMESTER-V**: BSc. (H) Physics/ Pool of DSEs/ BSc. Physical Science with Physics as one of the Core Disciplines/ BSc. Physical Science with Physics & Electronics as one of the Core Disciplines/ Common Pool of GEs ***(As per Annexure-1)***

(ii) **SEMESTER-VI**: BSc. (H) Physics/ Pool of DSEs/ BSc. Physical Science with Physics as one of the Core Disciplines/ BSc. Physical Science with Physics & Electronics as one of the Core Disciplines/ Common Pool of GEs ***(As per Annexure-2)***

REGISTRAR

ANNEXURE-1

INDEX
DEPARTMENT OF PHYSICS AND ASTROPHYSICS
Semester-V

B. SC. (HONOURS) PHYSICS

DISCIPLINE SPECIFIC CORE COURSE – DSC - 13: ELECTROMAGNETIC THEORY

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Electromagnetic Theory DSC – 13	**4**	**3**	**0**	**1**	Class XII pass with Physics and Mathematics as main subjects	Mathematical Physics I, II; Waves and Oscillation; Electricity and Magnetism papers of this course or their equivalents

LEARNING OBJECTIVES

This core course develops further the concepts learnt in the electricity and magnetism course to understand the properties of electromagnetic waves in vacuum and different media.

LEARNING OUTCOMES

At the end of this course the student will be able to,

- Apply Maxwell's equations to deduce wave equation, electromagnetic field energy, momentum and angular momentum density
- Understand electromagnetic wave propagation in unbounded media: Vacuum, dielectric medium, conducting medium, plasma
- Understand electromagnetic wave propagation in bounded media: reflection and transmission coefficients at plane interface in bounded media
- Understand polarization of electromagnetic waves: Linear, circular and elliptical polarization. Production as well as detection of waves in laboratory
- Learn the features of planar optical wave guide
- In the laboratory course, the students will get an opportunity to perform experiments with polarimeter, Babinet compensator, ultrasonic grating and simple dipole antenna. Also, to study phenomena of interference, refraction, diffraction and polarization

SYLLABUS OF DSC – 13

THEORY COMPONENT

Unit - I **(6 Hours)**

Review of Maxwell's equations; Coulomb gauge and Lorentz gauge; Poynting's theorem and Poynting's vector; electromagnetic (em) energy density; physical concept of electromagnetic field energy density

Unit – II **(10 Hours)**

EM wave propagation in unbounded media: Plane em waves through vacuum and isotropic dielectric medium: transverse nature, refractive index, dielectric constant, wave impedance. Plane em waves through conducting medium: relaxation time, skin depth, attenuation constant;

Wave propagation through dilute plasma: electrical conductivity of ionized gases, plasma frequency, refractive index, skin depth.

Unit – III **(9 Hours)**

EM waves in bounded media: Boundary conditions at a plane interface between two media; reflection and refraction of plane em waves at plane interface between two dielectric media - Laws of reflection and refraction; Fresnel's formulae for perpendicular and parallel polarization, Brewster's law; reflection and transmission coefficients; total internal reflection, evanescent waves; metallic reflection (normal incidence)

Unit – IV **(13 Hours)**

Polarization of EM waves: Propagation of em waves in an anisotropic media; symmetric nature of dielectric tensor; Fresnel's formula; uniaxial and biaxial crystals; light propagation in uniaxial crystal; double refraction; polarization by double refraction; Nicol prism; ordinary and extraordinary refractive indices; production and detection of plane, circular and elliptically polarized light; phase retardation plates: quarter wave and half wave plates

Optical rotation; Biot's laws for rotatory polarization; Fresnel's theory of optical rotation; specific rotation

Unit – V **(7 Hours)**

Wave guides: Planar optical wave guides; planar dielectric wave guide ($-d/2 < x < d/2$); condition of continuity at interface; phase shift on total reflection; Eigenvalue equations; phase and group velocity of guided waves; field energy and power transmission (TE mode only)

References:

Essential Readings:

1) Introduction to Electrodynamics, D. J. Griffiths, 3rd edition, 1998, Benjamin Cummings.
2) Electromagnetic Field and Waves, P. Lorrain and D. Corson, 2nd edition, 2003, CBS Publisher
3) Classical Electrodynamics, J. D. Jackson, 3rd edition, 2010, Wiley
4) Principle of Optics, M. Born and E. Wolf, 6th edition, 1980, Pergamon Press
5) Optics, A. Ghatak, 6th edition, 2017, McGraw-Hill Education, New Delhi

Additional Readings:

1) Electricity, Magnetism and Electromagnetic Theory, S. Mahajan, and S. R. Choudhary, 2017, TMH
2) Principles of Electromagnetic Theory, C. Jain, 2017, Narosa Publishing House
3) Elements of Electromagnetics, M. N. O. Sadiku, 2001, Oxford University Press.
4) Fundamentals of Electromagnetics, M. A. W. Miah, 1982, Tata McGraw Hill
5) Problems and solution in Electromagnetics, A. Ghatak, K. Thyagarajan and Ravi Varshney, 2015
6) Electromagnetic field Theory, R. S. Kshetrimayun, 2012, Cengage Learning
7) Engineering Electromagnetic, W. H. Hayt, 8th edition, 2012, McGraw Hill.
8) Electromagnetics, J. A. Edminster, Schaum Series, 2006, Tata McGraw Hill.
9) 2008+ Solved Problems in Electromagnetics, S. A. Nasar, 2001, SciTech

PRACTICAL COMPONENT

(15 Weeks with 2 hours of laboratory session per week)

- Mandatory sessions on the construction and use of specific measurement instruments and experimental apparatuses used in the lab, including necessary precautions.
- Mandatory sessions on the review of experimental data analysis, sources of error and their estimation in detail, writing of scientific laboratory reports including proper reporting of errors.
- Application to the specific experiments done in the lab.

At least six experiments to be performed from the following list

1) To verify the law of Malus for plane polarized light.
2) To determine the specific rotation of sugar solution using polarimeter.
3) To analyse elliptically polarized light by using a Babinet's compensator.
4) To study the elliptical polarized light using Fresnel rhomb.
5) To determine the wavelength and velocity of ultrasonic waves in a liquid (Kerosene Oil, Xylene, etc.) by studying the diffraction through ultrasonic grating.
6) To study the reflection and refraction of microwaves
7) To study polarization and double slit interference in microwaves.
8) To determine the refractive index of liquid by total internal reflection using Wollaston's air-film.
9) To determine the refractive index of (1) glass and (2) a liquid by total internal reflection using a Gaussian eyepiece.
10) To verify the Stefan's law of radiation and to determine Stefan's constant.
11) To determine Boltzmann constant using V-I characteristics of PN junction diode.
12) To find numerical aperture of an optical fibre.
13) To use a prism shaped double refracting crystal to determine the refractive indices of the quartz/ calcite corresponding to ordinary and extra-ordinary rays.
14) To measure birefringence of Mica
15) To determine the dielectric constant of solids using microwaves

References for laboratory work:

1) Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House
2) Advanced level Physics Practicals, M. Nelson and J. M. Ogborn, 4th edition, reprinted 1985, Heinemann Educational Publisher
3) Electromagnetic Field Theory for Engineers & Physicists, G. Lehner, 2010, Springer
4) Practical Physics, G. L. Squires, 4th edition, 2015, Cambridge University Press
5) Engineering Practical Physics, S. Panigrahi and B. Mallick, 2015, Cengage Learning India Pvt. Ltd

DISCIPLINE SPECIFIC CORE COURSE – DSC - 14: QUANTUM MECHANICS – I

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Quantum Mechanics – I DSC – 14	**4**	**3**	**0**	**1**	Class XII pass with Physics and Mathematics as main subjects	Light and Matter, and Elements of Modern Physics papers of this course or their equivalents

LEARNING OBJECTIVES

The development of quantum mechanics has revolutionized the human life. In this course, the students will be exposed to the probabilistic concepts of basic non-relativistic quantum mechanics and its applications to understand the sub atomic world.

LEARNING OUTCOMES

After completing this course, the students will be able to,

- Understand the applications of the Schrodinger equation to different cases of potentials namely finite square potential well, harmonic oscillator potential.
- Solve the Schrodinger equation in 3-D.
- Understand the spectrum and eigen functions for hydrogen atom
- Understand the angular momentum operators in position space, their commutators, eigenvalues and eigen functions.
- In the laboratory course, the students will be able to use computational methods to
    - Solve Schrödinger equation for ground state energy and wave functions of various simple quantum mechanical one- dimensional potentials
    - Solve Schrödinger equation for ground state energy and radial wave functions of some central potentials

SYLLABUS OF DSC - 14

THEORY COMPONENT

Unit – I **(10 Hours)**

General discussion of bound states in an arbitrary potential: Continuity of wave function, boundary conditions and emergence of discrete energy levels. Application to energy eigen states for a particle in a finite square potential well, Momentum space wavefunction, Time evolution of Gaussian Wave packet, Superposition Principle, linearity of Schrodinger Equation, General solution as a linear combination of discrete stationary states, Observables as operators, Commutator of position and momentum operators, Ehrenfest's theorem.

Unit – II **(8 Hours)**

Harmonic oscillator: Energy eigen values and eigen states of a 1-D harmonic oscillator using

algebraic method (ladder operators) and using Hermite polynomials. Zero point energy and uncertainty principle.

Unit – III **(15 Hours)**

Schrödinger Equation in three dimensions: Probability and probability densities in 3D. Schrödinger equation in spherical polar coordinates, its solution for Hydrogen atom solution using separation of angular and radial variables, Angular momentum operator, quantum numbers and spherical harmonics. Radial wave functions from Frobenius method; shapes of the probability densities for ground and first excited states; Orbital angular momentum quantum numbers l and m_l, s, p, d shells.

Unit – IV **(12 Hours)**

Angular momentum: Commutation relations of angular momentum operators; concept of spin and total angular momentum; ladder operators, eigenvalues, eigenvectors; Pauli matrices; addition of angular momenta

References:

Essential Readings:

1) Quantum Mechanics: Theory and Applications, A. Ghatak and S. Lokanathan, 6th edition, 2019, Laxmi Publications, New Delhi.
2) Introduction to Quantum Mechanics, D. J. Griffith, 2nd edition, 2005, Pearson Education.
3) A Text book of Quantum Mechanics, P. M. Mathews and K. Venkatesan, 2nd edition, 2010, McGraw Hill.
4) Quantum Mechanics, B. H. Bransden and C. J. Joachain, 2nd edition, 2000, Prentice Hall
5) Quantum Mechanics: Concepts and Applications, 2nd edition, N. Zettili, A John Wiley and Sons, Ltd., Publication
6) Atomic Physics, S. N. Ghoshal, 2010, S. Chand and Company

Additional Readings:

1) Quantum Mechanics for Scientists & Engineers, D. A. B. Miller, 2008, Cambridge University Press.
2) Introduction to Quantum Mechanics, R. H. Dicke and J. P. Wittke, 1966, Addison-Wesley Publications
3) Quantum Mechanics, L. I. Schiff, 3rd edition, 2010, Tata McGraw Hill.
4) Quantum Mechanics, R. Eisberg and R. Resnick, 2nd edition, 2002, Wiley
5) Quantum Mechanics, B. C. Reed, 2008, Jones and Bartlett Learning.
6) Quantum Mechanics, W. Greiner, 4th edition, 2001, Springer.
7) Introductory Quantum Mechanics, R. L. Liboff, 4th edition, 2003, Addison Wesley

PRACTICAL COMPONENT

(15 Weeks with 2 hours of laboratory session per week)

At least 4 programs must be attempted. The implementation may be done in C++/Scilab /Python. Use of available library functions may be encouraged. Similar programs may be added.

Unit 1

1) Visualize the spherical harmonics by plotting the probability density for various values of the quantum numbers (*l, m*)

2) Use the analytical solution for a particle in finite potential well. Numerically solve the transcendental equation one gets after putting the continuity and boundary conditions to determine the energy eigenvalues for various values of the potential width and depth. Plot the corresponding normalised eigen functions.

Unit 2

Solve the Schrödinger equation using shooting/finite difference or any other method for the following simple 1-D potentials and compare with the analytical solutions:

1) Particle in a box
2) Particle in a finite potential well
3) Harmonic Potential

Unit 3

Solve the s-wave Schrodinger equation for the following cases.

$$\frac{d^2u}{dr^2} = A(r)u(r), A(r) = \frac{2m}{\hbar^2}[V(r) - E],$$

1) Ground state and the first excited state of the hydrogen atom:

$$V(r) = \frac{-e^2}{r}$$

Here *m* is the reduced mass of the electron. Obtain the energy eigenvalues and plot the corresponding wave functions. Remember that the ground state energy of the hydrogen atom is ≈ -13.6 eV. Take e = 3.795 $(eVÅ)^{1/2}$, ħc = 1973 (eVÅ) and m = 0.511x10^6 eV/c^2.

2) For an atom in the screened coulamb potential

$$V(r) = \frac{-e^2}{r}e^{\frac{-r}{a}}$$

Here *m* is the reduced mass of the system (which can be chosen to be the mass of an electron). Find the energy (in eV) of the ground state of the atom to an accuracy of three significant digits. Also, plot the corresponding wavefunction. Take e = 3.795 $(eVÅ)^{1/2}$, m = 0.511x10^6 eV/c^2, and a = 3 Å, 5 Å, 7 Å. In these units ħc = 1973 (eVÅ). The ground state energy is expected to be above -12 eV in all three cases.

Unit 4

Solve the s-wave Schrodinger equation $\frac{d^2u}{dr^2} = A(r)u(r), A(r) = \frac{2m}{\hbar^2}[V(r) - E]$, for a particle of mass *m* for the following cases

1) Anharmonic oscillator potential

$$V(r) = \frac{1}{2}kr^2 + \frac{1}{3}br^3$$

for the ground state energy (in MeV) of particle to an accuracy of three significant digits. Also, plot the corresponding wave function. Choose m = 940 MeV/c^2, k = 100 MeV fm^{-2}, b= 0, 10, 30 MeV fm^{-3}. In these units, $c\hbar$ = 197.3 MeV fm. The ground state energy is expected to lie between 90 and 110 MeV for all three cases.

2) For the vibrations of hydrogen molecule with Morse potential

$$V(r) = D(e^{-2ar'} - e^{-ar'}), r' = \frac{r - r_0}{r}$$

Here m is the reduced mass of the two-atom system for the Morse potential
Find the lowest vibrational energy (in MeV) of the molecule to an accuracy of three significant digits. Also plot the corresponding wave function.
Take: $m = 940 \times 10^6$ eV/c^2, $D = 0.755501$ eV, $\alpha = 1.44$, $r_0 = 0.131349$ Å

References for laboratory work:

1) Schaum's Outline of Programming with C++, J. Hubbard, 2000, McGraw-Hill Education.
2) C++ How to Program, P. J. Deitel and Harvey Deitel, 2016, Pearson
3) Scilab (A Free Software to Matlab): H. Ramchandran, A. S. Nair, 2011, S. Chand and Co
4) Documentation at the Python home page (https://docs.python.org/3/) and the tutorials there (https://docs.python.org/3/tutorial/).
5) Documentation of NumPy and Matplotlib: https://numpy.org/doc/stable/user/ and https://matplotlib.org/stable/tutorials/
6) Computational Physics, Darren Walker, 1st edition, 2015, Scientific International Pvt. Ltd
7) An Introduction to Computational Physics, T. Pang, 2010, Cambridge University Press
8) A Guide to MATLAB, B. R. Hunt, R. L. Lipsman, J. M. Rosenberg, 3rd edition, 2014, Cambridge University Press

DISCIPLINE SPECIFIC CORE COURSE – DSC - 15: DIGITAL ELECTRONICS

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Digital Electronics DSC – 15	**4**	**3**	**0**	**1**	Class XII pass with Physics and Mathematics as main subjects	NIL

LEARNING OBJECTIVES

The objective of the course is to introduce digital electronics and its simple applications to physics Honours students. The course is designed to familiarize the students with the different number systems (binary, octal and hexadecimal), laws of Boolean algebra, logic gates and combinational and sequential logic circuits utilised in designing counters and registers.

LEARNING OUTCOMES

This paper is one of the core papers in the Physics curriculum. After studying this paper students will become familiar with,

- Digital signals, positive and negative logic, Boolean variables, truth table, various number system codes and their inter-conversions.
- Students will be able to learn to minimise a given Boolean function using laws of Boolean algebra and Karnaugh map to minimise the hardware requirement of digital logic circuits.
- Understand the working principle of data processing circuits, arithmetic circuits, sequential logic circuits, registers, counters based on flip flops

SYLLABUS OF DSC - 15

THEORY COMPONENT

Unit – I - Integrated circuits **(2 Hours)**

Integrated Circuits (Qualitative treatment only), active and passive components, discrete components, wafer, chip, advantages and drawbacks of ICs, scale of integration: SSI, MSI, LSI and VLSI (basic idea and definitions only), classification of ICs, examples of linear and digital lCs

Unit – II - Digital circuits and Boolean algebra **(14 Hours)**

Difference between analog and digital circuits, binary number, decimal to binary and binary to decimal conversion, BCD, octal and hexadecimal numbers, AND, OR and NOT gates (realization using diodes and transistor), NAND and NOR gates as universal gates, XOR and XNOR gates and application as parity checkers

De Morgan's theorems, Boolean laws, simplification of logic circuit using Boolean algebra, fundamental products, idea of minterms and maxterms, conversion of truth table into equivalent logic circuit by (1) Sum of Products method and (2) Karnaugh map simplification (upto four variables).

Unit – III - Combinational Logic Circuits (9 Hours)

Data processing circuits: Multiplexers and its applications, de-multiplexers, decoders, encoders Arithmetic logic circuits: Express binary number in signed and unsigned form, 1's and 2's complement representation, binary addition, binary subtraction using 2's complement, half and full Adders, half and full subtractors, 4-bit binary adder/subtractor using 2's complement method.

Unit – IV - Sequential Logic Circuits (8 Hours)

Flip Flops SR, D, and JK clocked (level and edge triggered) flip-flops, preset and clear operations, race-around conditions in JK flip-flop, master-slave JK flip-flop, conversion of one flip flop to another using an excitation table

Unit – V - Application of Sequential Logic Circuits (9 Hours)

Shift registers: Serial-in-Serial-out, Serial-in-Parallel-out, Parallel-in-Serial-out and Parallel-in-Parallel-out Shift Registers (only up to 4 bits).

Counters: Asynchronous counters, MOD-N synchronous counter designing using excitation table.

Unit – VI – Timers (3 Hours)

IC 555: Pin -out diagram, block diagram and its applications as astable multivibrator and monostable multivibrator

References:

Essential Readings:

1) Digital Principles and Applications, A. P. Malvino, D. P. Leach and Saha, 7th edition, 2011, Tata McGraw
2) Fundamentals of Digital Circuits, A. Kumar, 2nd edition, 2009, PHI Learning Pvt. Ltd.
3) Digital Fundamentals, T. L. Floyd, 1994, Pearson Education Asia
4) Digital Principles and Applications, D. P. Leach and A. P. Malvino, 1995, Tata McGraw Hill
5) Digital Design, M. M. Mano and M. D. Ciletti, 2007, Pearson Education Asia
6) Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill.
7) Digital Electronics G. K. Kharate, 2010, Oxford University Press

Additional Readings:

1) Logic circuit design, S. P. Vingron, 2012, Springer
2) Digital Principles, R. L. Tokheim, 1994, Schaum's Outline Series, Tata McGraw-Hill
3) Solved Problems in Digital Electronics, S. P. Bali, 2005, Sigma Series, Tata McGraw-Hill
4) Digital Electronics: An Introduction To Theory And Practice, W. H. Gothmann, 2000, Prentice Hall of India
5) Modern Digital Electronics, R. P. Jain, 2003, Tata McGraw-Hill
6) Digital Electronics, S. Ghoshal, 2012, Cengage Learning
7) Digital Electronics, S. K. Mandal, 2010, 1st edition, McGraw Hill

PRACTICAL COMPONENT

(15 Weeks with 2 hours of laboratory session per week)

At least five experiments should be performed from the following list.
All designing should be done on the bread boards.

1) (a) To design a combinational logic system for a specified truth table.
   (b) To convert Boolean expression into logic circuit and design it using basic logic gate ICs
2) To minimize a given logic circuit using K-map and design using NAND gates.
3) Designing of Half Adder and Half Subtractor using NAND gates
4) Designing of 4-bit binary adder using adder IC.
5) To build Flip-Flop (RS, Clocked RS) circuits using NAND gates.
6) To build Flip-Flop (D-type and JK) circuits using NAND gate
7) To build a 3-bit Counter using D-type/JK Flip-Flop ICs and study timing diagrams.
8) To make a 4-bit Shift Register (serial and parallel) using D-type/JK Flip-Flop ICs.
9) To design an astable multivibrator of given specifications using 555 Timer.

References for laboratory work:

1) Digital Fundamentals, T. L. Floyd, 1994, Pearson Education Asia
2) Digital Principles and Applications, D. P. Leach and A. P. Malvino, 1995, Tata McGraw Hill
3) Digital Design, M. M. Mano and M. D. Ciletti, 2007, Pearson Education Asia
4) Digital Circuits and Systems, Venugopal, 2011, Tata McGraw Hill

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 6: ASTRONOMY AND ASTROPHYSICS

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Astronomy and Astrophysics DSE – 6	**4**	**3**	**1**	**0**	Class XII pass with Physics and Mathematics as main subjects	Mechanics; Waves and Oscillation; Electricity & Magnetism; Mathematical Physics papers of this course or their equivalents

LEARNING OBJECTIVES

This course is meant to introduce undergraduate students to the wonders of the Universe. Students will understand how astronomers over millennia have come to understand mysteries of the universe using laws of geometry and physics. They will also be introduced to the Indian contribution to astronomy in the modern times, techniques to measure astronomical parameters, the different layers of the Sun and an overview of our Milky Way galaxy.

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LEARNING OUTCOMES

After completing this course, student will gain an understanding of,

- Basic concepts of positional astronomy and astronomical coordinate systems
- Astronomical instruments and the modern telescopes
- Measurement of astronomical parameters such as distance, stellar brightness, stellar mass, radii, temperature and spectra
- The different layers of solar atmosphere and basic results of solar magneto-hydrodynamics
- Basic structure of different galaxies and rotation of the Milky Way galaxy

It is advised that the tutorial sessions should involve discussion on problems meant to help students develop the ability to apply the theory they learn in lectures to diverse astrophysical phenomenon.

SYLLABUS OF DSE - 6

THEORY COMPONENT

Unit – I - Introduction to Astronomy **(12 Hours)**

Overview of the night sky; diurnal and yearly motions of the Sun; basic concepts of positional astronomy: celestial sphere, astronomical coordinate systems (Horizon and Equatorial systems of coordinates), circumpolar stars

Unit – II - Basic Parameters of Stars **(12 Hours)**

Measurement of astronomical distances (stellar parallax, aberration, proper motion), measurement of brightness, radiant flux and luminosity (apparent and absolute magnitude scales; distance modulus); determination of stellar mass (visual binaries, eclipsing binaries, spectroscopic binaries); measurement of stellar temperature and radius; stellar spectra,

dependence of spectral types on temperature; Stellar classification (Harvard classification scheme), H-R diagram

Unit – III - Sun **(9 Hours)**

Solar parameters, Sun's internal structure, solar photosphere, solar atmosphere, chromosphere, corona, solar activity, basics of solar magneto-hydrodynamics

Unit – IV - Physics of galaxies **(12 Hours)**

Nature of rotation of the Milky Way: Differential rotation of the Galaxy and Oort constants, rotation curve of the Galaxy and the dark matter, virial theorem

Cosmology: Standard Candles (Cepheids and SNe Type1a); cosmic distance ladder; expansion of the Universe, Cosmological principle, Newtonian cosmology and Friedmann models

References:

Essential Readings:

1) Fundamental Astronomy, H. Karttunen et al., Springer Berlin, Heidelberg
2) Modern Astrophysics, B. W. Carroll and D. A. Ostlie, Addison-Wesley Publishing Co.
3) Introductory Astronomy and Astrophysics, M. Zeilik and S. A. Gregory, Saunders College Publishing.
4) Astronomy in India: A Historical Perspective, T. Padmanabhan, Springer
5) Foundation of Astrophysics, B. Ryden and B. M. Peterson, Cambridge University Press
6) Astronomy: A Physical Perspective, M. Kutner, Cambridge University Press

Additional Readings:

1) Seven Wonders of the Cosmos, J. V. Narlikar, Cambridge University Press
2) Explorations: Introduction to Astronomy, T. Arny and S. Schneider, McGraw Hill
3) Astrophysics Stars and Galaxies, K. D. Abhyankar, Universities Press
4) An introduction to astrophysics, B. Basu, Prentice Hall of India Private Limited.
5) The Physical Universe: An Introduction to Astronomy, F. H. Shu, University Science Books
6) Telescopes and techniques, C. R. Kitchin, Springer New York, NY
7) Fundamentals of solar astronomy, A. Bhatnagar and W. C. Livingston, World Scientific
8) Astrophysics for Physicists, A. R. Choudhuri, Cambridge University Press

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 7: PHYSICS OF MATERIALS

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Physics of Materials DSE – 7	4	2	0	2	Class XII pass with Physics and Mathematics as main subjects	Solid state physics paper of this course or its equivalent

LEARNING OBJECTIVES

This course intends to provide knowledge of emerging topics in condensed matter physics. In addition, this course aims to provide a general introduction to advanced topics by covering polymers, liquid crystals, carbon-based materials, and Diluted Magnetic Semiconductors. More importantly, the students will be exposed to different characterization techniques used in experimental condensed matter physics.

LEARNING OUTCOMES

After completion of this course the students should be able to,

- Identify different materials of technological importance in appliances and objects around us
- Explain the importance of concepts like density of states and its role in determining device characteristics
- Elucidate the ferroelectric, piezoelectric and pyroelectric materials and their applications.
- Explain the properties of liquid crystals and their application.
- Differentiate between different form of carbon based materials and their applications
- Introduce the importance of dilute magnetic semiconductors as a new technologically advance material for electronic devices
- Explain various characterization techniques used in understanding properties of different material

SYLLABUS OF DSE - 7

THEORY COMPONENT

Unit – I – Semiconductors **(4 Hours)**

Basic concept of mobility and conductivity, density of states, determination of electron and hole concentration in doped semiconductor, Fermi level, Fermi energy, Fermi temperature, Fermi wavelength, Fermi surface.

Unit – II - Dielectric and magnetic materials **(9 Hours)**

Dielectrics, Ferroelectric, Piezoelectric and Pyroelectric materials, applications of ferroelectrics in capacitors and memory device, Piezoelectrics in micro positioner and actuator, Pyroelectrics in radiation detectors and thermometry

Classification and applications of soft and hard magnetic materials, application in transformers, memory device, introduction of spintronics based systems (spin transport)

Unit – III - Polymers **(3 Hours)**

Chemical structure of polymers of few thermoplastic (polyethylene, PVC, PTFE, PMMA, Polyester, Nylons) and thermosetting (Epoxy resin) polymers, conducting polymers-application in organic electronics

Unit – IV – Liquid crystals **(3 Hours)**

Classification of liquid crystals, structural and orientational ordering (isotropic to Nematic), thermotropic liquid crystals, Phases and phase transitions; anisotropic; Birefringence and display devices

Unit – V – Carbon based materials **(3 Hours)**

Structure and properties of Fullerenes, C_{60}, single walled and multi walled CNTs, Graphene and their energy band diagram.

Unit – VI – Synthesis of materials **(8 Hours)**

Ceramic (Calcination, Sintering, Grain), thin films (general idea of vacuum, thermal evaporation, molecular beam epitaxy, pulsed laser deposition), Crystals (qualitative idea of zone refining and Czochralski method), Polymers (Polymerization mechanism)

References:

Essential Readings:

1) Solid State Physics, M. A. Wahab, 2011, Narosa Publishing House
2) Elementary Solid State Physics, M. Ali Omar, 2006, Pearson
3) Semiconductor Devices: Physics and Technology, S. M. Sze, 2nd edition, 2002, Wiley India
4) Introduction to Polymer Physics, U. Eisele and S. D. Pask, 1990, Springer-Verlag
5) The physics of liquid crystals, Pierre-Gilles de Gennes, 2nd edition, 2003, Oxford University Press
6) Introduction to Liquid Crystals, P. J. Wojtowicz, E. Priestly and P. Sheng, 1975, Plenum Press
7) Dielectric Phenomenon in solids with Emphasis on Physical Concepts of Electronic Processes, K. C. Kao, Elsevier.
8) Physics of Ferroelectrics A Modern Perspective, K. M. Rabe Charles H. Ahn Jean-Marc Triscone, Springer
9) Carbon Nanotubes: Properties and Applications, M. J. O'Connell, 2006, CRC Press
10) Dilute Magnetic Semiconductors, M. Jain, World Scientific.

Additional Readings:

1) Encyclopaedia of materials characterization: surfaces, interfaces, thin films, R. C. Brundle et al., 1992, Butterworth-Heinemann
2) Physical Methods for Materials Characterization, P. E. J. Flewitt, R. K. Wild, (2nd Ed., CRC Press, 2015).
3) Dilute magnetic semiconducting materials, Br. R. Saravanan, MRF

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)

At least six experiments to be performed from the following list

1) Study phase transition in a ferroelectric sample by measuring its dielectric constant as a function of frequency and temperature.
2) Study dielectric properties of given polymer sample as a function of frequency and temperature.
3) Study dielectric properties of given piezoelectric sample as a function of frequency and temperature.
4) Determine the coupling coefficient of a given piezoelectric crystal.
5) BH Hysteresis of different ferromagnetic materials (Loop Tracer).
6) Analyse the XRD spectra of a given ferroelectric ceramic sample and determine its lattice parameter.
7) Analyse the XRD spectra of a given ferromagnetic sample (basically ferrites, Fe_3O_4, $CoFe_2O_3$) and determine its lattice parameter.
8) Analyse the XRD spectra of a given compound semiconductor (ZnO, TiO_2, etc) thin film/ceramic sample and determine its lattice parameter.
9) Analyse the UV-Vis spectra of a given wide band gap semiconductor and determine its bandgap.
10) Study the IV characteristics of a polymer material by depositing/painting Aluminum electrodes.
11) To determine the g-factor of a sample by ESR Spectrometer.
12) Analyse the given SEM/TEM/AFM micrographs of the deposited thin film or nanostructure of any material and determine surface roughness, crystallinity, particle size etc.
13) Deposition of any kind of thin film by any technique available in the lab.
14) Liquid crystals (reading project)

References for laboratory work:

1) Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House.
2) A Text Book of Practical Physics, I. Prakash and Ramakrishna, 11th edition, 2011, Kitab Mahal
3) Elements of Solid State Physics, J. P. Srivastava, 2nd edition, 2006, Prentice-Hall of India
4) Elements of X-Ray Diffraction, B. D. Cullity and S. R. Stock
5) Physical Methods for Materials Characterization, P. E. J. Flewitt, R. K. Wild, 2nd edition, 2015, CRC Press
6) Encyclopedia of materials characterization: surfaces, interfaces, thin films, R. C. Brundle et al., 1992, Butterworth-Heinemann

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 8: COMMUNICATION SYSTEM

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Communication System DSE – 8	**4**	**2**	**0**	**2**	Class XII pass with Physics and Mathematics as main subjects	Basics of Digital Electronics and Analog Electronics

LEARNING OBJECTIVES

This paper aims to describe the fundamental concepts of communication systems and communication techniques based on Analog Modulation, Analog and digital Pulse Modulation. Communication and Navigation systems such as GPS and mobile telephony system are also introduced. This paper will essentially connect the text book knowledge with the most popular communication technology in real world.

LEARNING OUTCOMES

At the end of this course, students will be able to,

- Understand fundamentals of electronic communication system and electromagnetic communication spectrum with an idea of frequency allocation for radio communication system in India.
- Gain an insight on the use of different modulation and demodulation techniques used in analog communication
- Learn the generation and detection of a signal through pulse and digital modulation techniques and multiplexing.
- Gain an in-depth understanding of different concepts used in a satellite communication system.
- Study the concept of Mobile radio propagation, cellular system design and understand mobile technologies like GSM and CDMA.
- In the laboratory course, students will apply the theoretical concepts to gain hands-on experience in building modulation and demodulation circuits; Transmitters and Receivers for AM and FM. Also to construct TDM, PAM, PWM, PPM and ASK, PSK and FSK modulator and verify their results.

SYLLABUS OF DSE - 8

THEORY COMPONENT

Unit – I - Electronic communication and analog modulation (8 Hours)

Electronic communication: Introduction to communication – means and modes. Need for modulation. Block diagram of an electronic communication system, channels and base-band signals

Analog Modulation: Amplitude modulation, modulation index and frequency spectrum. Generation of AM (emitter modulation), amplitude demodulation (diode detector), Single sideband (SSB) systems, advantages of SSB transmission, frequency modulation (FM) and

phase modulation (PM), modulation index and frequency spectrum, equivalence between FM and PM.

Unit – II - Analog Pulse Modulation (4 Hours)
Sampling theorem, basic principles - PAM, PWM, PPM, modulation and detection technique for PAM only, Multiplexing (time division multiplexing and frequency division multiplexing)

Unit – III - Digital Pulse Modulation (10 Hours)
Need for digital transmission, pulse code modulation, digital carrier modulation techniques, sampling, quantization and encoding, concept of amplitude shift keying (ASK), frequency shift keying (FSK), phase shift keying (PSK), and binary phase shift keying (BPSK)

Unit – IV - Satellite Communication and Mobile Telephony system (8 Hours)
Satellite communication: Need for satellite communication, geosynchronous satellite orbits, geostationary satellite advantages of geostationary satellites. Transponders (C - Band), uplink and downlink, Ground and earth stations
Mobile Telephony System: Concept of cell sectoring and cell splitting, SIM number, IMEI number, architecture (block diagram) of mobile communication network, idea of GSM, CDMA, TDMA and FDMA technologies, simplified block diagram of mobile phone handset.

References:
Essential Readings:

1) Electronic Communications, D. Roddy and J. Coolen, Pearson Education India.
2) Advanced Electronics Communication Systems, Tomasi, 6th edition, Prentice Hall.
3) Electronic Communication systems, G. Kennedy, 3rd edition, 1999, Tata McGraw Hill.
4) Principles of Electronic communication systems, Frenzel, 3rd edition, McGraw Hill
5) Modern Digital and Analog Communication Systems, B. P. Lathi, 4th edition, 2011, Oxford University Press.
6) Communication Systems, S. Haykin, 2006, Wiley India
7) Wireless communications, A. Goldsmith, 2015, Cambridge University Press

Additional Readings:

1) Electronic Communication, L. Temes and M. Schultz, Schaum's Outline Series, Tata McGraw- Hill.
2) Electronic Communication Systems, G. Kennedy and B. Davis, Tata McGraw-Hill
3) Analog and Digital Communication Systems, M. J. Roden, Prentice Hall of India

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)

At least six experiments to be performed from the following list

1) To design an amplitude modulator using transistor
2) To design envelope detector for demodulation of AM signal
3) To study FM - generator and detector circuit
4) To study AM transmitter and receiver
5) To study FM transmitter and receiver
6) To study time division multiplexing (TDM)
7) To design pulse amplitude modulator using transistor.

8) To design pulse width modulator using 555 timer IC.
9) To design pulse position modulator using 555 timer IC
10) To study ASK, PSK and FSK modulators and demodulators

References for laboratory work:

1) Electronic Communication system, Blake, 5th edition, Cengage
2) Introduction to Communication systems, U. Madhow, 1st edition, 2018, Cambridge University Press

Category II

Physical Science Courses
with Physics discipline as one of the Core Disciplines

(B. Sc. Physical Science with Physics as Major discipline)

DISCIPLINE SPECIFIC CORE COURSE – PHYSICS DSC 5: ELEMENTS OF MODERN PHYSICS

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Elements of Modern Physics PHYSICS DSC – 5	**4**	**2**	**0**	**2**	Class XII pass with Physics and Mathematics as main subjects	NIL

LEARNING OBJECTIVES

This course introduces modern development in Physics. Starting from Planck's law, it develops the idea of probability interpretation and then discusses the formulation of Schrodinger equation. This paper aims to provide knowledge about atomic physics, hydrogen atoms and X-rays. It also introduces concepts of nuclear physics and accelerators

LEARNING OUTCOMES

After getting exposure to this course, the following topics would be learnt.

- Main aspects of the inadequacies of classical mechanics as well as understanding of the historical development of quantum mechanics. Heisenberg's Uncertainty principle and its applications, photoelectric effect and Compton scattering
- The Schrodinger equation in 1-d, wave function, probability and probability current densities, normalization, conditions for physical acceptability of wave functions, position and momentum operators and their expectation values. Commutator of position and momentum operators.
- Time Independent Schrodinger Equation, derivation by separation of variables, wave packets, particle in a box problem, energy levels.
- Modification in Bohr's Quantum Model: Sommerfeld theory of elliptical orbits
- Hydrogen atom energy levels and spectra emission and absorption spectra.
- X-rays: their production and spectra: continuous and characteristic X-rays, Moseley Law.
- Basic Properties of Nuclei, nuclear binding energy, semi-empirical mass formula, nuclear force and meson theory.
- Types of Accelerators, Van de Graaff generator, linear accelerator, cyclotron, synchrotron

SYLLABUS OF PHYSICS DSC – 5

THEORY COMPONENT

Unit - I **(8 Hours)**

Origin of Quantum Theory: Black Body Radiation and failure of classical theory, Planck's Quantum Hypothesis, Planck's Radiation Law, Quantitative treatment of Photo-electric effect and Compton scattering. Wave properties of particles: de Broglie hypothesis, Group and Phase velocities and relation between them. Heisenberg's Uncertainty Principle, Gamma ray microscope thought experiment, Position-Momentum Uncertainty, consequences of uncertainty principle.

Unit - II **(7 Hours)**

The Schrodinger Equation: The Schrodinger equation in 1-d, statistical interpretation of wave function, probability and probability current densities. Normalization, conditions for physical acceptability of wave functions with examples, position and momentum operators and their expectation values; Commutator of position and momentum operators

Unit – III **(5 Hours)**

Time Independent Schrodinger Equation: Demonstration of separation of variable method for time independent Schrodinger equation: Free particle wave function, wave packets, application to energy eigen values and stationary states for particle in a box problem, energy levels.

Unit – IV **(5 Hours)**

Atomic Physics: Beyond the Bohr's Quantum model: Sommerfeld theory of elliptical orbits; hydrogen atom energy levels and spectra emission and absorption spectra
Correspondence principle
X-rays: Method of production, X-ray spectra: Continuous and characteristic X-rays, Moseley Law.

Unit – V **(5 Hours)**

Basic Properties of Nuclei: Introduction (basic idea about nuclear size, mass, angular momentum, spin), semi-empirical mass formula, nuclear force and meson theory.
Accelerators: Accelerator facility available in India: Van de Graaff generator, linear accelerator, cyclotron (principle, construction, working, advantages and disadvantages), discovery of new elements of the periodic table

References:

Essential Readings:

1) Concepts of Modern Physics, A. Beiser, 2002, McGraw-Hill.
2) Modern Physics, R. A. Serway, C. J. Moses and C. A. Moyer, 2012, Thomson Brooks Cole, Cengage
3) Schaum's Outline of Modern Physics, R. Gautreau and W. Savin, 2020, McGraw Hill LLC
4) Modern Physics for Scientists and Engineers, S. T. Thornton Rex, 4th edition, 2013, Cengage Learning
5) Introduction to Modern Physics, R. Meyer, Kennard, Coop, 2002, Tata McGraw Hill
6) Physics for scientists and Engineers with Modern Physics, Jewett and Serway, 2010.
7) Learning Modern Physics, G. Kaur and G.R. Pickrell, 2014, McGraw Hill.
8) Modern Physics, R. Murugeshan, S Chand & Co. Ltd
9) Schaum's Outline of Beginning Physics II | Waves, electromagnetism, Optics and Modern Physics, Alvin Halpern, Erich Erlbach, McGraw Hill.
10) Theory and Problems of Modern Physics, Schaum's outline, R. Gautreau and W. Savin, 2nd edition, Tata McGraw-Hill Publishing Co. Ltd.
11) Quantum Physics, Berkeley Physics, Vol.4. E. H. Wichman, 1971, Tata McGraw-Hill
12) Quantum Mechanics: Theory and Applications, A. Ghatak and S. Lokanathan, 2004, Macmillan Publishers India Limited
13) Introduction to Quantum Mechanics, D. J. Griffith, 2005, Pearson Education
14) Concepts of nuclear physics, B. Cohen, 2003, McGraw-Hill Education
15) Atomic Physics, Ghoshal, 2019, S. Chand Publishing House
16) Atomic Physics, J. B. Rajam & foreword by Louis De Broglie, 2010, S. Chand & Co.

17) Nuclear Physics, S. N. Ghoshal, S. Chand Publishers
18) Atomic and Molecular Physics, Rajkumar, RBSA Publishers

Additional Readings:

1) Six Ideas that Shaped Physics: Particles Behave like Waves, T. A. Moore, 2003, McGraw Hill.
2) Thirty years that shook physics: The story of quantum theory, G. Gamow, Garden City, NY: Doubleday, 1966.

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)

Mandatory activity:

- Sessions on the review of experimental data analysis, sources of error and their estimation in detail, writing of scientific laboratory reports including proper reporting of errors.
- Application to the specific experiments done in the lab
- Familiarization with Schuster`s focusing; determination of angle of prism.

At least six experiments to be performed from the following list

1) Measurement of Planck's constant using black body radiation and photo-detector
2) Photo-electric effect: photo current versus intensity and wavelength of light, maximum energy of photo-electrons versus frequency of light
3) To determine the work function of material of filament of directly heated vacuum diode.
4) To determine the Planck's constant using LEDs of at least 4 different colours.
5) To determine the wavelength of the H-alpha emission line of Hydrogen atoms.
6) To determine the ionization potential of mercury.
7) To determine the value of e/m by (a) Magnetic focusing or (b) Bar magnet.
8) To show the tunneling effect in tunnel diodes using I-V characteristics.
9) To determine the wavelength of a laser source using diffraction of a single slit.
10) 10. To determine the wavelength of a laser source using diffraction of double slits.
11) 11. To determine angular spread of He-Ne laser using plane diffraction grating
12) One innovative experiment designed by the teacher relevant to the syllabus.

References for laboratory work:

1) Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House.
2) A Text Book of Practical Physics, I. Prakash and Ramakrishna, 11th edition, 2011, Kitab Mahal.
3) Advanced level Physics Practicals, Michael Nelson and Jon M. Ogborn, 4th edition, reprinted, 1985, Heinemann Educational Publishers.
4) A Laboratory Manual of Physics for Undergraduate Classes, D. P. Khandelwal, 1985, Vani Publisher.
5) B.Sc. Practical Physics, H. Singh, S Chand & Co Ltd
6) B.Sc. Practical Physics, G. Sanon, R. Chand and Co.

DISCIPLINE SPECIFIC ELECTIVE COURSE – PHYSICS DSE 15a: FOUNDATION OF ASTROPHYSICS

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Foundation of Astrophysics PHYSICS DSE 15a	**4**	**3**	**1**	**0**	Class XII pass with Physics and Mathematics as main subjects	Mechanics; Electricity & Magnetism; Waves and Optics papers of this course or their equivalents

LEARNING OBJECTIVES

This course is meant to introduce undergraduate students to the wonders of the Universe. Students will understand how astronomers over millennia have come to understand mysteries of the universe using laws of geometry and physics. They will also be introduced to the Indian contribution to astronomy in the modern times, techniques to measure astronomical parameters, the different layers of the Sun, the characteristics of planets in the solar system, an overview of our Milky Way galaxy and astrobiology.

LEARNING OUTCOMES

After completing this course, student will gain an understanding of,

- Basic concepts of positional astronomy and astronomical coordinate systems
- Astronomical instruments and modern telescopes
- Measurement of basic astronomical parameters such as distance, stellar brightness, stellar mass, radii, temperature and spectra
- Different layers of the Sun's atmosphere
- The difference between the terrestrial planets and the Jovian planets
- Basic structure of different galaxies and rotation of the Milky Way galaxy
- Distribution of chemical compounds in the interstellar medium and astrophysical conditions necessary for the emergence and existence of life

It is advised that the tutorial sessions should involve discussion on problems meant to help students develop the ability to apply the theory they learn in lectures to diverse astrophysical phenomenon.

SYLLABUS OF PHYSICS DSE – 15a

THEORY COMPONENT

Unit – I - Introduction to Astronomy **(12 Hours)**

Overview of the night sky; diurnal and yearly motions of the Sun; basic concepts of positional astronomy: celestial sphere, astronomical coordinate systems (Horizon and Equatorial systems of coordinates), circumpolar stars

Unit – II - Basic Parameters of Stars **(15 Hours)**

Measurement of astronomical distances (stellar parallax, aberration, proper motion), measurement of brightness, radiant flux and luminosity (apparent and absolute magnitude scales; distance modulus); determination of stellar mass by Kepler's law; measurement of stellar temperature and radius; stellar spectra, dependence of spectral types on temperature; Stellar classification (Harvard classification scheme), H-R diagram

Unit – III - Sun and the solar system (9 Hours)

Solar parameters; Sun's internal structure; solar photosphere; solar atmosphere; chromosphere; corona; solar activity; solar system (characteristics of terrestrial and Jovian planets)

Unit – IV- Physics of galaxies, Cosmology, Astrobiology (9 Hours)

Physics of galaxies: Nature of rotation of the Milky Way: Differential rotation of the Galaxy, dark matter

Cosmology: Standard Candles (Cepheids and SNe Type1a); cosmic distance ladder; expansion of the Universe

Astrobiology: History of the Universe; chemistry of life; origin of life; chances of life in the solar system

References:

Essential Readings:

1) Seven Wonders of the Cosmos, J. V. Narlikar, Cambridge University Press
2) Fundamental Astronomy, H. Karttunen et al., Springer Berlin, Heidelberg
3) Modern Astrophysics, B. W. Carroll and D. A. Ostlie, Addison-Wesley Publishing Co.
4) Introductory Astronomy and Astrophysics, M. Zeilik and S. A. Gregory, Saunders College Publishing.
5) Astronomy in India: A Historical Perspective, T. Padmanabhan, Springer
6) Foundation of Astrophysics, B. Ryden and B. M. Peterson, Cambridge University Press
7) Astronomy: A Physical Perspective, M. Kutner, Cambridge University Press

Additional Readings:

1) Explorations: Introduction to Astronomy, Thomos Arny and Stephen Schneider, McGraw Hill
2) Astrophysics Stars and Galaxies, K. D. Abhyankar, Universities Press
3) An introduction to astrophysics, B. Basu, Prentice Hall of India Private Limited.
4) The Physical Universe: An Introduction to Astronomy, F. H. Shu, University Science Books
5) Telescopes and techniques, C. R. Kitchin, Springer New York, NY
6) Fundamentals of solar astronomy, A. Bhatnagar and W. C. Livingston, World Scientific
7) Astrophysics for Physicists, A. R. Choudhuri, Cambridge University Press

DISCIPLINE SPECIFIC ELECTIVE COURSE – PHYSICS DSE 15b: DIGITAL ELECTRONICS

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Digital Electronics PHYSICS DSE – 15b	**4**	**2**	**0**	**2**	Class XII pass with Physics and Mathematics as main subjects	NIL

LEARNING OBJECTIVES

The objective of the course is to introduce digital electronics and its simple applications to physics program students. The course is designed to familiarize the students with the different number systems (binary, octal and hexadecimal), laws of Boolean algebra, logic gates and combinational and sequential logic circuits utilised in designing counters and registers.

LEARNING OUTCOMES

After studying this paper students will become familiar with,

- Digital signals, positive and negative logic, Boolean variables, truth table, various number system codes and their inter-conversions.
- Students will be able to learn to minimise a given Boolean function using laws of Boolean algebra and Karnaugh map to minimise the hardware requirement of digital logic circuits
- Understand the working mechanism of data processing circuits, arithmetic circuits, sequential logic circuits, register and their applications.

SYLLABUS OF PHYSICS DSE 15b

THEORY COMPONENT

Unit – I - Integrated Circuits (qualitative treatment only) (2 Hours)

Advantages and drawbacks of ICs, scale of integration, SSI, MSI, LSI and VLSI (basic idea and definitions only), classification of ICs, examples of linear and digital lCs

Unit – II - Digital circuits and Boolean Aalgebra (13 Hours)

Binary numbers, decimal to binary and binary to decimal conversion, octal and hexadecimal numbers, NAND and NOR gates as universal gates, XOR and XNOR gates and their application as parity checkers

Boolean algebra: De Morgan's theorems, Boolean laws, idea of minterms, simplification of logic circuit using Boolean algebra and Karnaugh map

Unit – III - Combinational logic Circuits (7 Hours)

Data processing circuits: Multiplexers and its applications, de-multiplexers, decoders, encoders

Arithmetic circuits: Binary addition, binary subtraction using 2's complement, half and full adders, half and full subtractor

Unit – IV - Sequential Circuits (8 Hours)

Flip Flops: SR, D, and JK, clocked (edge triggered) flip-flops, race-around conditions in JK flip-flop, application of flip flops in designing shift register (serial -in- parallel out) and 2- bit (MOD-4) up-down asynchronous counter

References:

Essential Readings:

1) Digital Principles and Applications, A. P. Malvino, D. P. Leach and Saha, 7th edition, 2011, Tata McGraw
2) Fundamentals of Digital Circuits, A. Kumar, 2nd edition, 2009, PHI Learning Pvt. Ltd.
3) Digital Fundamentals, T. L. Floyd, 1994, Pearson Education Asia
4) Digital Principles and Applications, D. P. Leach and A. P. Malvino, 1995, Tata McGraw Hill
5) Digital Design, M. M. Mano and M. D. Ciletti, 2007, Pearson Education Asia
6) Digital Circuits and systems, Venugopal, 2011, Tata McGraw Hill.
7) Digital Electronics, G. K. Kharate, 2010, Oxford University Press

Additional Readings:

1) Logic circuit design, S. P. Vingron, 2012, Springer
2) Digital Principles, Schaum's Outline Series, R. L. Tokheim, 1994, Tata McGraw-Hill
3) Solved Problems in Digital Electronics, S. P. Bali, 2005, Sigma Series, Tata McGraw-Hill
4) Digital Electronics: An Introduction To Theory And Practice, W. H. Gothmann, 2000, Prentice Hall of India
5) Modern Digital Electronics, R. P. Jain, 2003, Tata McGraw-Hill
6) Digital Electronics, S. Ghoshal, 2012, Cengage Learning.
7) Digital Electronics, S. K. Mandal, 2010, 1st edition, McGraw Hill

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)

Either (1) At least 6 experiments or (II) 4 experiments and one project equivalent to two experiments and all designing should be done on the bread boards.

1) Study of truth tables of basic logic gates, universal logic gates XOR and XNOR logic gates
2) (a)To design a combinational logic system for a specified truth table.
   (b) To convert Boolean expression into logic circuit and design it using basic logic gate ICs
3) To minimize a given logic circuit using K-map and design using NAND gates.
4) Designing of Half Adder and Half Subtractor using NAND gates.
5) Designing of Full adder/Full Subtractor using NAND gates
6) Designing of 4-bit binary adder using adder IC.
7) To build Flip-Flop (RS, Clocked RS) circuits using NAND gates.
8) To build Flip-Flop (D-type and JK) circuits using NAND gate
9) To build a 2-bit Asynchronous Counter using D-type/JK Flip-Flop ICs and study timing diagrams.
10) To make a 3-bit Shift Register (serial in- and parallel out) using D-type/JK Flip-Flop ICs.

References for laboratory work:

1) Digital Fundamentals, T. L. Floyd, 1994, Pearson Education Asia
2) Digital Principles and Applications, D. P. Leach and A. P. Malvino, 1995, Tata McGraw

Hill
3) Digital Design, M. M. Mano and M. D. Ciletti, 2007, Pearson Education Asia
4) Digital Circuits and Systems, Venugopal, 2011, Tata McGraw Hill.

DISCIPLINE SPECIFIC ELECTIVE COURSE – PHYSICS DSE 15c: RADIATION AND ITS APPLICATIONS

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Radiation and its Applications PHYSICS DSE – 15c	**4**	**2**	**0**	**2**	Class XII pass with Physics and Mathematics as main subjects	NIL

LEARNING OBJECTIVES

The Learning Objectives of this course are as follows.

- To focus on the applications of nuclear techniques and radiation protection.
- To not only enhance the skills towards the basic understanding of the radiation but also provide the knowledge about the protective measures against radiation exposure.
- To impart all the skills required by a radiation safety officer or any job dealing with radiation such as X-ray operators, jobs dealing with nuclear medicine: chemotherapists, operators of PET, MRI, CT scan, gamma camera etc.

LEARNING OUTCOMES

After studying this course, the student will be able to,

- Understand and use the applications of nuclear techniques and radiation protection to guard against nuclear radiation hazards.
- Understand and use the units of radiations and their safety limits, the devices to detect and measure radiation.
- Understand and use radiation safety management, biological effects of ionizing radiation, operational limits and basics of radiation hazards evaluation and control, radiation protection standards,
- Use the devices which apply radiations in medical sciences, such as X - ray, MRI, PET, CT-scan with the required safety measures.
- Understand and perform experiments like study the background radiation levels using Radiation detectors, Determination of gamma ray linear and mass absorption coefficient of a given material for radiation shielding application.
- Use graphical software to plot the simulations done through SRIM or similar software.

SYLLABUS OF PHYSICS DSE 15c

THEORY COMPONENT

Unit – I **(8 Hours)**

Radiation and its interaction with matter: Basic ideas of different type of radiation electromagnetic (X-ray, gamma rays, cosmic rays etc.), nuclear radiation and their origin (stable and unstable isotopes), half life and mean life

Nuclear Radiation: Basic idea of alpha, beta, gamma and neutron radiation and their sources (sealed and unsealed sources). Kinematics of nuclear reactions, Q value

Interaction of charged particles (including alpha particles): Heavy charged particles (e.g.

accelerated ions) - Beth-Bloch formula, scaling laws, mass stopping power, range, straggling. Cherenkov radiation
Interaction of beta particles: Collision and Radiation loss (Bremsstrahlung).
Interaction of photons: Linear and Mass Attenuation Coefficients. Interaction of Neutrons: Collision, slowing down and Moderation.

Unit - II **(8 Hours)**

Radiation Units, dosage and safety management:
Radiation Quantities and Units: Biological effects of ionizing radiation, Interaction of ionising and non-ionising radiation at the cellular level. Basic idea of different units of activity, KERMA, exposure, absorbed dose, equivalent dose, effective dose, collective equivalent dose, quality factor, radiation and tissue weighting factors, annual limit of intake (ALI) and derived air concentration (DAC).
Radiation safety management: Operational limits and basics of radiation hazards, its evaluation and control: radiation protection standards. Concept of ALARA Principle using Distance, time and shielding

Unit - III **(8 Hours)**

Radiation detection and monitoring devices: Basic concepts and working principle of gas detectors, Scintillation Detectors, Solid State Detectors and Neutron Detectors, Types of Radiation Dosimeters: thermoluminescence, radiographic films, calorimetry, semiconductor diodes; Relation between detection and dosimetry, Interaction of ionising and non-ionising radiation at the cellular level.

Unit - IV **(6 Hours)**

Application of radiation as a technique: Application in medical science (e.g., basic principles of X- rays, MRI, PET, CT scan, Projection Imaging Gamma Camera, Radiation therapy), Archaeology, Art, Crime detection, Mining and oil. Industrial Uses: Tracing, Gauging, Material Modification, Sterilization, Food preservation.

References:

Essential Readings:

1) Basic ideas and concepts in nuclear physics: An introductory approach, K. Heyde, 3rd edition, 1999, IOP Publication.
2) Nuclear Physics, S. N. Ghoshal, 1st edition, 2010, S. Chand Publication
3) Nuclear Physics: Principles and Applications, J. Lilley, 2006, Wiley Publication
4) Fundamental Physics of Radiology, W. J. Meredith and B. Massey, 1989, John Wright and Sons, UK
5) An introduction to radiation protection by A Martin and S A Harbisor, John Willey & Sons, Inc. NewYork, 1981.
6) Radioactivity and Radiation, C. Grupen and M. Rodgers, 2016, Springer
7) Introduction to radiation protection, C. Grupen, 2010, Springer
8) An introduction to radiation protection, A. Martin, S. Harbison, K. Beach and P. Cole, H. Arnold, 2012.

Additional Readings:

1) Radiation detection and measurement, G. F. Knoll, 4th edition, 2010, Wiley Publications
2) Techniques for Nuclear and Particle Physics experiments, W. R. Leo, 1994, Springer
3) Thermoluminescence dosimetry, A. F. Mcknlay, Bristol, Adam Hilger (Medical Physics Hand book 5)

4) Medical Radiation Physics, W. R. Hendee, 1981, Year book Medical Publishers, Inc., London
5) Physics and Engineering of Radiation Detection, S. N. Ahmed, 2007, Academic Press Elsevier
6) Nuclear and Particle Physics, W. E. Burcham and M. Jobes, 1995, Harlow Longman Group
7) IAEA Publications: (a) General safety requirements Part 1, No. GSR Part 1 (2010), Part 3 No. GSR Part 3 (Interium) (2010); (b) Safety Standards Series No. RS-G-1.5 (2002), Rs-G-1.9 (2005), Safety Series No. 120 (1996); (c) Safety Guide GS-G-2.1 (2007).

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)

At least five experiments need to be performed from the following list.

1) Estimate the energy loss of different projectiles/ions (at least 3 projectiles between ZP = 1 to 92, where ZP is atomic number of projectile/ion) in water and carbon, using SRIM/TRIM etc. simulation software.
2) Simulation study (using SRIM/TRIM or any other software) of radiation depth in materials (Carbon, Silver, Gold, Lead) using H as projectile/ion.
3) Comparison of interaction of projectiles with ZP = 1 to 92 (where ZP is atomic number of projectile/ion) in a given medium (Mylar, Aluminium, cadmium, lead) using simulation software (SRIM etc).
4) SRIM/TRIM based experiments to study ion-matter interaction of heavy projectiles on heavy atoms. The range of investigations will be ZP = 6 to 92 on ZA = 16 to 92 (where ZP and ZA are atomic numbers of projectile and atoms respectively). Draw and infer appropriate Bragg Curves.
5) Calculation of absorption/transmission of X-rays, γ-rays through Mylar, Be, C, Al, Fe and ZA = 47 to 92 (where ZA is atomic number of atoms to be investigated as targets) using XCOM, NIST (https://physics.nist.gov/PhysRefData/Xcom/html/xcom1.html).
6) Study the background radiation in different places and identify the source material from gamma ray energy spectrum. (Data may be taken from the Department of Physics & Astrophysics; University of Delhi and gamma ray energies are available in the website http://www.nndc.bnl.gov/nudat2/).
7) Study the background radiation levels using Radiation meter
8) Study of characteristics of GM tube and determination of operating voltage and plateau length using background radiation as source (without commercial source).
9) Study of counting statistics using background radiation using GM counter.
10) Study of radiation in various materials (e.g. KSO_4 etc.). Investigation of possible radiation in different routine materials by operating GM counter at operating voltage.
11) Study of absorption of beta particles in Aluminium using GM counter.
12) Detection of α particles using reference source & determining its half life using spark counter.
13) Gamma spectrum of gas light mantle (Source of Thorium).
14) Demonstration of radiation detection equipment for dose, risk and crime scene management.

References for laboratory work:

1) Schaum's Outline of Modern Physics, 1999, McGraw-Hill
2) Schaum's Outline of College Physics, E. Hecht, 11th edition, 2009, McGraw Hill
3) Modern Physics, K Sivaprasath and R Murugeshan, 2010, S. Chand Publication
4) AERB Safety Guide (Guide No. AERB/RF-RS/SG-1), Security of radioactive sources in radiation facilities, 2011
5) AERB Safety Standard No. AERB/SS/3 (Rev. 1), Testing and Classification of sealed Radioactivity Sources., 2007.

Category II

Physical Science Courses (with Electronics)
with Physics and Electronics discipline as Core Disciplines

DISCIPLINE SPECIFIC CORE COURSE – PHYSICS DSC 9: ELEMENTS OF MODERN PHYSICS

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Elements of Modern Physics PHYSICS DSC 9	**4**	**2**	**0**	**2**	Class XII pass with Physics and Mathematics as main subjects	NIL

LEARNING OBJECTIVES

This course introduces modern development in Physics. Starting from Planck's law, it develops the idea of probability interpretation and then discusses the formulation of Schrodinger equation. This paper aims to provide knowledge about atomic physics, hydrogen atoms and X-rays. It also introduces concepts of nuclear physics and accelerators

LEARNING OUTCOMES

After getting exposure to this course, the following topics would be learnt.

- Main aspects of the inadequacies of classical mechanics as well as understanding of the historical development of quantum mechanics. Heisenberg's Uncertainty principle and its applications, photoelectric effect and Compton scattering
- The Schrodinger equation in 1-d, wave function, probability and probability current densities, normalization, conditions for physical acceptability of wave functions, position and momentum operators and their expectation values; Commutator of position and momentum operators.
- Time Independent Schrodinger Equation, derivation by separation of variables, wave packets, particle in a box problem, energy levels.
- Modification in Bohr's Quantum Model: Sommerfeld theory of elliptical orbits
- Hydrogen atom energy levels and spectra emission and absorption spectra.
- X-rays: their production and spectra: continuous and characteristic X-rays, Moseley Law.
- Basic Properties of Nuclei, nuclear binding energy, semi-empirical mass formula, nuclear force and meson theory.
- Types of Accelerators, Van de Graaff generator, linear accelerator, cyclotron, synchrotron

SYLLABUS OF PHYSICS DSC – 9

THEORY COMPONENT

Unit - I **(8 Hours)**

Origin of Quantum Theory: Black Body Radiation and failure of classical theory, Planck's Quantum Hypothesis, Planck's Radiation Law, Quantitative treatment of Photo-electric effect and Compton scattering. Wave properties of particles: de Broglie hypothesis, Group and Phase velocities and relation between them. Heisenberg's Uncertainty Principle, Gamma ray microscope thought experiment, Position-Momentum Uncertainty, consequences of uncertainty principle.

Unit - II **(7 Hours)**

The Schrodinger Equation: The Schrodinger equation in 1-d, statistical interpretation of wave function, probability and probability current densities. Normalization, conditions for physical acceptability of wave functions with examples, position and momentum operators and their expectation values; Commutator of position and momentum operators.

Unit – III **(5 Hours)**

Time Independent Schrodinger Equation: Demonstration of separation of variable method for time independent Schrodinger equation: Free particle wave function, wave packets, application to energy eigen values and stationary states for particle in a box problem, energy levels.

Unit – IV **(5 Hours)**

Atomic Physics: Beyond the Bohr's Quantum Model: Sommerfeld theory of elliptical orbits; hydrogen atom energy levels and spectra emission and absorption spectra.
Correspondence principle
X-rays: Method of production, X-ray spectra: Continuous and characteristic X-rays, Moseley law

Unit – V **(5 Hours)**

Basic Properties of Nuclei: Introduction (basic idea about nuclear size, mass, angular momentum, spin), semi-empirical mass formula, nuclear force and meson theory.
Accelerators: Accelerator facility available in India: Van de Graaff generator, linear accelerator, cyclotron (principle, construction, working, advantages and disadvantages); discovery of new elements of the periodic table

References:

Essential Readings:

1) Concepts of Modern Physics, A. Beiser, 2002, McGraw-Hill.
2) Modern Physics, R. A. Serway, C. J. Moses and C. A. Moyer, 2012, Thomson Brooks Cole, Cengage
3) Schaum's Outline of Modern Physics, R. Gautreau and W. Savin, 2020, McGraw Hill LLC
4) Modern Physics for Scientists and Engineers, S. T. Thornton Rex, 4th edition, 2013, Cengage Learning
5) Introduction to Modern Physics, R. Meyer, Kennard, Coop, 2002, Tata McGraw Hill
6) Physics for scientists and Engineers with Modern Physics, Jewett and Serway, 2010.
7) Learning Modern Physics, G. Kaur and G.R. Pickrell, 2014, McGraw Hill.
8) Modern Physics, R. Murugeshan, S Chand & Co. Ltd
9) Schaum's Outline of Beginning Physics II | Waves, electromagnetism, Optics and Modern Physics, Alvin Halpern, Erich Erlbach, McGraw Hill.
10) Theory and Problems of Modern Physics, Schaum's outline, R. Gautreau and W. Savin, 2nd edition, Tata McGraw-Hill Publishing Co. Ltd.
11) Quantum Physics, Berkeley Physics, Vol.4. E. H. Wichman, 1971, Tata McGraw-Hill
12) Quantum Mechanics: Theory and Applications, A. Ghatak and S. Lokanathan, 2004, Macmillan Publishers India Limited
13) Introduction to Quantum Mechanics, D. J. Griffith, 2005, Pearson Education
14) Concepts of nuclear physics, B. Cohen, 2003, McGraw-Hill Education
15) Atomic Physics, Ghoshal, 2019, S. Chand Publishing House
16) Atomic Physics, J. B. Rajam & foreword by Louis De Broglie, 2010, S. Chand & Co.

17) Nuclear Physics, S. N. Ghoshal, S. Chand Publishers
18) Atomic and Molecular Physics, Rajkumar, RBSA Publishers

Additional Readings:

1) Six Ideas that Shaped Physics: Particles Behave like Waves, T. A. Moore, 2003, McGraw Hill.
2) Thirty years that shook physics: The story of quantum theory, G. Gamow, Garden City, NY: Doubleday, 1966.

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)

Mandatory activity:

- Sessions on the review of experimental data analysis, sources of error and their estimation in detail, writing of scientific laboratory reports including proper reporting of errors.
- Application to the specific experiments done in the lab
- Familiarization with Schuster`s focusing; determination of angle of prism.

At least six experiments to be performed from the following list

1) Measurement of Planck's constant using black body radiation and photo-detector
2) Photo-electric effect: photo current versus intensity and wavelength of light, maximum energy of photo-electrons versus frequency of light
3) To determine the work function of material of filament of directly heated vacuum diode.
4) To determine the Planck's constant using LEDs of at least 4 different colours.
5) To determine the wavelength of the H-alpha emission line of Hydrogen atoms.
6) To determine the ionization potential of mercury.
7) To determine the value of e/m by (a) Magnetic focusing or (b) Bar magnet.
8) To show the tunneling effect in tunnel diodes using I-V characteristics.
9) To determine the wavelength of a laser source using diffraction of a single slit.
10) 10. To determine the wavelength of a laser source using diffraction of double slits.
11) 11. To determine angular spread of He-Ne laser using plane diffraction grating
12) One innovative experiment designed by the teacher relevant to the syllabus.

References for laboratory work:

1) Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House.
2) A Text Book of Practical Physics, I. Prakash and Ramakrishna, 11th edition, 2011, Kitab Mahal.
3) Advanced level physics practicals, Michael Nelson and Jon M. Ogborn, 4th edition, reprinted, 1985, Heinemann Educational Publishers.
4) A laboratory manual of physics for undergraduate classes, D. P. Khandelwal, 1985, Vani Publisher.
5) B.Sc. Practical Physics, H. Singh, S Chand & Co Ltd
6) B.Sc. Practical Physics, G. Sanon, R. Chand and Co.

DISCIPLINE SPECIFIC ELECTIVE COURSE – PHYSICS DSE 3: SEMICONDUCTOR DEVICES FABRICATION

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Semiconductor Devices Fabrication PHYSICS DSE 3	**4**	**2**	**0**	**2**	Class XII pass with Physics and Mathematics as main subjects	NIL

LEARNING OBJECTIVES

This course provides a review of basics of semiconductors such as energy bands, doping, defects etc. and introduces students to various semiconductor and memory devices, thin film growth techniques and processes including various vacuum pumps, sputtering, evaporation, oxidation and VLSI processing are described in detail. By the end of the syllabus, students will have an understanding of MEMS based transducers.

LEARNING OUTCOMES

At the end of this course, students will be able to achieve the following learning outcomes.

- Learn to distinguish between single crystal, polycrystalline and amorphous materials based on their structural morphology and learn about the growth of single crystals of silicon, using Czochralski technique, on which a present day electronics and IT revolution is based.
- Students will understand about the various techniques of thin film growth and processes.
- Appreciate the various VLSI fabrication technologies and learn to design the basic fabrication process of R, C, P- N Junction diode, BJT, JFET, MESFET, MOS, NMOS, PMOS and CMOS technology.
- Gain basic knowledge on overview of MEMS (Micro-Electro-Mechanical System) and MEMS based transducers.

SYLLABUS OF PHYSICS DSE – 3

THEORY COMPONENT

Unit – I **(9 Hours)**

Introduction: Review of energy bands in materials, metal, semiconductor and insulator, doping in semiconductors, defects (point, line, Schottky and Frenkel), single crystal, polycrystalline and amorphous materials, Czochralski technique for silicon single crystal growth, silicon wafer slicing and polishing.

Vacuum Pumps: Primary pump (mechanical) and secondary pumps (diffusion, turbomolecular, cryopump, sputter-ion) – basic working principle, throughput and characteristics in reference to pump selection, vacuum gauges (Pirani and Penning)

Unit – II **(10 Hours)**

Thin film growth techniques and processes: Sputtering, evaporation (thermal, electron beam),

pulse laser deposition (PLD), chemical vapour deposition (CVD), epitaxial growth
Thermal oxidation process (dry and wet) passivation, metallization, diffusion

Unit – III **(7 Hours)**

VLSI Processing: Clean room classification, line width, photolithography: resolution and process, positive and negative shadow masks, photoresist, step coverage, developer, electron beam lithography, etching: wet etching, dry etching (RIE and DRIE), basic fabrication process of R, C, P-N Junction diode, BJT, JFET, MESFET, MOS, NMOS, PMOS and CMOS technology, wafer bonding, wafer cutting, wire bonding and packaging issues (qualitative idea)

Unit – IV **(4 Hours)**

Micro Electro-Mechanical System (MEMS): Introduction to MEMS, materials selection for MEMS devices, selection of etchants, surface and bulk micromachining, sacrificial subtractive processes, additive processes, cantilever, membranes, general idea of MEMS based pressure, force, and capacitance transducers

References:

Essential Readings:

1) Physics of Semiconductor Devices, S. M. Sze. Wiley-Interscience.
2) Fundamentals of Semiconductor Fabrication, S.M. Sze and G. S. May, John-Wiley and Sons, Inc.
3) Introduction to Semiconductor materials and Devices, M. S. Tyagi, John Wiley & Sons
4) VLSI Fabrication Principles (Si and GaAs), S. K. Gandhi, John Wiley & Sons, Inc.

Additional Readings:

1) Handbook of Thin Film Technology, L. I. Maissel and R. Glang

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)

At least six experiments to be performed from the following list

1) Deposition of thin films using dip coating and deposition of metal contacts using thermal Evaporation and study its IV characteristics
2) Deposition of thin films using spin coating and deposition of metal contacts using thermal evaporation and study its I-V characteristics
3) Fabrication of p-n Junction diode and study its I-V characteristics
4) Create vacuum in a small tube (preferably of different volumes) using a mechanical rotary pump and measure pressure using vacuum gauges.
5) Selective etching of different metallic thin films using suitable etchants of different concentrations.
6) Wet chemical etching of Si for MEMS applications using different concentration of etchant.
7) Calibrate semiconductor type temperature sensor (AD590, LM 35, LM 75)
8) To measure the resistivity of a semiconductor (Ge) crystal with temperature (up to 150C) by four-probe method.
9) To fabricate a ceramic and study its capacitance using LCR meter.
10) To fabricate a thin film capacitor using dielectric thin films and metal contacts and study its capacitance using LCR meter

References for laboratory work:

1) The science and Engineering of Microelectronics Fabrication, S. A. Champbell, 2010, Oxford University Press
2) Introduction to Semiconductor Devices, F. Kelvin Brennan, Cambridge University Press, 2010

DISCIPLINE SPECIFIC ELECTIVE COURSE – PHYSICS DSE 4: ELECTRONICS INSTRUMENTATION

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Electronics Instrumentation Physics DSE 4	4	2	0	2	Class XII pass with Physics and Mathematics as main subjects	Basics of digital electronics and analog electronics

LEARNING OBJECTIVES

This course aims to provide an exposure on basics of measurement and instrumentation and its various aspects and their usage through hands-on mode. It also aims to provide exposure of various measurement instruments such as power supply, oscilloscope, multivibrators, signal generators are also discussed. It also aims to develop an understanding of virtual instrumentation and transducers.

LEARNING OUTCOMES

At the end of this course, students will have understanding of,

- Basic principles of the measurement and errors in measurement, specifications of basic Measurement instruments and their significance with hands on mode.
- Principles of voltage measurement, advantages of electronic voltmeter over conventional multimeter in terms of sensitivity etc.
- Measurement of impedance using bridges, Power supply, Filters, IC regulators and Load and line regulation.
- Specifications of CRO and their significance, the use of CRO and DSO for the measurement of voltage (dc and ac), frequency and time period.
- Multivibrators, working circuits of astable and monostable multivibrators.
- Explanation and specifications of signal and pulse generators
- The Interfacing techniques, Arduino microcontroller and interfacing software,
- Understanding and usage of transducers

SYLLABUS OF PHYSICS DSE 4

THEORY COMPONENT

Unit – I **(12 Hours)**

Measurements: Shielding and grounding, electromagnetic interference

Basic Measurement Instruments: DC measurement-ammeter, voltmeter, ohm meter, AC measurement, digital voltmeter systems (integrating and non-integrating), digital multimeter, block diagram, principle of measurement of I, V, C, measurement of impedance - A.C. bridges, measurement of self-inductance (Anderson's bridge), measurement of capacitance (De-Sauty's bridge), measurement of frequency (Wien's bridge)

Unit - II **(6 Hours)**

Power supply: Using IC regulators (78XX and 79XX), line and load regulation, short circuit protection, idea of switched mode power supply (SMPS) and uninterrupted power supply

(UPS)
Oscilloscope: Block diagram, CRT, deflection (qualitative), screens for CRT, oscilloscope probes, measurement of voltage, frequency, and phase by oscilloscope, digital storage oscilloscope

Unit – III **(3 Hours)**
Multivibrators (IC 555): Block diagram, astable and monostable multivibrator circuits
Signal Generators: Function generator (black box approach)

Unit – IV **(9 Hours)**
Virtual Instrumentation: Introduction, interfacing techniques (RS 232, GPIB, USB), idea about Arduino microcontroller and interfacing software like lab View
Transducers: Classification of transducers, measurement of temperature (RTD, semiconductor IC sensors), light transducers (photo resistors and photovoltaic cells)

References:
Essential Readings:

1) Electronic Instrumentation and Measurement Techniques, W. D. Cooper and A. D. Helfrick, 2005, Prentice Hall
2) Measurement Systems: Application and Design, E. O. Doebelin, 5th edition, 2003, McGraw Hill Book
3) Electronic Devices and Circuits, D. A. Bell, 2015, Oxford University Press

Additional Readings:

1) Instrumentation Devices and Systems, S. Rangan, G. R. Sarma and V. S. Mani, 1998, Tata McGraw Hill

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)
- Sessions on the construction and use of specific measurement instruments and experimental apparatuses used in the lab, including necessary precautions.
- Sessions on the review of experimental data analysis, sources of error and their estimation in detail, writing of scientific laboratory reports including proper reporting of errors.
- Application to the specific experiments done in the lab."

At least eight experiments to be performed from the following list
1) Measurement of resistance by Wheatstone bridge and measurement of bridge sensitivity.
2) Measurement of Capacitance by De Sauty's bridge.
3) Design a regulated power supply of given rating (5 V or 9V).
4) To determine the Characteristics of Thermistors and RTD.
5) Measurement of temperature by Thermocouples.
6) To design an astable multivibrator of given specification using IC 555 Timer.
7) To design a monostable multivibrator of given specification using IC 555 Timer.
8) To design and study the sample and hold circuit.
9) To plot the frequency response of a microphone.
10) Glow an LED via USB port of PC.
11) Sense the input voltage at a pin of USB port and subsequently glow the LED connected with another pin of USB port.

References for laboratory work:

1) Measurement and Instrumentation Principles, A. S. Morris, 2008, Elsevier (Butterworth Heinmann)
2) Basic Electronics: A text lab manual, P. B. Zbar, A. P. Malvino and M. A. Miller, 1990, Mc-Graw Hill

DISCIPLINE SPECIFIC ELECTIVE COURSE – PHYSICS DSE 5: DIGITAL SIGNAL PROCESSING

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Digital Signal Processing Physics DSE 5	**4**	**2**	**0**	**2**	Class XII pass with Physics and Mathematics as main subjects	Basics of digital electronics and analog electronics

LEARNING OBJECTIVES

This paper describes the discrete-time signals and systems, Fourier transform representation of aperiodic discrete time signals. This paper also highlights the concept of filters and realization of digital filters. At the end of the syllabus, students will develop an understanding of discrete and fast Fourier transform.

LEARNING OUTCOMES

At the end of this course, students will be able to develop following learning outcomes.

- Students will learn basic discrete-time signal and system types, convolution sum, impulse and frequency response concepts for linear time-invariant (LTI) systems.
- The student will be in position to understand use of different transforms and analyse the discrete time signals and systems. They will learn to analyse a digital system using z-transforms and discrete time Fourier transforms, region of convergence concepts, their properties and perform simple transform calculations.
- The student will realize the use of LTI filters for filtering different real world signals. The concept of transfer Function and difference-equation system will be introduced. Also, they will learn to solve difference equations.
- Students will develop an ability to analyse DSP systems like linear-phase, FIR, IIR, All-pass, averaging and notch Filter etc.
- Students will be able to understand the discrete Fourier transform (DFT) and realize its implementation using FFT techniques.
- Students will be able to learn the realization of digital filters, their structures, along with their advantages and disadvantages. They will be able to design and understand different types of digital filters such as finite and infinite impulse response filters for various applications.

SYLLABUS OF PHYSICS DSE 5

THEORY COMPONENT

Unit – I **(7 Hours)**

Discrete-Time Signals and Systems: Classification of signals, transformations of the independent variable, periodic and aperiodic signals, energy and power signals, even and odd signals, discrete time systems, system properties, impulse response, convolution sum, graphical and analytical method, properties of convolution (general idea), sum property system response to periodic inputs, relationship between LTI system properties and the impulse response

Unit – II **(9 Hours)**

Discrete time Fourier transform: Fourier transform representation of aperiodic discrete time signals, periodicity of DTFT, properties; linearity; time shifting; frequency shifting; differencing in Time Domain; Differentiation in Frequency Domain; Convolution Property. The z-Transform: Bilateral (Two-Sided) z-Transform, Inverse z- Transform, Relationship Between z-Transform and Discrete-Time Fourier Transform, z-plane, Region-of-Convergence; Differentiation in the z-Domain; Power Series Expansion Method (General Idea). Transfer Function and Difference-Equation System.

Unit – III **(10 Hours)**

Filter Concepts: Phase Delay and Group delay, Zero-Phase Filter, Linear-Phase Filter, Simple FIR Digital Filters.Only Qualitative treatment

Discrete Fourier Transform: Frequency Domain Sampling (Sampling of DTFT), The Discrete Fourier Transform (DFT) and its Inverse, DFT as a Linear transformation, Properties; Periodicity; Linearity; Circular Time Shifting; Circular Frequency Shifting; Circular Time Reversal; Multiplication Property; Parseval's Relation (General Idea), Linear Convolution Using the DFT (Linear Convolution Using Circular Convolution).

Unit – IV **(4 Hours)**

Realization of Digital Filters: FIR Filter structures; Direct-Form; Cascade-Form

Finite Impulse Response Digital Filter: Advantages and Disadvantages of Digital Filters, Types of Digital Filters: FIR Filters

References:

Essential Readings:

1) Digital Signal Processing, T. K. Rawat, 2015, Oxford University Press, India
2) Digital Signal Processing, S. K. Mitra, McGraw Hill, India.
3) Principles of Signal Processing and Linear Systems, B. P. Lathi, 1st edition, 2009, Oxford University Press.
4) Fundamentals of signals and systems, P.D. Cha and J.I. Molinder, 2007, Cambridge University Press
5) Digital Signal Processing Principles Algorithm & Applications, J. G. Proakis and D. G. Manolakis, 4th edition, 2007, Prentice Hall.

Additional Readings:

1) Digital Signal Processing, A. Kumar, 2nd edition, 2016, PHI learning Private Limited.
2) Digital Signal Processing, P. S. R. Diniz, E. A. B. da Silva and S. L. Netto, 2nd edition, 2017, Cambridge University Press

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)

- Introduction to numerical computation software Scilab/Matlab/Python be introduced in the lab.
- Sessions on the review of experimental data analysis, sources of error and their estimation in detail, writing of scientific laboratory reports including proper reporting of errors.
- Application to the specific experiments done in the lab"

At least six experiments to be performed from the following using Scilab/ Matlab/ Python

1) Write a program to generate and plot the following sequences: (a) Unit sample sequence $\delta(n)$, (b) unit step sequence *u(n)*, (c) ramp sequence *r(n)*, (d) real valued exponential sequence $x(n) = (0.8)^n u(n)$ for $0 \leq n \leq 50$.
2) Write a program to compute the convolution sum of a rectangle signal (or gate function) with itself for N = 5

$$x(n) = rect\left(\frac{n}{2N}\right) = \prod \quad \left(\frac{n}{2N}\right) = \{1 \quad -N \leq n \leq N \; 0 \qquad otherwise$$

3) An LTI system is specified by the difference equation *y(n)=0.8y(n-1)+x(n)*
   (a)Determine $H(e^{iw})$
   (b) Calculate and plot the steady state response *y(n)* to $x(n) = cos\ cos\ (0.5\pi n)\ u(n)$
4) Given a casual system *y(n)=0.9y(n-1)+x(n)*
   (a) Find H(z) and sketch its pole-zero plot
   (b) Plot the frequency response $\left|H(e^{jw})\right|$ and $\angle H(e^{jw})$
5) Design a digital filter to eliminate the lower frequency sinusoid of *x(t)=sin7t+sin200t*. The sampling frequency is 500 Hz. Plot its pole zero diagram, magnitude response, input and output of the filter.
6) Let *x(n)* be a 4-point sequence:
   $x(n) = \{1,1,1,1\} = \{1 \;\; 0 \leq n \leq 3 \; 0 \;\; otherwise$
   Compute the DTFT $X(e^{jw})$ and plot its magnitude
   (a) Compute and plot the 4 point DFT of *x(n)*
   (b) Compute and plot the 8 point DFT of *x(n)* (by appending 4 zeros)
   (c) Compute and plot the 16 point DFT of *x(n)* (by appending 12 zeros)

7) Let *x(n)* and *h(n)* be the two 4-point sequences,
   x(n)={1,2,2,1} *h(n)={1,-1,-1,1}*
   Write a program to compute their linear convolution using circular convolution.

8) Using a rectangular window, design a FIR low-pass filter with a pass-band gain of unity, cut off frequency of 1000 Hz and working at a sampling frequency of 5 KHz. Take the length of the impulse response as 17.
9) Design an FIR filter to meet the following specifications:
   Passband edge F_p=2 KHz
   Stopband edge F_s=5 KHz
   Passband attenuation A_p=2 dB
   Stopband attenuation A_s=42 dB
   Sampling frequency F_{sf}=20 KHz
10) The frequency response of a linear phase digital differentiator is given by

$$H_d(e^{jw}) = jwe^{-j\tau w} \; |w| \leq \pi$$

Using a Hamming window of length M = 21, design a digital FIR differentiator. Plot the amplitude response

References for laboratory work:

1) A Guide to MATLAB, B. R. Hunt, R. L. Lipsman and J. M. Rosenberg, 3rd edition, 2014, Cambridge University Press.
2) Fundamentals of Digital Signal processing using MATLAB, R. J. Schilling and S. L. Harris, 2005, Cengage Learning.
3) Getting started with MATLAB, R. Pratap, 2010, Oxford University Press.

ANNEXURE-2

INDEX
DEPARTMENT OF PHYSICS AND ASTROPHYSICS
Semester-VI

B. SC. (HONOURS) PHYSICS

DISCIPLINE SPECIFIC CORE COURSE – DSC -16: STATISTICAL MECHANICS

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Statistical Mechanics DSC – 16	**4**	**3**	**1**	**0**	Class XII pass with Physics and Mathematics as main subjects	Thermal physics and quantum mechanics papers of this course or their equivalents. Basics of probability and statistics

LEARNING OBJECTIVES

Statistical Mechanics deals with the derivation of the macroscopic parameters (internal energy, pressure, specific heat etc.) of a physical system consisting of large number of particles (solid, liquid or gas) from knowledge of the underlying microscopic behaviour of atoms and molecules that comprises it. The main objective of this course is to introduce the techniques of statistical mechanics which has applications in various fields including astrophysics, semiconductor physics, plasma physics, biophysics etc. and in many other directions. All the problems of different units should be done in the tutorial classes.

LEARNING OUTCOMES

By the end of the course, students will be able to,

- Understand the concepts of phase space, macrostate, microstate, thermodynamic probability and partition function.
- Understand the use of thermodynamic probability and partition function for calculation of thermodynamic properties for physical systems (ideal gas, finite level system).
- Understand the difference between classical and quantum statistics and their applicability.
- Understand the properties and laws associated with thermal radiation.
- Apply the Fermi- Dirac distribution to model problems such as electrons in solids and white dwarf stars
- Apply the Bose-Einstein distribution to model problems such as blackbody radiation and liquid Helium.

SYLLABUS OF DSC – 16

THEORY COMPONENT

Unit - I **(22 Hours)**

Classical Statistics: Phase space, macrostates and microstates, entropy and thermodynamic probability, concept of ensemble - Introduction to three types, Maxwell-Boltzmann distribution law, partition function, thermodynamic functions of an ideal gas, Gibbs paradox, Sackur-Tetrode equation. Saha's ionization formula, Law of equipartition of energy (with proof) – Applications to specific heat of gases (monoatomic and diatomic), solids and its

limitations, thermodynamic functions of a finite level system, negative temperature

Unit – II **(5 Hours)**

Radiation: Blackbody radiation and its spectral distribution. Kirchhoff law (No Proof), Planck's quantum postulates, Planck's law of blackbody radiation, deduction of Wien's distribution law, Rayleigh-Jeans law, Stefan-Boltzmann law and Wien's displacement law from Planck's law, ultraviolet catastrophe

Unit – III **(9 Hours)**

Bose-Einstein Statistics: Bose-Einstein distribution law, thermodynamic functions of a strongly degenerate Bose gas (non- relativistic), Bose-Einstein condensation, properties of liquid He (qualitative description), Radiation as a photon gas and thermodynamic functions of photon gas. Bose derivation of Planck's law

Unit – IV **(9 Hours)**

Fermi-Dirac Statistics: Fermi-Dirac distribution law, thermodynamic functions of a completely and strongly degenerate fermions (non-relativistic), specific heat of metals, relativistic Fermi gas, white dwarf stars, Chandrasekhar mass limit.

References:

Essential Readings:

1) Statistical Mechanics, R. K. Pathria and P. D. Beale, Academic Press
2) Introductory Statistical Mechanics, R. Bowley and M. Sanchez, Oxford Univ. Press
3) Statistical Physics, F. Mandl, Wiley
4) A treatise on Heat, M. N. Saha and B. N. Srivastava, Indian Press
5) Problems and Solutions on Thermodynamics and Statistical Mechanics, Lim Yung-Kou, Sarat Book House
6) An Introduction to Thermal Physics, D. Schroeder, Pearson
7) Statistical Physics, Berkeley Physics Course, F. Reif, McGraw-Hill

Additional Readings:

1) An Introduction to Statistical Physics, W. G. V. Rosser, Wiley
2) Thermal Physics, Kittel and Kroemer, CBS
3) Concepts in Thermal Physics, Blundell and Blundell, Oxford University Press
4) Statistical and Thermal Physics, Loknathan and Gambhir, PHI
5) Thermodynamics, Kinetic theory and Statistical thermodynamics, Sears and Salinger, PHI
6) Statistical Mechanics, G. Sanon, Alpha Science International Ltd.

DISCIPLINE SPECIFIC CORE COURSE – DSC - 17: ATOMIC, MOLECULAR AND NUCLEAR PHYSICS

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Atomic, Molecular and Nuclear Physics DSC – 17	**4**	**3**	**1**	**0**	Class XII pass with Physics and Mathematics as main subjects	Light and Matter, Modern Physics and Quantum Mechanics-I of this course or their equivalent

LEARNING OBJECTIVES

This course introduces the basic concepts of atomic, molecular and nuclear physics to an undergraduate student. Advanced mathematics is avoided and the results of quantum mechanics are attempts to explain, or even to predict, the experimental observations of spectroscopy. The student learns to visualize a nucleus, an atom or molecule as a physical entity rather than a series of mathematical equations.

LEARNING OUTCOMES

On successful completion of the module students should be able to elucidate the following main features.

- Stern-Gerlach experiment, electron spin, spin magnetic moments, space quantization and Zeeman effect, spectral notations for atomic and molecular states and corresponding term symbols, understanding of atomic spectra and molecular spectra
- Basic principle of Raman spectroscopy and Franck Condon principle.
- The radioactive processes, stability of the nuclei and the nuclear models
- The full scientific potential lies on how we are able to interpret the fundamental astrophysical and nuclear data. The acquired knowledge can be applied in the areas of astrophysics, nuclear, medical, geology and other interdisciplinary fields of Physics, Chemistry and Biology. It will enhance the special skills required for these fields

SYLLABUS OF DSC - 17

THEORY COMPONENT

Unit – I - Atomic Physics **(15 Hours)**

One-electron atoms: Degeneracy of energy levels and selection rules, modes of relaxation of an excited atomic state.

Fine structure of Hydrogenic atoms: Shifting of energy levels, Splitting of spectral lines, relativistic correction to kinetic energy, spin-orbit term, Darwin term, fine structure spectral lines, Lamb shift (qualitative idea).

Atoms in external magnetic fields: Larmor's theorem, Stern-Gerlach experiment, normal Zeeman Effect, Paschen Back effect, anomalous Zeeman effect, Lande g-factor.

Unit - II – Molecular Physics **(15 Hours)**

Molecular structure: The Born-Oppenheimer approximation, Concept of bonding and anti-bonding molecular orbitals, Concept of Potential energy curve for a diatomic molecule, Morse potential, Classification of molecular states of diatomic molecule, The Franck-Condon principle

Molecular spectra of diatomic molecule: Rotational Spectra (rigid and non-rigid rotor), Vibrational Spectra (harmonic and anharmonic), Vibration-Rotation Spectrum of a diatomic molecule, Isotope effect, Intensity of spectral lines

Raman Effect: Classical theory (with derivation) of Raman effect, pure rotational Raman Lines, Stoke's and Anti-Stoke's Lines, comparison with Rayleigh scattering.

Unit – III – Nuclear Physics **(15 Hours)**

Nucleus stability: *Alpha decay:* Energetics of alpha-particle decay, barrier penetration model, Geiger-Nuttall rule, α- decay spectroscopy, decay Chains. *Beta Decay:* Q-values for beta decay, β-spectrum, positron emission, electron capture, neutrino hypothesis, Qualitative idea about Fermi theory, Fermi and Gamow-Teller decays, the role of angular momentum and parity, electron capture, and selection rules. *Gamma decay:* Gamma-ray production, and multipolarities, Weisskopf estimates, the role of angular momentum and parity, internal conversion.

Nuclear models: Evidence of shell structure in nuclei, Magic numbers, nuclear mean field, single particle shell model, spin-orbit splitting, shell model configurations for nuclear ground states, and low-lying excited levels

References:

Essential Readings:

1) Physics of Atoms and Molecules, B. H. Bransden and C. J. Jochain, 2nd edition, Pearson
2) Fundamentals of Molecular Spectroscopy, C. N. Banwell and E. M. McCash, 1994, Tata McGraw – Hill
3) Atomic physics, J. B. Rajam and foreword by Louis De Broglie, 2010, S. Chand & Co.
4) Atoms, Molecules and Photons, W. Demtroder, 2nd edition, 2010, Springer
5) Introduction to Spectroscopy, D. L. Pavia, G. M. Lampman, G. A. Kriz and J. R. Vyvyan, 5th edition, 2014, Brookes/Cole
6) Concept of Nuclear Physics, B. L. Cohen, 2003, Tata McGraw – Hill
7) Nuclear Physics, S. N. Ghoshal, 1st edition, 2019, S. Chand Publication
8) Introducing Nuclear Physics, K. S. Krane, 2008, Wiley India

Additional Readings:

1) Basic Atomic and Molecular Spectroscopy, J. M. Hollas, Royal Society of Chemistry
2) Molecular Spectra and Molecular Structure, G. Herzberg
3) Basic Ideas and Concepts in Nuclear Physics: An Introductory Approach (Series in Fundamental and Applied Nuclear Physics), K. Heyde (Institute of Physics Publishing 3rd edition
4) Nuclear Physics: principles and applications, John Lilley, 2006, Wiley
5) Schaum's Outline of Modern Physics, 1999, McGraw-Hill Education
6) Introduction to elementary particles, D. J. Griffiths, 2008, Wiley
7) Atomic and molecular Physics, R. Kumar, 2013, Campus Book Int.
8) The Fundamentals of Atomic and Molecular Physics (Undergraduate Lecture Notes in Physics), 2013, Springer

DISCIPLINE SPECIFIC CORE COURSE – DSC - 18: STATISTICAL ANALYSIS IN PHYSICS

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Statistical Analysis in Physics DSC – 18	**4**	**2**	**0**	**2**	Class XII pass with Physics and Mathematics as main subjects	Basic understanding of statistics and probability

LEARNING OBJECTIVES

This course provides an elementary introduction to the principles of Bayesian statistics and working knowledge of some of the data analysis techniques. The objective is to equip the students with certain techniques so that they may successfully apply these to the real world problems, in their research areas as well as in industry.

LEARNING OUTCOMES

After completing this course, students will be able to,

- Understand the fundamental concepts in statistical data analysis.
- Define in a Bayesian context, the likelihood, prior and posterior distributions and their role in Bayesian inference and hypothesis testing.
- Estimate the parameters of a distribution from sample.
- Perform hypothesis testing and validate a model.
- Apply multi-linear and logistic models to real life situation.

In the practical component, students will be able to

- Learn basic data analysis techniques such as linear and non-linear fittings
- Apply hypothesis testing techniques in physics
- Perform multi-linear and logistic regression analysis for a given data
- Understand the concept of gradient descent and use it for the regression analysis
- Understand the stochastic processes, Markov chains and transition probability matrix.

SYLLABUS OF DSC - 18

THEORY COMPONENT

Unit – I **(8 Hours)**

Random variables, Discrete and Continuous Probability Distributions. Bivariate and multivariate random variables, Joint Distribution Functions (with examples from Binomial, Poisson and Normal). Mean, variance and moments of a random vector, covariance and correlation matrix, eigendecomposition of the covariance matrix (bivariate problem). Cumulative Distribution Function and Quantiles. Point Estimation, Interval estimation, Central Limit Theorem (statement, consequences and limitations).

Unit – II **(11 Hours)**

Bayesian Statistics: Conditional probability and Bayes Theorem, Prior and Posterior

probability distributions, examples of Bayes theorem in everyday life. Bayesian parameter estimation. Normal, Poisson and Binomial distributions, their conjugate priors and properties. Bayes factors and model selection.

Unit – III **(11 Hours)**

Bayesian Regression: Introduction to Bayesian Linear Regression. Bayesian logistic regression and its applications. Bayesian parameter estimation for regression models. Posterior distribution of model parameters and the posterior predictive distributions.

References:

Essential Readings:

1) Schaum's Outline Series of Probability and Statistics, M. R. Spiegel, J. J. Schiler and R. A. Srinivasan, 2012, McGraw Hill Education
2) Schaum's Outline Series of Theory and Problems of Probability, Random Variables, and Random Processes, H. Hsu, 2019, McGraw Hill Education
3) Bayesian Logical Data Analysis for the Physical Sciences: A Comparative Approach with Mathematica Support, P. Gregory, 2010, Cambridge University Press
4) Linear Regression: An Introduction to Statistical Models, P. Martin, 2021, Sage Publications Ltd.
5) Data Analysis: A Bayesian Tutorial, D. S. Sivia and J. Skilling, 2006, Oxford University Press
6) Data Reduction and Error analysis for the Physical Sciences, P. R. Bevington and D. K. Robinson, 2002, McGraw-Hill Education

Additional Readings:

1) A Guide to the Use of Statistical Methods in the Physical Sciences, R. J. Barlow, 1993, Wiley Publication
2) An Introduction to Error Analysis, J. R. Taylor, 1996, Univ. Sci. Books
3) Applied Multivariate Data Analysis, Volume I: Regression and Experimental Design, J. D. Jobson, 2012, Springer-Verlag
4) Statistical Rethinking A Bayesian Course with Examples in R and STAN, Richard McElreath, 2020, CRC Press
5) Introduction to Bayesian Statistics, W. Bolstad, 2007, John Wiley

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)

The objective of this lab is to familiarise the students with the techniques of data analysis. The instructors are required to discuss the concepts and the pseudo-codes of the recommended programs in the practical sessions before their implementation. The implementation can be in any programming language. Inbuilt libraries can be used wherever applicable. **All units are mandatory.**

Unit 1 (12 Hours)

Probability Distributions

1) Generate sequences of N random numbers M (at least 10000) number of times from different distributions (e.g. Binomial, Poisson, Normal). Use the arithmetic mean of each random vector (of size N) and plot the distribution of the arithmetic means. Verify the Central Limit Theorem (CLT) for each distribution. Show that CLT is violated for the

Cauchy-Lorentz distribution.

2) Given a data for two independent variables (x_i, y_i). Write a code to compute the joint probability in a given sample space. Verify the same for the data generated by random number generator based on a given probability distribution of pair of independent variables (both discrete and continuous).

Unit 2 (16 Hours)

1) Hypothesis testing
   Make a random number generator to simulate the tossing of a coin *n* times with the probability for the head being *q*. Write a code for a Binomial test with the Null hypothesis H_0 ($q = 0.5$) against the alternative hypothesis H_1 ($q \neq 0.5$).

2) Bayesian Inference
   a) In an experiment of flipping a coin *N* times, *M* heads showed up (fraction of heads $f = M/N$). Write a code to determine the posterior probability, given the following prior for the probability of *f*:
      i. Beta Distribution $B(a, b)$ with given values of *a* and *b* .
      ii. Gaussian Distribution with a given mean and variance.
   b) Using the Likelihood of Binomial distribution, determine the value of *f* (fraction of heads) that maximizes the probability of the data.
   c) Plot the Likelihood (normalised), Prior and Posterior Distributions.

Unit 3 (20 hours)

Regression Analysis and Gradient Descent:

1) Given a dataset (*Xi, Yi*). Write a code to obtain the parameters of linear regression equation using the method of least squares with both constant and variable errors in the dependent variable (*Y*). The data obtained in a physics lab may be used for this purpose. Also obtain the correlation coefficient and the 90% confidence interval for the regression line. Make a scatter plot along with error bars. Also, overlay the regression line and show the confidence interval.

2) Write a code to minimize the cost function (mean squared error) in the linear regression using gradient descent (an iterative optimization algorithm, which finds the minimum of a differentiable function) with at least two independent variables. Determine the correlation matrix for the regression parameters.

3) Write a code to map a random variable *X* that can take a wide range of values to another variable *Y* with values lying in limited interval say [0, 1] using a sigmoid function (logistic function). Considering the Log Loss as the cost function of logistic regression, compute its minimum with gradient descent method and estimate the parameters.

Unit 4 (12 Hours)

Markov Chain (Any one)

1) Write a code to generate a Markov chain by defining (a finite number of) *M* (say 2) states. Encode states using a number and assign their probabilities for changing from state *i* to state *j*. Compute the transition matrix for *1, 2,..., N* steps. Following the rule, write a code for Markovian Brownian motion of a particle.

2) Given that a particle may exist in one of the given energy states (E_i, $i = 1, \ldots 4$) and the

transition probability matrix T, so that T_{ij} gives the probability for the particle to make transition from energy state E_i to state E_j. Determine the long-term probability of a particle to be in state in the state E_f if the particle was initially in state E_i.

References for laboratory work:

1) Data Science from Scratch – First Principles with Python, J. Grus, O'Reilly, 2019, Media Inc.
2) Bayes' Rule with Python: A tutorial introduction to Bayesian Analysis, J. V. Stone, 2016, Sebtel Press
3) Practical Bayesian Inference, B. Jones, 2017, Cambridge University Press
4) Modeling and Simulation in Scilab/Scicos with Scicos Lab 4.4, S. L. Campbell, Jean-P. Chancelier and R. Nikoukhah, Springer.
5) Scilab Textbook Companion for Probability And Statistics For Engineers And Scientists, S. M. Ross, 2005, Elsevier
6) Numerical Recipes: The art of scientific computing, W. H. Press, S. A. Teukolsky and W. Vetterling, 2007, Cambridge University Press

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 9: ADVANCED MATHEMATICAL PHYSICS II

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Advanced Mathematical Physics II DSE – 9	**4**	**3**	**1**	**0**	Class XII pass with Physics and Mathematics as main subjects	DSC Mathematical Physics-I and Mathematical Physics-II of this course or their equivalent

LEARNING OBJECTIVES

The emphasis of the course is to acquire advanced mathematical inputs while solving problems of interest to physicists. The course aims to introduce the students to the principles of tensor analysis and equip them to use the concept in modelling of continuous media, electrodynamics, elasticity theory and the general theory of relativity. The mathematical skills developed during course will prepare them not only for doing fundamental and applied research but also for a wide variety of careers.

LEARNING OUTCOMES

After completing this course, student will,

- Have a knowledge and understanding of tensor analysis and tensor calculus
- Be able to do computation with tensors, both in coordinates and in coordinate-free form.
- Understand the transformation properties of covariant, contravariant and mixed tensors under general coordinate transformation.
- Be able to apply the concepts of tensors in anisotropic media with examples of moment of inertia tensor, elasticity tensor and polarizability tensor.
- Understand physical examples of tensors such as Moment of Inertia and Elasticity of asymmetrical physical systems.
- Be able to write down the Lorentz Transformation in four vector notation.
- Understand inner product and outer product of general tensors.
- Understand the concept of covariant derivatives.

SYLLABUS OF DSE - 9

THEORY COMPONENT

Unit - I **(12 Hours)**

Cartesian Tensors: Transformation of co-ordinates under rotation of axes. Einstein's Summation Convention. Relation between direction cosines. Transformation Law for a tensor of rank *n*. Sum, inner product and outer product of tensors, contraction of tensors, Quotient Law of tensors, symmetric and anti-symmetric tensors. Invariant tensors (Kronecker and Alternating Tensor). Association of anti-symmetric tensor of rank two with vectors. Vector algebra and calculus in tensor notation. Differentiation, gradient, divergence and curl of Tensor Fields. Vector Identities in tensor notation.

Unit - II **(12 hours)**

Applications of Cartesian Tensors: Equation of a Line, Angle between Lines, Projection of a Line on another Line, Condition for Two Lines to be Coplanar and Length and Foot of the Perpendicular from a Point on a Line. Rotation Tensor and its properties.

Moment of Inertia Tensor, Stress and Strain Tensors, Elasticity Tensor, Generalized Hooke's Law, Electric Polarizability Tensor.

Unit - III **(9 hours)**

General Tensors: Transformation of co-ordinates and contravariant and covariant vectors. Transformation law for contravariant, covariant and mixed tensors. Kronecker Delta and permutation tensors. Algebra of general tensors. Quotient Law general tensors. Symmetric and anti-symmetric tensors. Metric Tensor. Reciprocal Tensors. Associated Tensors.

Unit - IV **(12 hours)**

Christoffel Symbols of first and second kind and their transformation laws. Covariant derivative, gradient, divergence and curl of tensor fields.

Minkowski Space, Four Vectors (four-displacement, four-velocity, four-momentum, four-vector potential, four- current density,). Tensorial form of Lorentz Transformation.

References:

Essential Readings:

1) Vector Analysis and Cartesian Tensors, 3rd edition, D. E. Bourne, P. C. Kendall, 1992
2) Cartesian Tensors, H. Jeffreys, 1931, Cambridge University Press.
3) Mathematical Methods for Physicists, H. J. Weber and G. B. Arfken, 2010, Elsevier.
4) A Brief on Tensor Analysis, J. G. Simmonds, 1997, Springer.
5) Schaum's outlines series on Vector Analysis, M. Spiegel, 2nd edition, 2017.
6) Schaum's Outline Series on Tensor Calculus, D. Kay, Revised 1st edition, 2011.
7) An Introduction to Tensor Calculus and Relativity, D. F. Lawden, 2013, Literary Licensing
8) Matrices and tensors in physics by A. W. Joshi, 1995, New Age International Publications.

Additional Readings:

1) A Student's Guide to Vectors and Tensors, D. A. Fleisch, 2011, Cambridge Univ. Press.
2) The Feynman Lectures on Physics, Volume II, Feynman, Leighton and Sands, 2008, Narosa Publishing House.
3) Classical Electrodynamics, J. D. Jackson, 3rd edition, 2009, Wiley Publication.
4) A Primer in Tensor Analysis and Relativity, I. L. Shapiro, 1st edition, 2019, Springer.
5) Gravity-An introduction to Einstein's General Relativity, J. B. Hartle, 2009, Pearson Education.
6) A first course in general relativity, B. F. Schutz, 2004, Cambridge University Press.

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 10: MICROPROCESSOR

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Microprocessor DSE – 10	**4**	**2**	**0**	**2**	Class XII pass with Physics and Mathematics as main subjects	Basics of Digital Electronics

LEARNING OBJECTIVES

Students will be able to outline the types and the functions of storage, learn the characteristics of RAM and ROM and their architecture, describe the architecture of 8085 microprocessors and develop programs for microprocessor 8085

LEARNING OUTCOMES

At the end of the course, students will develop ability to,

- Define storage state the types and functions of storage
- Describe the characteristics of RAM and ROM and their architecture.
- Describe memory organization, addressing, interfacing and mapping
- Describe the architectures of 8085 microprocessors
- Draw timing diagram
- Write programs using 8085

SYLLABUS OF DSE - 10

THEORY COMPONENT

Unit – I - Introduction to 8085 Microprocessor Architecture (16 Hours)

Introduction to microprocessor: Basic computer system organization, introduction, classification and applications of microprocessors, types of memory-primary memory types (SRAM, DRAM, PROM, EPROM, EEPROM), secondary memory (SSD, Optical Drive) memory organization and addressing

Microprocessor 8085 Architecture: Features, architecture-block diagram, general purpose registers, register pairs, flags, stack pointer, program counter, types of buses, multiplexed address and data bus, generation of control signals, pin description of microprocessor 8085, basic memory interfacing concepts, Memory mapped I/O and I/O mapped I/O.

Unit – II - 8085 Programming (14 Hours)

Operation code, operand and mnemonics, instruction set of 8085, instruction classification, addressing modes, instruction format, data transfer instructions, arithmetic instructions, increment & decrement instructions, logical instructions, branch instructions and machine control instructions, subroutine, call and return instructions, timing diagrams-instruction cycle, machine cycle, T- states, basic idea of interrupts, assembly language programming examples (addition with and without carry, subtraction with and without borrow, double addition, multiplication by repeated addition, division by repeated subtraction, block data

transfer and checking of parity of a binary number)

References:
Essential Readings:
1) Microprocessor Architecture Programming and applications with 8085, R. S. Gaonkar, 2002, Prentice Hall
2) Microelectronic Circuits, S. Sedra
3) Fundamentals of Microprocessor and Microcomputer, B. Ram, Dhanpat Rai Publications
4) The Intel Microprocessors - Architecture, Programming and Interfacing, B. Brey, 2003, Pearson Education

Additional Readings:
1) Microprocessors and Microcontrollers, M. Ali Mazidi, 2006, Pearson

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)

At least six experiments to be performed from the following list.

8085 Assembly language programs
1) Add two 8-bit numbers using Direct and Indirect Addressing Mode
2) Subtract two 8-bit numbers using Direct and Indirect Addressing Mode
3) Multiply two 8-bit numbers with and without subroutine
4) Divide two-8 bit numbers with and without subroutine
5) Add a list of 8-bit numbers
6) Transfer a Block of Data
7) Add two 16 bit numbers with DAD and without DAD
8) Convert byte to Nibble
9) Convert nibble to Byte
10) Check the parity of a given number

References for laboratory work:
1) Microprocessor Architecture Programming and applications with 8085, R. S. Gaonkar, 2002, Prentice Hall
2) Microelectronic Circuits, S. Sedra
3) Fundamentals of Microprocessor and Microcomputer, B. Ram, Dhanpat Rai Publications
4) Microprocessors and Microcontrollers, M. Ali Mazidi, 2006, Pearson
5) The Intel Microprocessors - Architecture, Programming and Interfacing, B. Brey, 2003, Pearson Education

DISCIPLINE SPECIFIC ELECTIVE COURSE – DSE 11: RESEARCH METHODOLOGY

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Research Methodology DSE – 11	**4**	**3**	**0**	**1**	Class XII pass with Physics and Mathematics as main subjects	Basic ICT related skills

LEARNING OBJECTIVES

This course has been designed to explore the basic dimensions of research and to impart quantitative and qualitative knowledge for conducting meaningful research. Starting from the philosophy of research, through awareness about the publication ethics and misconducts, this course covers all the methodological and conceptual issues required for a successful conduct of research. It gives an overview of research techniques, data management and analysis, and commonly used statistical methods in physical sciences.

LEARNING OUTCOMES

After successful completion of this course, students will be trained in the following.

- Skills to review literature and frame research problem
- Comprehend the relevance of the tools for data collection and analysis
- Writing a scientific report/research proposal
- Software tools for research in physical sciences
- Research integrity and publication ethics
- Importance of intellectual property rights
- Role of funding agencies in research

SYLLABUS OF DSE - 11

THEORY COMPONENT

Unit - I - Introduction to research methodology **(6 Hours)**

Brief history of scientific method and research, role and objectives of research, basic tenets of qualitative research; research problem and review of literature: identifying a research problem (philosophy and meaning of research, identification and definition of research problem, formulation of research problem, sources of prejudice and bias); literature survey (open-source and paid tools for keeping track of the literature)

Unit - II - Data collection, analysis and interpretation **(15 Hours)**

Methods of data collection: survey, interview, observation, experimentation and case study;
Descriptive statistics: Measures of central tendency (mean, median, mode) and dispersion (range, standard deviation);
Inferential statistics: Hypothesis testing, Z test, T test; regression analysis (basic concepts of multiple linear regression analysis and theory of attributes);
Curve fitting using linear and nonlinear regression (parameter space, gradient search method

and Marquardt method);
Role of simulation, calibration methods, error analysis, and background handling in experimental design

Unit - III – Journals, Database and Research Metrics (7 Hours)
Journals: Free, open source and paid journals, concept of peer reviewed journals, predatory and fake journals
Databases: Indexing databases; citation databases (Web of science, Scopus); experimental physics databases (astrophysics (ADS, NED, SIMBAD, VizieR), biophysics (PubMed), particle physics (INSPIRE, CDS), condensed matter physics (X-ray database))
Research Metrics: Journal impact factor, SNIP, SJR, IPP, cite score; metrics (h-index, g index, i10 index, altmetrics), variations in research metrics across various disciplines, other limitations of the research metrics and impact factors

Unit - IV – Scientific Conduct and Publication Ethics (8 Hours)
Current understanding of ethics; intellectual honesty and research integrity; communicating errors (erratum, correction and withdrawal); records and logs (maintaining records of samples, raw data, experimental protocols, observation logs, analysis calculations, and codes); scientific publication misconducts: plagiarism (concept, importance, methods and ways to detect and avoid plagiarism) and redundant publications (salami slicing, duplicate and overlapping publications, selective reporting and misrepresentation of data); environmental and other clearances (waste management, disposal of hazardous waste).
COPE guidelines on best practices in publication ethics

Unit V – Scientific Writing and Software Tools (5 Hours)
Writing a research paper and report: introduction, motivation, scientific problem, its methodology, any experimental set up, data analysis, discussion of results, conclusions
Referencing formats (APA, MLA) and bibliography management
Graphical software (open source, magic plot, gnu plot, origin); presentation tools (beamer)

Unit VI - Intellectual Property Right and Research Funding (4 Hours)
Basic concepts and types of intellectual property (patent, copyright and trademark)
Role of funding agencies in research, overview of various funding agencies (DST-SERB, UGC, CSIR, BRNS, DRDO), national and international research project grants and fellowships

References:
Essential Readings:

1) Management Research Methodology, K. N. Krishnaswamy, A. I. Sivakumar, M. Mathirajan, 2006, Pearson Education, New Delhi.
2) Research Methodology, Methods and Techniques, C. R. Kothari, 2nd edition, 2008, New Age International Publication.
3) Research Methodology, A step by step guide for beginners, R. Kumar, 6th edition, 2009, Pearson Education
4) Data reduction and error analysis for the physical sciences, P. R. Bevington and D. K. Robinson, 3rd edition, McGraw-Hill
5) Intellectual property: Patents, Trademarks, Copyrights, Trade Secrets, C. J. Holland, 2007, Entrepreneur Press

Additional Readings:

1) Research Methods, R. Ahuja, 2001, Rawat Publications, New Delhi.
2) Research design: Qualitative, quantitative, and mixed methods approaches, J. W. Creswell, and J. D. Creswell, 2017, Sage Publications.
3) Intellectual Property: Patents, Trademarks and Copyright in a Nutshell, A. R. Miller and M. H. Davis, 2000, West Group Publishers

PRACTICAL COMPONENT

(15 Weeks with 2 hours of laboratory session per week)

Students should perform at least six practicals from the following list, such that all the units mentioned below are covered.

Unit 1:

1) Identify a research problem, write its brief summary and make a corresponding flow chart
2) Identify a survey-based research problem in physics and create a questionnaire to collect data to perform meaningful research.
3) Write a literature review for a research problem.
4) Create a list of research topics (at least three) and read at least one research paper in each topic.

Unit 2:

1) Attend a research seminar and write a brief summary in 1000 words. Check the extent of plagiarism in this summary by using on-line plagiarism detection tools
2) Read a research paper based on the use of statistics in experimental physics and summarise its importance.
3) Collect publicly available experimental physics data. Identify the independent, dependent and control variables. Fit at least two mathematical models that can describe the data and compare their statistical significance.

Unit 3:

1) Review any three research papers.
    a) List the major strengths and weakness of all of them.
    b) For any one of these, create a referee report assuming you are a reviewer of the paper. Also draft a response to the referee's report assuming you are the author.
2) Review any research paper. Rewrite it as if the work has been done by you for the first time. Use two different referencing and bibliography styles

Unit 4:

1) Take data from any publicly available experimental physics database. Use Microsoft Office tools (such as chart/bar diagrams, equation editor etc. in Word, PowerPoint or Excel) to present, plot and infer relevant information from the data.
2) Write a scientific synopsis of a research paper using LaTeX.
3) Create a presentation using LaTeX and Beamer on any research topic
4) Select a funding agency and any two schemes or fellowships offered by them. Make a report (using LaTeX) describing the objectives, areas of research support and various components of grants offered by them.

Category II

Physical Science Courses
with Physics discipline as one of the Core Disciplines

(B. Sc. Physical Science with Physics as Major discipline)

DISCIPLINE SPECIFIC CORE COURSE – PHYSICS DSC 6: SOLID STATE PHYSICS

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Solid State Physics PHYSICS DSC – 6	**4**	**2**	**0**	**2**	Class XII pass with Physics and Mathematics as main subjects	Understanding of basic concepts of Physics

LEARNING OBJECTIVES

This course introduces the basic concepts and principles required to understand the various properties exhibited by condensed matter, especially solids. It enables the students to appreciate how the interesting and wonderful properties exhibited by matter depend upon its atomic and molecular constituents. It also communicates the importance of solid state physics in modern society.

LEARNING OUTCOMES

On successful completion of the module students should be able to,

- Elucidate the concept of lattice, crystals and its planes
- Understand the elementary lattice dynamics and its influence on the properties of materials
- Understanding about origin of energy bands, and their influence on electronic behaviour
- Explain the origin of dia-, para-, and ferro-magnetic properties of solids
- Explain the origin of the dielectric properties exhibited by solids and the concept of polarizability
- In the laboratory students will carry out experiments based on the theory that they have learned to measure the magnetic susceptibility, dielectric constant, trace hysteresis loop. They will also employ to four probe methods to measure electrical conductivity and the hall set up to determine the hall coefficient of a semiconductor.

SYLLABUS OF PHYSICS DSC – 6

THEORY COMPONENT

Unit – I - Crystal Structure **(10 Hours)**

Solids: amorphous and crystalline materials, lattice translation vectors, lattice with a basis, unit cell, types of lattices, Miller indices, reciprocal lattice, Ewald's construction (geometrical approach), Brillouin zones, diffraction of X-rays by crystals. Bragg's law

Unit – II - Elementary Lattice Dynamics **(6 Hours)**

Lattice vibrations and phonons: linear monoatomic and diatomic chains, acoustical and optical phonons, Dulong and Petit's law, qualitative discussion of Einstein and Debye theories, T^3 law.

Unit – III - Elementary Band Theory (5 Hours)

Qualitative understanding of Kronig and Penny model (without derivation) and formation of bands in solids, concept of effective mass, Hall effect in semiconductor, Hall coefficient, application of Hall Effect, basic introduction to superconductivity

Unit – IV - Magnetic Properties of Matter (6 Hours)

dia-, para-, and ferro- magnetic materials, classical Langevin theory of dia– and para-magnetism (no quantum mechanical treatment), qualitative discussion about Weiss's theory of ferromagnetism and formation of ferromagnetic domains, B-H curve hysteresis and energy loss

Unit – V - Dielectric Properties of Materials (3 Hours)

Polarization, local electric field in solids, electric susceptibility, polarizability, Clausius Mossoti equation, qualitative discussion about ferroelectricity and PE hysteresis loop

References:

Essential Readings:

1) Introduction to Solid State Physics, C. Kittel, 8th edition, 2004, Wiley India Pvt. Ltd.
2) Elements of Solid-State Physics, J. P. Srivastava, 2nd edition, 2006, Prentice-Hall of India
3) Introduction to Solids, L. V. Azaroff, 2004, Tata Mc-Graw Hill
4) Solid State Physics, N. W. Ashcroft and N. D. Mermin, 1976, Cengage Learning
5) Solid State Physics, M. A. Wahab, 2011, Narosa Publications

Additional Readings:

1) Elementary Solid State Physics, M. Ali Omar, 2006, Pearson
2) Solid State Physics, R. John, 2014, McGraw Hill
3) Superconductivity: A very short introduction, S. J. Blundell, Audiobook

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)

At least six experiments to be performed from the following list

1) Measurement of susceptibility of paramagnetic solution (Quinck's tube method)
2) To measure the magnetic susceptibility of solids
3) To determine the coupling coefficient of a piezoelectric crystal
4) To study the dielectric response of materials with frequency
5) To determine the complex dielectric constant and plasma frequency of a metal using Surface Plasmon Resonance (SPR) technique
6) To determine the refractive index of a dielectric layer using SPR technique
7) To study the PE Hysteresis loop of a ferroelectric crystal
8) To draw the BH curve of iron (Fe) using a Solenoid and determine the energy loss from hysteresis loop
9) To measure the resistivity of a semiconductor (Ge) crystal with temperature (up to 150° C) by four-probe method and determine its band gap
10) To determine the Hall coefficient of a semiconductor sample
11) Analysis of X-ray diffraction data in terms of unit cell parameters and estimation of particle size
12) Measurement of change in resistance of a semiconductor with magnetic field.

References for laboratory work:

1) Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House
2) Advanced level Physics Practicals, M. Nelson and J. M. Ogborn, 4th edition, reprinted 1985, Heinemann Educational Publishers
3) Elements of Solid-State Physics, J. P. Srivastava, 2nd edition, 2006, Prentice-Hall of India
4) An Advanced Course in Practical Physics, D. Chattopadhyay and P. C. Rakshit, 2013, New Book Agency (P) Ltd.
5) Practical Physics, G. L. Squires, 4th edition, 2015
6) Practical Physics, C. L. Arora, 19th edition, 2015, S. Chand

DISCIPLINE SPECIFIC ELECTIVE COURSE – PHYSICS DSE 16a: MATHEMATICAL PHYSICS II

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Mathematical Physics II PHYSICS DSE 16a	**4**	**3**	**1**	**0**	Class XII pass with Physics and Mathematics as main subjects	Mathematics as DSC course containing linear algebra and calculus

LEARNING OBJECTIVES

The emphasis of course is to equip students with the mathematical tools required in solving problem of interest to physicists. The mathematical tools might be building blocks to understand the fundamental computational physics skills and hence enable them to solve a wide range of physics problems. Overall, to help students develop critical skills and knowledge that will prepare them not only for doing fundamental and applied research but also prepare them for a wide variety of careers.

LEARNING OUTCOMES

After completing this course, student will be able to,

- Understand Complex Analysis
- Understand algebraic structures in n-dimension and basic properties of the linear vector spaces.
- Apply vector spaces and matrices in the quantum world.
- Learn Fourier Transforms (FTs)

SYLLABUS OF PHYSICS DSE 16a

THEORY COMPONENT

Unit – I **(20 Hours)**

Complex Analysis: Introduction to complex variables, Functions of Complex variable, limit, continuity, Analytic functions, Cauchy-Riemann equations, singular points, Cauchy Integral Theorem, Cauchy's Integral Formula, Residues, Cauchy's residue theorem, application of contour integration in solving real integrals.

Unit – II **(15 Hours)**

Linear Algebra: Linear Vector Spaces, Inner Product of Vectors and Norm of a Vector, Euclidean spaces, unitary spaces and inner product spaces. Properties of inner product spaces, Cauchy-Schwartz inequality, concept of length and distance, metric spaces. Orthogonality of vectors, orthonormal basis. Eigenvalue and Eigenvector, Adjoint of a linear operator, Hermitian or Self adjoint operators and their properties and Unitary Operators. Hilbert Space (Definition only).

Unit – III **(10 Hours)**

Fourier Transforms (FTs): Fourier Integral Theorem. Sine and Cosine Transforms. Properties of FTs: (1) FTs of Derivatives of Functions, (2) Change of Scale Theorem, (3) FTs of Complex Conjugates of Functions, (4) Shifting Theorem, (5) Modulation Theorem, (6) Convolution Theorems, and (7) Parseval's Identity.

References:

Essential Readings:

1) Complex Variables and Applications, J. W. Brown and R. V. Churchill, 9th edition, 2021, Tata McGraw-Hill
2) Mathematical Tools for Physics, J. Nearing, 2010, Dover Publications
3) Theory and Problems of Linear Algebra, S. Lipschutz, 1987, McGraco-Hill Inc.
4) Mathematical Methods for Physicists, H. J. Weber and G. B. Arfken, 2010, Elsevier.
5) Introduction to Matrices & Linear Transformations, D. T. Finkbeiner, 1978, Dover Pub.
6) Matrices and tensors in Physics: A.W. Joshi, 2017, New Age International Pvt.
7) Mathematical Methods in the Physical Sciences, M. L. Boas, 3rd edition, 2007, Wiley India.
8) Advanced Engineering Mathematics, E. Kreyszig, 2008, Wiley India.

Additional Readings:

1) Elementary Linear Algebra, Applications Version, H. Anton and C. Rorres, Wiley Student edition.
2) Mathematics for Physicists, S. M. Lea, 2004, Thomson Brooks/Cole
3) An Introduction to Linear Algebra and Tensors, M. A. Akivis, V. V. Goldberg, Richard and Silverman, 2012, Dover Publications

DISCIPLINE SPECIFIC ELECTIVE COURSE – PHYSICS DSE 16b: COMMUNICATION SYSTEM

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Communication System PHYSICS DSE 16b	4	2	0	2	Class XII pass with Physics and Mathematics as main subjects	Basics of digital and analog electronics

LEARNING OBJECTIVES

This paper aims to describe the fundamental concepts of communication systems and communication techniques based on analog modulation, analog and digital pulse modulation. Communication and Navigation systems such as GPS and mobile telephony system are also introduced. This paper will essentially connect the text book knowledge with the most popular communication technology in real world.

LEARNING OUTCOMES

At the end of this course, students will be able to

- Understand fundamentals of electronic communication system and electromagnetic communication spectrum with an idea of frequency allocation for radio communication system in India.
- Gain an insight on the use of different modulation and demodulation techniques used in analog communication
- Learn the generation and detection of a signal through pulse and digital modulation techniques and multiplexing.
- Gain an in-depth understanding of different concepts used in a satellite communication system.
- Study the concept of Mobile radio propagation, cellular system design and understand mobile technologies like GSM and CDMA.
- In the laboratory course, students will apply the theoretical concepts to gain hands-on experience in building modulation and demodulation circuits; Transmitters and Receivers for AM and FM. Also to construct TDM, PAM, PWM, PPM and ASK, PSK and FSK modulator and verify their results.

SYLLABUS OF PHYSICS DSE 16b

THEORY COMPONENT

Unit – I - Electronic communication and analog modulation (8 Hours)

Electronic communication: Introduction to communication – means and modes. Need for modulation. Block diagram of an electronic communication system, channels and base-band signals

Analog Modulation: Amplitude modulation, modulation index and frequency spectrum. Generation of AM (emitter modulation), amplitude demodulation (diode detector), Single sideband (SSB) systems, advantages of SSB transmission, frequency modulation (FM) and

phase modulation (PM), modulation index and frequency spectrum, equivalence between FM and PM.

Unit – II - Analog Pulse Modulation (4 Hours)
Sampling theorem, basic principles - PAM, PWM, PPM, modulation and detection technique for PAM only, Multiplexing (time division multiplexing and frequency division multiplexing)

Unit – III - Digital Pulse Modulation (10 Hours)
Need for digital transmission, pulse code modulation, digital carrier modulation techniques, sampling, quantization and encoding, concept of amplitude shift keying (ASK), frequency shift keying (FSK), phase shift keying (PSK), and binary phase shift keying (BPSK)

Unit – IV - Satellite Communication and Mobile Telephony system (8 Hours)
Satellite communication: Need for satellite communication, geosynchronous satellite orbits, geostationary satellite advantages of geostationary satellites. Transponders (C - Band), uplink and downlink, Ground and earth stations
Mobile Telephony System: Concept of cell sectoring and cell splitting, SIM number, IMEI number, architecture (block diagram) of mobile communication network, idea of GSM, CDMA, TDMA and FDMA technologies, simplified block diagram of mobile phone handset.

References:
Essential Readings:

1) Electronic Communications, D. Roddy and J. Coolen, Pearson Education India.
2) Advanced Electronics Communication Systems- Tomasi, 6th edition, Prentice Hall.
3) Electronic Communication systems, G. Kennedy, 3rd edition, 1999, Tata McGraw Hill.
4) Principles of Electronic communication systems – Frenzel, 3rd edition, McGraw Hill
5) Modern Digital and Analog Communication Systems, B. P. Lathi, 4th edition, 2011, Oxford University Press.
6) Communication Systems, S. Haykin, 2006, Wiley India
7) Wireless communications, A. Goldsmith, 2015, Cambridge University Press

Additional Readings:

1) Electronic Communication, L. Temes and M. Schultz, Schaum's Outline Series, Tata McGraw- Hill.
2) Electronic Communication Systems, G. Kennedy and B. Davis, Tata McGraw-Hill
3) Analog and Digital Communication Systems, M. J. Roden, Prentice Hall of India

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)

At least six experiments to be performed from the following list

1) To design an amplitude modulator using transistor
2) To design envelope detector for demodulation of AM signal
3) To study FM - generator and detector circuit
4) To study AM transmitter and receiver
5) To study FM transmitter and receiver
6) To study time division multiplexing (TDM)

7) To design pulse amplitude modulator using transistor.
8) To design pulse width modulator using 555 timer IC.
9) To design pulse position modulator using 555 timer IC
10) To study ASK, PSK and FSK modulators and demodulators

References for laboratory work:

1) Electronic Communication system, Blake, Cengage, 5th edition
2) Introduction to Communication systems, U. Madhow, 1st edition, 2018, Cambridge University Press

DISCIPLINE SPECIFIC ELECTIVE COURSE – PHYSICS DSE 16c: LASER PHYSICS AND ITS APPLICATIONS

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Laser Physics and its Applications PHYSICS DSE 16c	**4**	**2**	**0**	**2**	Class XII pass with Physics and Mathematics as main subjects	Waves and optics paper of this course or its equivalent. Basic idea of energy levels in atoms and molecules

LEARNING OBJECTIVES

Laser physics is a branch of optics that covers the fundamental and applied aspects of laser science. Laser is an acronym for 'Light Amplification by Stimulated Emission of Radiation'. This radiation has some specific properties different from the common light. The main objective of this course is to introduce the basic principle of its production, its types, the different kinds and techniques of laser devices and applications of laser in various fields including research, high energy applications, medical applications, industrial applications, and nuclear science. Also to perform experiments and to measure some physical quantities based on the experiments using lasers.

LEARNING OUTCOMES

After completing this course, students should be able to,

- Understand the nature of interaction of radiation with matter in the form of absorption of light, spontaneous and stimulated emission of radiation.
- Understand the principle of laser action, including population inversion, metastable states, gain medium, optical pumping, feedback mechanism and threshold condition for laser beam generation
- Understand the various types of lasers such as three and four-level lasers
- Understand various characteristic properties of lasers and how they are utilized in different applications
- Know the importance of lasers in holography and in fibre optics
- Perform some experiments based on the laser technique and to be able to measure some quantities through these experiments

SYLLABUS OF PHYSICS DSE 16c

THEORY COMPONENT

Unit 1 – Introduction **(12 Hours)**

Planck's theory of radiation (qualitative idea), energy levels, absorption process, spontaneous and stimulated emission processes, theory of laser action, population inversion, Einstein's A and B coefficients of transition, optical pumping, optical amplification, threshold for laser oscillation, line shape function (various line broadening mechanisms: collisional broadening, natural broadening, Doppler broadening), coherence (temporal and spatial type, role of

coherence in laser action), optical resonator (different configurations and stability condition)

Unit 2 – Types of Laser **(8 Hours)**

Doped insulator laser (Nd:YAG laser, Ruby laser)

Semiconductor lasers (GaAs laser): Energy bands and carrier distribution in semiconductors, absorption and emission in a semiconductor, optical gain, laser oscillation, threshold current density, power output

Gas lasers: He-Ne laser, noble gas ion laser, carbon dioxide laser

Unit 3 – Applications of Laser **(10 Hours)**

Properties of laser light: Mono-chromaticity, directionality, line width, beam coherence, intensity, focussing

Applications: Measurement of distance (interferometry method, beam modulation telemetry), Holography (basic principle, coherence, recording and reconstruction method, white light reflection hologram, application in microscopy and character recognition), medical applications, laser tweezers, high energy applications, industrial applications, laser induced nuclear fusion

References:

Essential Readings:

1) Laser Physics, M. Sargent, M. O. Scully and W. E. Lamb Jr., 1974, Western Press
2) Laser Physics and Spectroscopy, P. N. Ghosh, 2016, Levant Books, India
3) Lasers: Fundametnals and applications, K. Thyagarajan and A. K. Ghatak, 2010, Tata McGraw Hill
4) Optical systems and processes, J. Shamir, 2009, PHI Learning Pvt. Ltd.
5) Fundamental of optics, A. Kumar, H. R. Gulati and D. R. Khanna, 2011, R. Chand and Co. Publications
6) Optics, E. Hecht, 4th edition, 2014, Pearson Education
7) Laser applications, M. Ross, 1968, McGraw Hill

Additional Readings:

1) Physics for scientists and engineers with modern physics, Jewett and Serway, 2010, Cengage Learning
2) Optical Physics, A. Lispon, S. G. Lipson and H. Lipson, 4th edition, 1996, Cambridge University Press
3) Fibre optics through experiments, M. R. Shenoy, S. K. Khijwania, et.al. 2009, Viva Books
4) Industrial applications of lasers, J. F. Ready, 2nd edition, 1997, Academic Press
5) Semiconductor optoelectronics, J. Singh, 1995, McGraw Hill

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)

At least six experiments to be performed from the following list

1) To determine the wavelength and angular spread of laser light by using plane diffraction grating.
2) To determine the wavelength of laser source using diffraction of single slit.
3) To determine the wavelength of laser source using diffraction of double slits.

4) To determine the grating radial spacing of the compact disc by reflection using He-Ne or solid state laser.
5) To find the width of the wire or width of the slit using diffraction pattern obtained by a He-Ne or solid state laser.
6) To find the polarization angle of laser light using polarizer and analyser
7) To measure the numerical aperture of an optical fibre
8) To study the variation of the bending loss in a multimode fibre
9) To study thermal expansion of quartz using laser
10) To study the characteristics of solid state laser

References for laboratory work:

1) Advanced Practical Physics for students: B. L. Flint and H. T. Worsnop, Asia Publishing
2) Optoelectronics: An introduction, 3rd edition, 1998, Pearson Education
3) Introduction to fibre optics, A. K. Ghatak and K. Thyagarajan, 1998, Cambridge University Press

DISCIPLINE SPECIFIC ELECTIVE COURSE – PHYSICS DSE 16d: RESEARCH METHODOLOGY

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Research Methodology PHYSICS DSE 16d	**4**	**3**	**0**	**1**	Class XII pass with Physics and Mathematics as main subjects	Basic ICT related skills

LEARNING OBJECTIVES

This course has been designed to explore the basic dimensions of research and to impart quantitative and qualitative knowledge for conducting meaningful research. Starting from the philosophy of research, through awareness about the publication ethics and misconducts, this course covers all the methodological and conceptual issues required for a successful conduct of research. It gives an overview of research techniques, data management and analysis, and commonly used statistical methods in physical sciences.

LEARNING OUTCOMES

After successful completion of this course, students will be sufficiently trained in the following.

- Skills to review literature and frame research problem
- Comprehend the relevance of the tools for data collection and analysis
- Writing a scientific report/research proposal
- Software tools for research in physical sciences
- Research integrity and publication ethics
- Importance of intellectual property rights
- Role of funding agencies in research

SYLLABUS OF Physics DSE 16d

THEORY COMPONENT

Unit - I - Introduction to research methodology **(6 Hours)**

Brief history of scientific method and research, role and objectives of research, basic tenets of qualitative research; research problem and review of literature: identifying a research problem (philosophy and meaning of research, identification and definition of research problem, formulation of research problem, sources of prejudice and bias); literature survey (open-source and paid tools for keeping track of the literature)

Unit - II - Data collection, analysis and interpretation **(15 Hours)**

Methods of data collection: survey, interview, observation, experimentation and case study;
Descriptive statistics: Measures of central tendency (mean, median, mode) and dispersion (range, standard deviation);
Inferential statistics: Hypothesis testing, Z test, T test; regression analysis (basic concepts of multiple linear regression analysis and theory of attributes);

Curve fitting using linear and nonlinear regression (parameter space, gradient search method and Marquardt method);
Role of simulation, calibration methods, error analysis, and background handling in experimental design

Unit - III – Journals, Database and Research Metrics (7 Hours)

Journals: Free, open source and paid journals, concept of peer reviewed journals, predatory and fake journals
Databases: Indexing databases; citation databases (Web of science, Scopus); experimental physics databases (astrophysics (ADS, NED, SIMBAD, VizieR), biophysics (PubMed), particle physics (INSPIRE, CDS), condensed matter physics (X-ray database))
Research Metrics: Journal impact factor, SNIP, SJR, IPP, cite score; metrics (h-index, g index, i10 index, altmetrics), variations in research metrics across various disciplines, other limitations of the research metrics and impact factors

Unit - IV – Scientific Conduct and Publication Ethics (8 Hours)

Current understanding of ethics; intellectual honesty and research integrity; communicating errors (erratum, correction and withdrawal); records and logs (maintaining records of samples, raw data, experimental protocols, observation logs, analysis calculations, and codes); scientific publication misconducts: plagiarism (concept, importance, methods and ways to detect and avoid plagiarism) and redundant publications (salami slicing, duplicate and overlapping publications, selective reporting and misrepresentation of data); environmental and other clearances (waste management, disposal of hazardous waste).
COPE guidelines on best practices in publication ethics

Unit V – Scientific Writing and Software Tools (5 Hours)

Writing a research paper and report: introduction, motivation, scientific problem, its methodology, any experimental set up, data analysis, discussion of results, conclusions
Referencing formats (APA, MLA) and bibliography management
Graphical software (open source, magic plot, gnu plot, origin); presentation tools (beamer)

Unit VI - Intellectual Property Right and Research Funding (4 Hours)

Basic concepts and types of intellectual property (patent, copyright and trademark)
Role of funding agencies in research, overview of various funding agencies (DST-SERB, UGC, CSIR, BRNS, DRDO), national and international research project grants and fellowships

References:

Essential Readings:

1) Management Research Methodology, K. N. Krishnaswamy, A. I. Sivakumar, M. Mathirajan, 2006, Pearson Education, New Delhi.
2) Research Methodology, Methods and Techniques, C. R. Kothari, 2nd edition, 2008, New Age International Publication.
3) Research Methodology, A step by step guide for beginners, R. Kumar, 6th edition, 2009, Pearson Education
4) Data reduction and error analysis for the physical sciences, P. R. Bevington and D. K. Robinson, 3rd edition, McGraw-Hill
5) Intellectual property: Patents, Trademarks, Copyrights, Trade Secrets, C. J. Holland, 2007, Entrepreneur Press

Additional Readings:

1) Research Methods, R. Ahuja, 2001, Rawat Publications, New Delhi.
2) Research design: Qualitative, quantitative, and mixed methods approaches, J. W. Creswell, and J. D. Creswell, 2017, Sage Publications.
3) Intellectual Property: Patents, Trademarks and Copyright in a Nutshell, A. R. Miller and M. H. Davis, 2000, West Group Publishers

PRACTICAL COMPONENT

(15 Weeks with 2 hours of laboratory session per week)
Students should perform at least six practicals from the following list, such that all the units mentioned below are covered.

Unit 1:

1) Identify a research problem, write its brief summary and make a corresponding flow chart
2) Identify a survey-based research problem in physics and create a questionnaire to collect data to perform meaningful research.
3) Write a literature review for a research problem.
4) Create a list of research topics (at least three) and read at least one research paper in each topic.

Unit 2:

1) Attend a research seminar and write a brief summary in 1000 words. Check the extent of plagiarism in this summary by using on-line plagiarism detection tools
2) Read a research paper based on the use of statistics in experimental physics and summarise its importance.
3) Collect publicly available experimental physics data. Identify the independent, dependent and control variables. Fit at least two mathematical models that can describe the data and compare their statistical significance.

Unit 3:

1) Review any three research papers.
    a) List the major strengths and weakness of all of them.
    b) For any one of these, create a referee report assuming you are a reviewer of the paper. Also draft a response to the referee's report assuming you are the author.
2) Review any research paper. Rewrite it as if the work has been done by you for the first time. Use two different referencing and bibliography styles

Unit 4:

1) Take data from any publicly available experimental physics database. Use Microsoft Office tools (such as chart/bar diagrams, equation editor etc. in Word, PowerPoint or Excel) to present, plot and infer relevant information from the data.
2) Write a scientific synopsis of a research paper using LaTeX.
3) Create a presentation using LaTeX and Beamer on any research topic
4) Select a funding agency and any two schemes or fellowships offered by them. Make a report (using LaTeX) describing the objectives, areas of research support and various components of grants offered by them.

Category II

Physical Science Courses (with Electronics)
with Physics and Electronics discipline as Core Disciplines

DISCIPLINE SPECIFIC CORE COURSE – PHYSICS DSC 10: SOLID STATE PHYSICS

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Solid State Physics PHYSICS DSC 10	4	2	0	2	Class XII pass with Physics and Mathematics as main subjects	Understanding of basic concepts of Physics

LEARNING OBJECTIVES

This course introduces the basic concepts and principles required to understand the various properties exhibited by condensed matter, especially solids. It enables the students to appreciate how the interesting and wonderful properties exhibited by matter depend upon its atomic and molecular constituents. It also communicates the importance of solid state physics in modern society.

LEARNING OUTCOMES

On successful completion of the module students should be able to,

- Elucidate the concept of lattice, crystals and its planes
- Understand the elementary lattice dynamics and its influence on the properties of materials
- Understanding about origin of energy bands, and their influence on electronic behaviour
- Explain the origin of dia-, para-, and ferro-magnetic properties of solids
- Explain the origin of the dielectric properties exhibited by solids and the concept of polarizability
- In the laboratory students will carry out experiments based on the theory that they have learned to measure the magnetic susceptibility, dielectric constant, trace hysteresis loop. They will also employ to four probe methods to measure electrical conductivity and the hall set up to determine the hall coefficient of a semiconductor.

SYLLABUS OF PHYSICS DSC – 10

THEORY COMPONENT

Unit – I - Crystal Structure **(10 Hours)**

Solids: amorphous and crystalline materials, lattice translation vectors, lattice with a basis, unit cell, types of lattices, Miller indices, reciprocal lattice, Ewald's construction (geometrical approach), Brillouin zones, diffraction of X-rays by crystals. Bragg's law

Unit – II - Elementary Lattice Dynamics **(6 Hours)**

Lattice vibrations and phonons: linear monoatomic and diatomic chains, acoustical and optical phonons, Dulong and Petit's law, qualitative discussion of Einstein and Debye theories, T^3 law.

Unit – III - Elementary Band Theory **(5 Hours)**

Qualitative understanding of Kronig and Penny model (without derivation) and formation of bands in solids, concept of effective mass, Hall effect in semiconductor, Hall coefficient, application of Hall effect, basic introduction to superconductivity

Unit – IV - Magnetic Properties of Matter **(6 Hours)**

dia-, para-, and ferro- magnetic materials, classical Langevin theory of dia– and para-magnetism (no quantum mechanical treatment), qualitative discussion about Weiss's theory of ferromagnetism and formation of ferromagnetic domains, B-H curve hysteresis and energy loss

Unit – V - Dielectric Properties of Materials **(3 Hours)**

Polarization, local electric field in solids, electric susceptibility, polarizability, Clausius Mossoti equation, qualitative discussion about ferroelectricity and PE hysteresis loop

References:

Essential Readings:

1) Introduction to Solid State Physics, C. Kittel, 8th edition, 2004, Wiley India Pvt. Ltd.
2) Elements of Solid-State Physics, J. P. Srivastava, 2nd edition, 2006, Prentice-Hall of India
3) Introduction to Solids, L. V. Azaroff, 2004, Tata Mc-Graw Hill
4) Solid State Physics, N. W. Ashcroft and N. D. Mermin, 1976, Cengage Learning
5) Solid State Physics, M. A. Wahab, 2011, Narosa Publications

Additional Readings:

1) Elementary Solid State Physics, M. Ali Omar, 2006, Pearson
2) Solid State Physics, R. John, 2014, McGraw Hill
3) Superconductivity: A Very short Introduction – Stephen J Blundell - Audiobook

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)

At least six experiments to be performed from the following list

1) Measurement of susceptibility of paramagnetic solution (Quinck's tube method)
2) To measure the magnetic susceptibility of solids
3) To determine the coupling coefficient of a piezoelectric crystal
4) To study the dielectric response of materials with frequency
5) To determine the complex dielectric constant and plasma frequency of a metal using Surface Plasmon Resonance (SPR) technique
6) To determine the refractive index of a dielectric layer using SPR technique
7) To study the PE Hysteresis loop of a ferroelectric crystal
8) To draw the BH curve of iron (Fe) using a solenoid and determine the energy loss from hysteresis loop
9) To measure the resistivity of a semiconductor (Ge) crystal with temperature (up to 150° C) by four-probe method and determine its band gap
10) To determine the Hall coefficient of a semiconductor sample
11) Analysis of X-ray diffraction data in terms of unit cell parameters and estimation of particle size

12) Measurement of change in resistance of a semiconductor with magnetic field.

References for laboratory work:

1) Advanced Practical Physics for students, B. L. Flint and H. T. Worsnop, 1971, Asia Publishing House
2) Advanced level Physics Practicals, M. Nelson and J. M. Ogborn, 4th edition, reprinted 1985, Heinemann Educational Publishers
3) Elements of Solid-State Physics, J. P. Srivastava, 2nd edition, 2006, Prentice-Hall of India
4) An Advanced Course in Practical Physics, D. Chattopadhyay and P. C. Rakshit, 2013, New Book Agency (P) Ltd.
5) Practical Physics, G. L. Squires, 4th edition, 2015
6) Practical Physics, C. L. Arora, 19th edition, 2015, S. Chand

DISCIPLINE SPECIFIC ELECTIVE COURSE – PHYSICS DSE 13: RESEARCH METHODOLOGY

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Research Methodology PHYSICS DSE 13	**4**	**3**	**0**	**1**	Class XII pass with Physics and Mathematics as main subjects	Basic ICT related skills

LEARNING OBJECTIVES

This course has been designed to explore the basic dimensions of research and to impart quantitative and qualitative knowledge for conducting meaningful research. Starting from the philosophy of research, through awareness about the publication ethics and misconducts, this course covers all the methodological and conceptual issues required for a successful conduct of research. It gives an overview of research techniques, data management and analysis, and commonly used statistical methods in physical sciences.

LEARNING OUTCOMES

After successful completion of this course, students will be trained in the following.

- Skills to review literature and frame research problem
- Comprehend the relevance of the tools for data collection and analysis
- Writing a scientific report/research proposal
- Software tools for research in physical sciences
- Research integrity and publication ethics
- Importance of intellectual property rights
- Role of funding agencies in research

SYLLABUS OF Physics DSE - 13

THEORY COMPONENT

Unit - I - Introduction to research methodology **(6 Hours)**

Brief history of scientific method and research, role and objectives of research, basic tenets of qualitative research; research problem and review of literature: identifying a research problem (philosophy and meaning of research, identification and definition of research problem, formulation of research problem, sources of prejudice and bias); literature survey (open-source and paid tools for keeping track of the literature)

Unit - II - Data collection, analysis and interpretation **(15 Hours)**

Methods of data collection: survey, interview, observation, experimentation and case study;
Descriptive statistics: Measures of central tendency (mean, median, mode) and dispersion (range, standard deviation);
Inferential statistics: Hypothesis testing, Z test, T test; regression analysis (basic concepts of multiple linear regression analysis and theory of attributes);

Curve fitting using linear and nonlinear regression (parameter space, gradient search method and Marquardt method);
Role of simulation, calibration methods, error analysis, and background handling in experimental design

Unit - III – Journals, Database and Research Metrics (7 Hours)

Journals: Free, open source and paid journals, concept of peer reviewed journals, predatory and fake journals
Databases: Indexing databases; citation databases (Web of science, Scopus); experimental physics databases (astrophysics (ADS, NED, SIMBAD, VizieR), biophysics (PubMed), particle physics (INSPIRE, CDS), condensed matter physics (X-ray database))
Research Metrics: Journal impact factor, SNIP, SJR, IPP, cite score; metrics (h-index, g index, i10 index, altmetrics), variations in research metrics across various disciplines, other limitations of the research metrics and impact factors

Unit - IV – Scientific Conduct and Publication Ethics (8 Hours)

Current understanding of ethics; intellectual honesty and research integrity; communicating errors (erratum, correction and withdrawal); records and logs (maintaining records of samples, raw data, experimental protocols, observation logs, analysis calculations, and codes); scientific publication misconducts: plagiarism (concept, importance, methods and ways to detect and avoid plagiarism) and redundant publications (salami slicing, duplicate and overlapping publications, selective reporting and misrepresentation of data); environmental and other clearances (waste management, disposal of hazardous waste).
COPE guidelines on best practices in publication ethics

Unit V – Scientific Writing and Software Tools (5 Hours)

Writing a research paper and report: introduction, motivation, scientific problem, its methodology, any experimental set up, data analysis, discussion of results, conclusions
Referencing formats (APA, MLA) and bibliography management
Graphical software (open source, magic plot, gnu plot, origin); presentation tools (beamer)

Unit VI - Intellectual Property Right and Research Funding (4 Hours)

Basic concepts and types of intellectual property (patent, copyright and trademark); Role of funding agencies in research, overview of various funding agencies (DST-SERB, UGC, CSIR, BRNS, DRDO), national and international research project grants and fellowships

References:

Essential Readings:

1) Management Research Methodology, K. N. Krishnaswamy, A. I. Sivakumar, M. Mathirajan, 2006, Pearson Education, New Delhi.
2) Research Methodology, Methods and Techniques, C. R. Kothari, 2nd edition, 2008, New Age International Publication.
3) Research Methodology, A step by step guide for beginners, R. Kumar, 6th edition, 2009, Pearson Education
4) Data reduction and error analysis for the physical sciences, P. R. Bevington and D. K. Robinson, 3rd edition, McGraw-Hill
5) Intellectual property: Patents, Trademarks, Copyrights, Trade Secrets, C. J. Holland, 2007, Entrepreneur Press

Additional Readings:

1) Research Methods, R. Ahuja, 2001, Rawat Publications, New Delhi.
2) Research design: Qualitative, quantitative, and mixed methods approaches, J. W. Creswell, and J. D. Creswell, 2017, Sage Publications.
3) Intellectual Property: Patents, Trademarks and Copyright in a Nutshell, A. R. Miller and M. H. Davis, 2000, West Group Publishers

PRACTICAL COMPONENT

(15 Weeks with 2 hours of laboratory session per week)
Students should perform at least six practicals from the following list, such that all the units mentioned below are covered.

Unit 1:
1) Identify a research problem, write its brief summary and make a corresponding flow chart
2) Identify a survey-based research problem in physics and create a questionnaire to collect data to perform meaningful research.
3) Write a literature review for a research problem.
4) Create a list of research topics (at least three) and read at least one research paper in each topic.

Unit 2:
1) Attend a research seminar and write a brief summary in 1000 words. Check the extent of plagiarism in this summary by using on-line plagiarism detection tools
2) Read a research paper based on the use of statistics in experimental physics and summarise its importance.
3) Collect publicly available experimental physics data. Identify the independent, dependent and control variables. Fit at least two mathematical models that can describe the data and compare their statistical significance.

Unit 3:
1) Review any three research papers.
    a) List the major strengths and weakness of all of them.
    b) For any one of these, create a referee report assuming you are a reviewer of the paper. Also draft a response to the referee's report assuming you are the author.
2) Review any research paper. Rewrite it as if the work has been done by you for the first time. Use two different referencing and bibliography styles

Unit 4:
1) Take data from any publicly available experimental physics database. Use Microsoft Office tools (such as chart/bar diagrams, equation editor etc. in Word, PowerPoint or Excel) to present, plot and infer relevant information from the data.
2) Write a scientific synopsis of a research paper using LaTeX.
3) Create a presentation using LaTeX and Beamer on any research topic
4) Select a funding agency and any two schemes or fellowships offered by them. Make a report (using LaTeX) describing the objectives, areas of research support and various components of grants offered by them.

DISCIPLINE SPECIFIC ELECTIVE COURSE – PHYSICS DSE 14: VERILOG AND FPGA BASED SYSTEM DESIGN

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Verilog and FPGA based System Design Physics DSE 14	**4**	**2**	**0**	**2**	Class XII pass with Physics and Mathematics as main subjects	Basics of digital electronics

LEARNING OBJECTIVES

This course trains the students to use VLSI design methodologies and simulate simple digital systems. Students will understand the HDL design flow and the fundamental Verilog concepts in-lieu of today's most advanced digital design techniques. The emphasis of this course is to enhance the understanding of Programmable Logic Devices so as to implement the Digital Designs on FPGAs using Verilog HDL

LEARNING OUTCOMES

At the end of this course, students will be able to,

- Write synthesizable Verilog code.
- Write a Verilog test bench to test Digital Logic Design.
- Design and simulate digital circuits using Verilog modules.
- Understand various types of programmable logic building blocks such as PAL, PLA, CPLDs and FPGAs and their trade-offs.
- Design and implement digital systems on programmable logic device FPGA using Verilog HDL.

SYLLABUS OF PHYSICS DSE 14

THEORY COMPONENT

Unit – I **(20 Hours)**

Introduction to Verilog: Introduction to HDL, importance of HDL, popularity of Verilog HDL, design flow, structure of HDL module, Verilog modules (design and stimulus), introduction to language elements - keywords, identifiers, white space, comments, format, integers, real and strings, logic values, data types, scalars and vector nets, parameters, system tasks, compiler directives

Gate level modelling: Introduction, built in primitive gates, buffers, multiple input gates, gate delays.

Data flow modelling: Continuous assignment, net declaration assignments, net delays, operator types and operators precedence

Behavioral modelling: Always and initial constructs, procedural assignment (blocking and non-blocking statements), If-else, case statements, loop structures (while, for, repeat and forever), sequential and parallel Blocks

Modelling of combinational and sequential digital circuits using different levels of abstraction

Hierarchical modelling concepts: Design methodologies, design a 4-bit adder using four 1-bit full adders

Unit – II **(10 Hours)**

Look up Tables: 2-input, 3-input and 4-input LUTs, Implement logic functions with LUT, advantages and disadvantages of lookup tables

Programmable Logic Devices: Difference between PAL and PLA, Realize simple logic functions using PAL and PLA, CPLD and FPGA architectures, types of FPGA, logic cell structure, programmable interconnects, logic blocks and I/O Ports, placement and routing, applications of FPGAs

References:

Essential Readings:

1) Verilog HDL. Pearson Education, S. Palnitkar, 2nd edition, 2003
2) FPGA Based System Design. W. Wolf, Pearson Education
3) Digital Signal processing, S. K. Mitra, 1998, McGraw Hill
4) VLSI design, D. P. Das, 2nd edition, 2015, Oxford University Press.
5) Digital Signal Processing with FPGAs, U. Meyer Baese, Springer, 2004

Additional Readings:

1) Fundamentals of Digital Logic with Verilog Design, S. B. Zvonko Vranesic, 2016, McGraw Hill

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)

- Session on how to write the design module and test benches using required software and simulate the combinational and sequential circuits.
- Sessions on how to configure FPGA using Verilog HDL for the final implementation of the logic design.

At least six experiments to be performed from the following list

1) Half adder, Full Adder using basic and derived gates.
2) Half subtractor and Full Subtractor using basic and derived gates.
3) Design and simulate 4-bit Adder using Data Flow Modeling.
4) Multiplexer (4x1) and Demultiplexer(1X4) using Data Flow Modeling.
5) Decoder and Encoder using case structure/gates.
6) Clocked D, JK and T Flip flops (with Reset inputs)
7) 4-bit Synchronous up/downCounter
8) To design and study switching circuits (LED blink shift)
9) To interface LCD using FPGA
10) To interface a multiplexed seven segment display.
11) To interface a stepper motor and DC motor.

References for laboratory work:

1) Digital System Designs and Practices: Using Verilog HDL and FPGAs, Ming-Bo Lin, Wiley India Pvt Ltd.

2) Verilog Digital System Design, Z. Navabi, 2nd edition, TMH
3) Designing Digital Computer Systems with Verilog, D. J. Laja and S. Sapatnekar, 2015, Cambridge University Press
4) Verilog HDL primer, J. Bhasker. BSP, 2nd edition, 2003

DISCIPLINE SPECIFIC ELECTIVE COURSE – PHYSICS DSE 15: PHOTONIC DEVICES AND POWER ELECTRONICS

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Photonic Devices and Power Electronics Physics DSE 15	4	2	0	2	Class XII pass with Physics and Mathematics as main subjects	Analog electronics

LEARNING OBJECTIVES

This paper aims to provide students with in-depth understanding of the principles, concepts, and applications of photonic devices and power electronics. The course covers a range of topics, including, semiconductor lasers, fibre optics, power diodes, power MOSFETs, and power electronics applications. Students will develop the necessary knowledge and skills to design and analyse various photonic and power electronic devices and systems. The course also emphasizes the practical aspects of device design, fabrication, and characterization, preparing students for real-world challenges and opportunities in these fields.

LEARNING OUTCOMES

Upon completion of the course on Photonic Devices and Power Electronics, students are expected to achieve the following learning outcomes.

- Understand the basic principles and concepts of photonic devices and power electronics, including semiconductor lasers, fibre optics, power diodes, power MOSFETs, and power electronics applications.
- Develop the necessary knowledge and skills to design and analyse various photonic and power electronic devices and systems.
- Gain practical experience in device design, fabrication, and characterization.
- Apply the knowledge and skills learned in the course to real-world challenges and opportunities in the fields of photonics and power electronics.
- Develop problem-solving skills, critical thinking skills, and the ability to apply scientific and engineering principles to practical problems.
- Understand the ethical considerations and professional responsibilities associated with the development and use of photonic and power electronic devices and systems.
- Overall, students will gain a comprehensive understanding of photonic devices and power electronics and be well-equipped to pursue careers in these fields or continue their studies at the graduate level.

SYLLABUS OF PHYSICS DSE 15

THEORY COMPONENT

Unit – I **(4 Hours)**

Classification of photonic devices: Radiative transition and optical absorption. Light Emitting Diodes (Construction, materials and operation)

Semiconductor LASER: Condition for amplification, laser cavity, LASER diode.

Unit – II **(8 Hours)**

Photodetectors: Photoconductor, photodiodes (p-i-n, avalanche) and photo transistors, quantum efficiency and responsivity

Solar Cell: Construction, working and characteristics.

LCD Displays: Types of liquid crystals, Principle of Liquid Crystal Displays, applications, advantages over LED displays.

Unit – III **(4 Hours)**

Introduction to Fiber Optics: Element of an Optical Fiber Transmission link- Optical Fiber Modes and Configurations, Overview of Modes -Single Mode Fibers-Graded Index fiber structure.

Unit – IV **(8 Hours)**

Power Devices: Need for semiconductor power devices, Power MOSFET (qualitative); introduction to family of thyristors; Silicon Controlled Rectifier (SCR) - structure, I-V characteristics, Turn-On and Turn-Off characteristics, ratings, Gate-triggering circuits; DIAC and TRIAC- Basic structure, working and V-I characteristics

Insulated Gate Bipolar Transistors (IGBT): Basic structure, I-V Characteristics, switching characteristics, device limitations and safe operating area (SOA)

Unit – V **(6 Hours)**

Applications of SCR: Phase controlled rectification, AC voltage control using SCR and Triac as a switch. Power Invertors- Need for commutating circuits and their various types, dc link invertors, Parallel capacitor commutated invertors.

References:

Essential Readings:

1) Optoelectronics, J. Wilson and J. F. B. Hawkes, 1996, Prentice Hall India
2) Optoelectronics and Photonics, S. O. Kasap, 2009, Pearson Education
3) Electronic Devices and Circuits, D. A. Bell, 2015, Oxford University Press
4) Introduction to fibre optics, A. K. Ghatak and K. Thyagarajan, 1998, Cambridge University Press
5) Power Electronics, M. D. Singh and K. B. Khanchandani, Tata McGraw Hill.

Additional Readings:

1) Power Electronics, J. S. Chitode, Technical Publications
2) Basic Electrical and Electronics Engineering, R. Saravanakumar V. Jegathesan and K. V. Kumar, Wiley
3) Power Electronics: Essentials & Applications, L. Umanand, Wiley

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)

At least six experiments to be performed from the following list

1) Diffraction experiments using a LASER.
2) To determine characteristics of (a) LEDs, (b) Photovoltaic cell and (c) Photodiode.
3) To study the Characteristics of LDR and Photodiode with (i) Variable Illumination

intensity, and (ii) Linear Displacement of source.

4) To measure the numerical aperture of an optical fiber.
5) Output and transfer characteristics of a power MOSFET.
6) Study of I-V characteristics of SCR.
7) SCR as a half wave and full wave rectifier with R and R - L loads.
8) AC voltage controller using TRIAC with UJT triggering.
9) Study of I-V characteristics of DIAC.
10) Study of I-V characteristics of TRIAC

References for laboratory work:

1) Power Electronics, P. C. Sen, Tata McGraw Hill.
2) Power Electronics Circuits, Devices & Applications, 3rd edition, M. H. Rashid, Pearson Education
3) A Textbook of Electrical Technology, Vol-II, B. L. Thareja and A. K. Thareja, S. Chand.

DISCIPLINE SPECIFIC ELECTIVE COURSE – PHYSICS DSE 16: ANTENNA THEORY AND WIRELESS NETWORK

Course Title & Code	Credits	Credit distribution of the course			Eligibility Criteria	Pre-requisite of the course
		Lecture	Tutorial	Practical		
Antenna Theory and Wireless Network Physics DSE 16	**4**	**2**	**0**	**2**	Class XII pass with Physics and Mathematics as main subjects	Basics of digital and analog electronics and communication systems

LEARNING OBJECTIVES

This course gives an overview of wireless communication elements and networks. Students will develop an understanding of basics of antenna, its various parameters, its usage as a transmitter and receiver. Cellular concept and system design fundamentals are described and the evolution of current wireless systems in real world such as 2G, 3G, 4G and LTE networks is discussed.

LEARNING OUTCOMES

At the end of this course, students will be able to achieve the following learning outcomes.

- Identify basic antenna parameter (radiating wire structures).
- Determine directions of maximum signal radiations and the nulls in the radiation patterns.
- Design array antenna systems from specifications.
- Identify the characteristics of radio-wave propagation.
- Identify wireless networks 4G and LTE, and 5G.
- Design cellular systems

SYLLABUS OF PHYSICS DSE 16

THEORY COMPONENT

Unit – I **(14 Hours)**

ANTENNA THEORY

Introduction: Antenna as an element of wireless communication system, antenna radiation mechanism, types of antennas, fundamentals of EMFT: Maxwell's equations and their applications to antennas

Antenna Parameters: Antenna parameters: Radiation pattern (polarization patterns, field and phase patterns), field regions around antenna, radiation parameters (general idea): intensity, beam width, gain, directivity, polarization, bandwidth, efficiency and antenna temperature

Unit – II **(5 Hours)**

Antenna as a transmitter/receiver: Effective height and aperture, power delivered to antenna, input impedance, general idea of radiation from an infinitesimal small current element and radiation from an elementary dipole (Hertzian dipole)

Unit – III **(5 Hours)**

WIRELESS NETWORKS:
Introduction: General idea of cellular and wireless systems, current wireless systems, examples of wireless communication systems, idea about global mobile communication system

Unit – IV **(3 Hours)**
Modern wireless communication systems: General idea 2G,3G and wi-fi, 4G and LTE, and 5G wireless networks, wireless local area networks (WLANs), bluetooth and personal area networks (PANs).

Unit – V **(3 Hours)**
Cellular Concept and System Design Fundamentals: Cellular concept and cellular system fundamentals, cellular systems design considerations (qualitative idea only)

References:
Essential Readings:

1) Antenna Theory, Ballanis, 2nd edition, 2003, John Wiley & Sons
2) Electro Magnetic Waves and Radiating Systems, Jordan and Balmain, E. C., 3rd edition, 1968, Reprint (2003), PHI
3) Fundamentals of Wireless Communication, D. Tse and P. Viswanathan, 2014, Cambridge University Press
4) Wireless communication and Networks, U. Dalal, 2015, Oxford University Press.
5) Mobile Communication Design and Fundamentals, Lee, William C.Y., 4th edition, 1999

Additional Readings:

1) Wireless communications, A. Goldsmith, 2015, Cambridge University Press
2) Modern Wireless Communication, H. S. and M. M. Pearson, 3rd edition, 2005

PRACTICAL COMPONENT

(15 Weeks with 4 hours of laboratory session per week)

At least six experiments to be performed from the following list

1) Study of simple dipole and folded dipole (l/2) antenna, plot and compare the radiation pattern of both antennas.
2) Study of simple dipole 5 element Yagi-UDA and folded dipole 5 element Yagi Uda antenna, plot and compare the radiation pattern of both antennas
3) Study of loop antenna and slot antennas and plot their radiation patterns
4) Study the radiation pattern of ground plane antenna and observe the difference in radiation pattern with single element rod, detector and reflector rods
5) To study the variation of radiated field with distance from transmitting antenna.
6) To study modulation of sine wave on RF transmitted and observe the demodulated wave on detector receiver
7) Study of the reciprocity theorem for antennas
8) Study the role of matching stub in antenna transmission.
9) To study working of current sensor and measurement of current in various elements of antenna.
10) To study and measure SWR using various types of antennas.
11) To study different parts of a 4G Volte mobile phone and observe constellation diagram

for transmitter and receiver IQ signals

12) To study various types of faults in a 4G volte mobile phone.

References for laboratory work:

1) Antenna Theory, Ballanis, 2nd edition, 2003, John Wiley & Sons
2) Fundamentals of Wireless Communication, D. Tse and P. Viswanathan, 2014, Cambridge University Press
3) Mobile Communication Design and Fundamentals, Lee, William C.Y., 4th edition, 1999

Details and Proof of Faculty Participation in Course Making and Revision

S. No.	Name of the Faculty Member	Details of Participation in Course Making and Revision
1.	Dr. Vibha Sharma	Academic council/BoS of Affiliating university: Faculty of Science Committee, University of Delhi
2.	Dr. Harish Kumar Yadav	Academic council/BoS of Affiliating university: Committee of Courses (CoC) for B.Sc. Physics (H) and B.Sc. (programme) courses
3.	Dr. Harish Kumar Yadav	Academic council/BoS of Affiliating university: Committee of Courses (CoC) for B.Sc. Physics (H) and B.Sc. (programme) courses
4.	Dr. Sabina Kazmi	Design and Development of Curriculum for Add on/ certificate/ Diploma Courses: Rise of Modern West-II (designed and contributed several modules to the certificate course offered by SWAYAM, Ministry of Education, coordinated by EMRC, Patiala University)
5.	Dr. Sangeeta Sachdeva	Academic council/BoS of Affiliating university: Member of the Sub-Committee of the combined Committee of Courses in Physics and Moderation Committee for the UG examinations 2023
6.	Dr. Sangeeta Sachdeva	Academic council/BoS of Affiliating university: Member of the Sub-Committee of the combined Committee of Courses in Physics and Moderation Committee for the UG examinations 2024
7.	Dr. Sanjay Kumar	Academic council/BoS of Affiliating university: Combine Sub Committee of the Committee of Courses of the Department of Physics, University of Delhi
8.	Dr. Geetanjali Sethi	Design and Development of Curriculum for Add on/ certificate/ Diploma Courses: SCAL, Course on Public Policy
9.	Dr. Geetanjali Sethi	Design and Development of Curriculum for Add on/ certificate/ Diploma Courses: SCAL, Course on International relations
10.	Dr. Rakhi Thareja	Academic council/BoS of Affiliating university: Board of Officers for finalizing the subjects for Precis for NCC
11.	Dr. Sujay John	Academic council/BoS of Affiliating university: DELHI UNIVERSITY SPORTS COUNCIL Member Organizing Committee Member Technical and Selection Committee

FACULTY OF SCIENCE
विज्ञान संकाय
UNIVERSITY OF DELHI
दिल्ली विश्वविद्यालय

MINUTES

A Meeting of the Faculty of Science in Online mode was held on Wednesday, the 24th July, 2024 at 11.00 A.M. via Google Meet https://meet.google.com/ops-atzr-hrr.

The following members ~~~ joined the meeting:-

1.	Prof. Debajyoti Choudhary	**Dean, Faculty of Science**
2.	Prof. Rajni Abbi	Proctor, University of Delhi
3.	Prof. Sunit Kumar Singh	Dr.B. R. Ambdekar Centre for Biomedical Research
4.	Prof. Madhu Chopra	Dr.B. R. Ambdekar Centre for Biomedical Research
5.	Prof. Dinabandhu Sahoo	Department of Botany
6.	Prof. Renu Deswal	Department of Botany
7.	Prof. Firasat Hussain	Department of Chemistry
8.	Prof. Indrajit Roy	Department of Chemistry
9.	Prof. Chirashree Ghosh	Department of Environmental Studies
10	Prof. Gyun Prakash Sharma	Department of Environmental Studies
11	Prof. Swati Diwakar	Department of Environmental Studies
12	Prof. Anupa Siddhu	Department of Home Science
13	Prof. Rupa Upadhyay	Department of Home Science
14	Prof. Aparna Khanna	Department of Home Science
15	Prof. Archna Kumar	Department of Home Science
16	Prof. Lalita Verma	Department of Home Science
17	Prof. Meenakshi Mittal	Department of Home Science
18	Prof. Puja Gupta	Department of Home Science
19	Prof. Ravinder Chadha	Department of Home Science
20	Prof. Sarita Anand	Department of Home Science
21	Prof. Simmi Bhagat	Department of Home Science
22	Prof. T.G. Rupa	Department of Home Science
23	Prof. Amita Chandra	Department of Physics & Astrophysics
24	Prof. Poonam Silotia	Department of Physics & Astrophysics
25	Prof. Suresh Kumar	Department of Physics & Astrophysics
26	Prof. Alok Chandra Bharti	Department of Zoology
27	Prof. J.K. Roy	Department of Zoology
28	Prof.Mallikarjun N. Shakarad	Department of Zoology
29	Prof. Neeta Sahgal	Department of Zoology
30	Prof. Rina Chakarbarti	Department of Zoology
31	Prof. Vinay Kr. Singh	Department of Zoology
32	Prof. Pankaj Srivastava	Deptt. of Geology
33	Prof.ParthaPratim Chakraborty	Deptt. of Geology
34	Prof. Vimal Singh	Deptt. of Geology
35	Prof. Sandip Das	Deptt.of Botany
36	Prof. A. K. Verma	Deptt.of Chemistry
37	Prof. Rekha Sapra	Deptt.of Family & Child Welfare
38	Prof. Radhika Bakshi	Department of Home Science
39	Prof. Savita Aggarwal	Institute of Home Economics
40	Prof. R.P. Singh	Jawaharlal Nehru University
41	Prof. Heena K. Bijli	School of Continuing, IGNOU
42	Prof. Jitender Sharma	Pt. Deendayal Upadhyaya National Institute for Persons With physical Disabilities (Divyangjan) **(Special Invitee)**
43	Dr. Pinkey Dureja	A.R.S.D. College
44	Dr.(Ms.) Priya Punjabi Massand	Department of Botany
45	Dr. Vibha Sharma	Department of Chemistry
46	Dr. Alok Kumar Rai	Department of Chemistry

Gmail harish yadav <harish789@gmail.com>

NOTICE : Meeting of the Combined Sub-committee of the Committee of Courses on Wednesday, 20.09.2023 at 1:30 p.m.

1 message

Physics Dept., Delhi University <head.physics.du@gmail.com> Mon, Sep 25, 2023 at 4:39 PM
To: jagjiwanrambalai@dsc.du.ac.in, Sangeeta Gadre <sdgadre@gmail.com>, "Dr. Arijit Chowdhuri" <arijitchowdhuri@andc.du.ac.in>, subhashkumar@andc.du.ac.in, Deepak jain sir <djain@ddu.du.ac.in>, Savinder Kaur <savinder@sgtbkhalsa.du.ac.in>, ashokkumar <ashok_bpdu@yahoo.co.in>, sonialumb@gmail.com, sangeeta@ststephens.edu, Pradeep Kumar <pradeep.tachyons@gmail.com>, seema rawat <rawatseema1@rediffmail.com>, sharmistha.lahiry@gmail.com, Naorem Santakrus Singh <25santacruz@gmail.com>, Vivek Kumar Verma <vivekverma@hinducollege.ac.in>, "vverma_mh@yahoo.co.in" <vverma_mh@yahoo.co.in>, ykumar@arsd.du.ac.in, agam jha <agamjha_2001@yahoo.co.in>, Mamta Dahiya <mamta.phy26@gmail.com>, Nimmi Singh <nimmi@sgtbkhalsa.du.ac.in>, harish yadav <harish789@gmail.com>, chetanajain11 <chetanajain11@gmail.com>, Naveen Gaur <gaur.nav@gmail.com>, Sanju <sanju@mirandahouse.ac.in>, Yogesh Kumar <yogesh.du81@gmail.com>, bilasini.devi@mirandahouse.ac.in, Supreeti Das <supreeti25@gmail.com>, mamtasingh@shivaji.du.ac.in, nitichin@yahoo.co.in, "arvindkumar.physics@dsc.du.ac.in" <arvindkumar.physics@dsc.du.ac.in>
Cc: Physics Department <head.physics.du@gmail.com>, "dngupta@physics.du.ac.in" <dngupta@physics.du.ac.in>, ajit physics du <ajit.physics.du@gmail.com>, Debajyoti Choudhury <debchou.physics@gmail.com>

Dear Colleagues,

The next meeting of the combined Sub-Committee of the Committee of Courses in Physics for B.Sc. (Physics) Hons/Program will be held on Wednesday September 27, 2023 at 3:00 p.m. in the Department. All the members are requested to kindly attend the meeting.

Head of the Department

Combine Sub-Committee of the Committee of Courses Members:

1.	Prof. D.N. Gupta	-	Department
2.	Prof. Ajit Mahapatro	-	Department
3.	Dr. Jagjiwan Balai	–	Dyal Singh College
4.	Dr. Sangeeta Gadre	-	Kirori Mal College
5.	Dr. Arijit Chowdhuri	-	AND College
6.	Dr. Naveen Gaur	-	Dyal Singh College
7.	Dr. Subhash Kumar	-	AND College
8.	Dr. Deepak Jain	-	DDU College
9.	Dr. Sanju	-	Miranda House
10.	Dr. Savinder Kaur	-	SGTB Khalsa College
11.	Dr. Ashok Kumar	-	Ramjas College
12.	Dr. Mamta	-	Shivaji College
13.	Dr. Sonia Lumb	-	Rajdhani College
14.	Dr. Sangeeta Sachdeva	-	St. Stephen's College
15.	Dr. Pradeep Kumar	-	Hans Raj College
16.	Dr. Seema Rawat	-	Zakir Hussain College
17.	Dr. Yogesh Kumar	-	Hansraj College
18.	Dr. Niti Agarwal	-	Shyam Lal College
19.	Dr. N. Santacruz	-	Hindu College
20.	Dr. Vivek Verma	-	Hindu College
21.	Dr. Bilasani Devi	-	Miranda House
22.	Dr.Yogesh Kumar	-	ARSD College
23.	Dr. Agam Jha	-	Kirori Mal College

24. Dr. Mamta Dahiya - SGTB Khalsha College
25. Dr. Harish Kumar – St. Stephen's College
26. Dr. Nimmi Singh - SGTB Khalsha College
27. Dr. Chetana Jain - Hans Raj College
28. Dr. Supreeti Das - Gargi College
29. Dr. Arvind Kumar - Dyal Singh College

NOTICE : Emergent Meeting of the Combined Sub-committee of the Committee of Courses on Monday, 11.12.2023 at 02:00 p.m.

5 messages

Physics Dept., Delhi University <head.physics.du@gmail.com> Fri, Dec 8, 2023 at 5:35 PM
To: jagjiwanrambalai@dsc.du.ac.in, Sangeeta Gadre <sdgadre@gmail.com>, "Dr. Arijit Chowdhuri" <arijitchowdhuri@andc.du.ac.in>, subhashkumar@andc.du.ac.in, Deepak jain sir <djain@ddu.du.ac.in>, Savinder Kaur <savinder@sgtbkhalsa.du.ac.in>, ashokkumar <ashok_bpdu@yahoo.co.in>, sonialumb@gmail.com, sangeeta@ststephens.edu, Pradeep Kumar <pradeep.tachyons@gmail.com>, seema rawat <rawatseema1@rediffmail.com>, sharmistha.lahiry@gmail.com, Naorem Santakrus Singh <25santacruz@gmail.com>, Vivek Kumar Verma <vivekverma@hinducollege.ac.in>, "vverma_mh@yahoo.co.in" <vverma_mh@yahoo.co.in>, ykumar@arsd.du.ac.in, agam jha <agamjha_2001@yahoo.co.in>, Mamta Dahiya <mamta.phy26@gmail.com>, Nimmi Singh <nimmi@sgtbkhalsa.du.ac.in>, harish yadav <harish789@gmail.com>, chetanajain11 <chetanajain11@gmail.com>, Naveen Gaur <gaur.nav@gmail.com>, Sanju <sanju@mirandahouse.ac.in>, Yogesh Kumar <yogesh.du81@gmail.com>, bilasini.devi@mirandahouse.ac.in, Supreeti Das <supreeti25@gmail.com>, mamtasingh@shivaji.du.ac.in, nitichin@yahoo.co.in
Cc: "dngupta@physics.du.ac.in" <dngupta@physics.du.ac.in>, ajit physics du <ajit.physics.du@gmail.com>

Dear Colleagues,

As directed by Convener of the committee, an emergent meeting of the combined Sub-Committee of the Committee of Courses in Physics for B.Sc. (Physics) Hons/Program will be held on Monday December 11, 2023 at 2:00 p.m. in the Department. All the members are requested to kindly attend the meeting.

HoD office Team

Combine Sub-Committee of the Committee of Courses Members:

1.	Prof. D.N. Gupta	-	Department
2.	Prof. Ajit Mahapatro	-	Department
3.	Dr. Jagjiwan Balai	–	Dyal Singh College
4.	Dr. Sangeeta Gadre	-	Kirori Mal College
5.	Dr. Arijit Chowdhuri	-	AND College
6.	Dr. Naveen Gaur	-	Dyal Singh College
7.	Dr. Subhash Kumar	-	AND College
8.	Dr. Deepak Jain	-	DDU College
9.	Dr. Sanju	-	Miranda House
10.	Dr. Savinder Kaur	-	SGTB Khalsha College
11.	Dr. Ashok Kumar	-	Ramjas College
12.	Dr. Mamta	-	Shivaji College
13.	Dr. Sonia Lumb	-	Rajdhani College
14.	Dr. Sangeeta Sachdeva	-	St. Stephen's College
15.	Dr. Pradeep Kumar	-	Hans Raj College
16.	Dr. Seema Rawat	-	Zakir Hussain College
17.	Dr. Yogesh Kumar	-	Hansraj College
18.	Dr. Niti Agrawal	-	Shyam Lal College
19.	Dr. N. Santakrus Singh	-	Hindu College
20.	Dr. Vivek Verma	-	Hindu College
21.	Dr. Bilasini Devi Naorem	-	Miranda House
22.	Dr.Yogesh Kumar	-	ARSD College
23.	Dr. Agam Jha	-	Kirori Mal College
24.	Dr. Mamta Dahiya	-	SGTB Khalsha College

25. Dr. Harish Kumar – St. Stephen's College
26. Dr. Nimmi Singh - SGTB Khalsa College
27. Dr. Chetana Jain - Hans Raj College
28. Dr. Supreeti Das - Gargi Colleg

Mamta Dahiya <mamta.phy26@gmail.com> Sat, Dec 9, 2023 at 5:33 PM
To: "Physics Dept., Delhi University" <head.physics.du@gmail.com>
Cc: jagjiwanrambalai@dsc.du.ac.in, Sangeeta Gadre <sdgadre@gmail.com>, "Dr. Arijit Chowdhuri" <arijitchowdhuri@andc.du.ac.in>, "Dr. Subhash Kumar" <subhashkumar@andc.du.ac.in>, Deepak jain sir <djain@ddu.du.ac.in>, Savinder Kaur <savinder@sgtbkhalsa.du.ac.in>, ashokkumar <ashok_bpdu@yahoo.co.in>, sonialumb@gmail.com, sangeeta@ststephens.edu, Pradeep Kumar <pradeep.tachyons@gmail.com>, seema rawat <rawatseema1@rediffmail.com>, sharmistha.lahiry@gmail.com, Naorem Santakrus Singh <25santacruz@gmail.com>, Vivek Kumar Verma <vivekverma@hinducollege.ac.in>, Vandana Verma <vverma_mh@yahoo.co.in>, ykumar@arsd.du.ac.in, agam jha <agamjha_2001@yahoo.co.in>, Nimmi Singh <nimmi@sgtbkhalsa.du.ac.in>, harish yadav <harish789@gmail.com>, chetanajain11 <chetanajain11@gmail.com>, Naveen Gaur <gaur.nav@gmail.com>, Sanju <sanju@mirandahouse.ac.in>, Yogesh Kumar <yogesh.du81@gmail.com>, bilasini.devi@mirandahouse.ac.in, Supreeti Das <supreeti25@gmail.com>, mamtasingh@shivaji.du.ac.in, nitichin@yahoo.co.in, Devaki Nandan Gupta <dngupta@physics.du.ac.in>, ajit physics du <ajit.physics.du@gmail.com>

Dear sir,
We have our staff council meeting on 11th December at 2pm. So it will not be possible for me to attend the meeting of combined sub committee of the COC. I am really sorry for that.

Regards
Mamta
[Quoted text hidden]

Dr. Subhash Kumar <subhashkumar@andc.du.ac.in> Sat, Dec 9, 2023 at 5:38 PM
To: "Physics Dept., Delhi University" <head.physics.du@gmail.com>
Cc: Deepak jain sir <djain@ddu.du.ac.in>, "Dr. Arijit Chowdhuri" <arijitchowdhuri@andc.du.ac.in>, Mamta Dahiya <mamta.phy26@gmail.com>, Naorem Santakrus Singh <25santacruz@gmail.com>, Naveen Gaur <gaur.nav@gmail.com>, Nimmi Singh <nimmi@sgtbkhalsa.du.ac.in>, Pradeep Kumar <pradeep.tachyons@gmail.com>, Sangeeta Gadre <sdgadre@gmail.com>, Sanju <sanju@mirandahouse.ac.in>, Savinder Kaur <savinder@sgtbkhalsa.du.ac.in>, Supreeti Das <supreeti25@gmail.com>, Vivek Kumar Verma <vivekverma@hinducollege.ac.in>, Yogesh Kumar <yogesh.du81@gmail.com>, agam jha <agamjha_2001@yahoo.co.in>, ajit physics du <ajit.physics.du@gmail.com>, ashokkumar <ashok_bpdu@yahoo.co.in>, bilasini.devi@mirandahouse.ac.in, chetanajain11 <chetanajain11@gmail.com>, "dngupta@physics.du.ac.in" <dngupta@physics.du.ac.in>, harish yadav <harish789@gmail.com>, jagjiwanrambalai@dsc.du.ac.in, mamtasingh@shivaji.du.ac.in, nitichin@yahoo.co.in, sangeeta@ststephens.edu, seema rawat <rawatseema1@rediffmail.com>, sharmistha.lahiry@gmail.com, sonialumb@gmail.com, "vverma_mh@yahoo.co.in" <vverma_mh@yahoo.co.in>, ykumar@arsd.du.ac.in

Dear Sir,
I will be involved in the conduct of practical examination as an internal examiner on 11th December 2022 at my college. It will not be possible for me to be present for this meeting.
My regrets
(Subhash)

Prof. Subhash Kumar
Department of Physics
Acharya Narendra Dev College
(University of Delhi)
New Delhi-110019
[Quoted text hidden]

Nimmi Singh <nimmi@sgtbkhalsa.du.ac.in> Sat, Dec 9, 2023 at 7:28 PM
To: Mamta Dahiya <mamta.phy26@gmail.com>
Cc: "Physics Dept., Delhi University" <head.physics.du@gmail.com>, jagjiwanrambalai@dsc.du.ac.in, Sangeeta Gadre <sdgadre@gmail.com>, "Dr. Arijit Chowdhuri" <arijitchowdhuri@andc.du.ac.in>, "Dr. Subhash Kumar" <subhashkumar@andc.du.ac.in>, Deepak jain sir <djain@ddu.du.ac.in>, Savinder Kaur <savinder@sgtbkhalsa.du.ac.in>, ashokkumar <ashok_bpdu@yahoo.co.in>, sonialumb@gmail.com, sangeeta@ststephens.edu, Pradeep Kumar <pradeep.tachyons@gmail.com>, seema rawat <rawatseema1@rediffmail.com>, sharmistha.lahiry@gmail.com, Naorem Santakrus Singh <25santacruz@gmail.com>, Vivek Kumar Verma <vivekverma@hinducollege.ac.in>, Vandana Verma

St. Stephen's College Delhi MAIL

Dr Sangeeta Sachdeva <sangeeta@ststephens.edu>

Appointment of a member of the Sub-Committee of the Combine CoC/Moderation Committee for UG exam-2023

1 message

Physics Dept., Delhi University <head.physics.du@gmail.com> Tue, Jan 17, 2023 at 3:13 PM
To: jagjiwanrambalai@dsc.du.ac.in, Sangeeta Gadre <sdgadre@gmail.com>, "Dr. Arijit Chowdhuri" <arijitchowdhuri@andc.du.ac.in>, Jacob Cherian <jacob1.cherian@gmail.com>, subhashkumar@andc.du.ac.in, Deepak jain sir <djain@ddu.du.ac.in>, Lalit Chauhan <lalitkrchauhan@gmail.com>, Savinder Kaur <savinder@sgtbkhalsa.du.ac.in>, ashokkumar <ashok_bpdu@yahoo.co.in>, bhartibaniwal9@gmail.com, sonialumb@gmail.com, sangeeta@ststephens.edu, Pradeep Kumar <pradeep.tachyons@gmail.com>, seema rawat <rawatseema1@rediffmail.com>, Punita verma <drpunitaverma.nature@gmail.com>, sharmistha.lahiry@gmail.com, Naorem Santakrus Singh <25santacruz@gmail.com>, Vivek Kumar Verma <vivekverma@hinducollege.ac.in>, "vverma_mh@yahoo.co.in" <vverma_mh@yahoo.co.in>, ykumar@arsd.du.ac.in, agam jha <agamjha_2001@yahoo.co.in>, Mamta Dahiya <mamta.phy26@gmail.com>, Sukanta Dutta <sukantadutta@gmail.com>, Nimmi Singh <nimmi@sgtbkhalsa.du.ac.in>, harish yadav <harish789@gmail.com>, chetanajain11 <chetanajain11@gmail.com>
Cc: DN Gupta <dngupta2001@gmail.com>, ajit physics du <ajit.physics.du@gmail.com>, Senthilkumar P <senthupk@gmail.com>, Physics Department <head.physics.du@gmail.com>, Brajesh Choudhary <brajesh@fnal.gov>

NOTIFICATION

The following faculty member have been appointed as a member of the Sub-Committee of the combined Committee of Courses in Physics and Moderation Committee (to appoint the examiners/paper-setter etc./for moderation of question papers)
for the UG examinations – 2023:

Head of the Department

Combine Sub-Committee of the Committee of Courses Members:

1.	Prof. D.N. Gupta	-	Department
2.	Prof. Ajit Mahapatro	-	Department
3.	Dr. P. Senthil Kumar	-	Department
4.	Dr. Jagjiwan Balai	–	Dyal Singh College
5.	Dr. Sangeeta Gadre	-	Kirori Mal College
6.	Dr. Arijit Choudhary	-	AND College
7.	Dr. Jacob Cherian	-	St. Stephen's College
8.	Dr. Subhash Kumar	-	AND College
9.	Dr. Deepak Jain	-	DDU College
10.	Dr. Lalit Kumar	-	Hindu College
11.	Dr. Savinder Kaur	-	SGTB Khalsha College
12.	Dr. Ashok Kumar	-	Ramjas College
13.	Dr. Bharti	-	Shivaji College
14.	Dr. Sonia Lumb	-	Rajdhani College
15.	Dr. Sangeeta Sachdeva	-	St. Stephen's College
16.	Dr. Pradeep Kumar	-	Hans Raj College
17.	Dr. Seema Rawat	-	Zakir Hussain College
18.	Dr. Punita Verma	-	Kalindi College
19.	Dr. Sharmishtha Lahiri	-	Aurobindo College
20.	Dr. N. Santacruz	-	Hindu College
21.	Dr. Vivek Verma	-	Hindu College
22.	Dr. Vandana Verma	-	Miranda House
23.	Dr.Yogesh Kumar	-	ARSD College
24.	Dr. Agam Jha	-	Kirori Mal College

25.	Dr. Mamta Dahiya	-	SGTB Khalsha College
26.	Dr. Sukanto Dutta	-	SGTB Khalsha College
27.	Dr. Nimmi Singh	-	SGTB Khalsha College
28.	Dr. Harish Kumar	–	St. Stephen's College
29.	Dr. Chetana Jain	-	Hans Raj College

Sub-Committee_UG-2023.pdf
661K

DEPARTMENT OF PHYSICS & ASTROPHYSICS
UNIVERSITY OF DELHI DELHI -110 007
INDIA

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+91-11-27667155
Admn. Office Ph.:
+ 91-11-27666796
e-mail:
head@physics.du.ac.in,
head.physics.du@gmail.com

Ref. No...PDH/DC/2024/

Date: 08.03.2024

NOTIFICATION

The following faculty members have been appointed as a member of the Sub-Committee of the combined Committee of Courses in Physics and Moderation Committee (to appoint the examiners/paper-setter etc./ for moderation of question papers) for the UG examinations – 2024:

Combine Sub-Committee of the Committee of Courses Members:

1.	Prof. D.N. Gupta	-	Department
2.	Prof. Ajit Mahapatro	-	Department
3.	Dr. Arun Kumar	-	Department
4.	Dr. Mangilal Choudhury	-	Department
5.	Dr. Jagjiwan Balai	–	Dyal Singh College
6.	Dr. Sangeeta Gadre	-	Kirori Mal College
7.	Dr. Arijit Chowdhuri	-	AND College
8.	Dr. Naveen Gaur	-	Dyal Singh College
9.	Dr. Subhash Kumar	-	AND College
10.	Dr. Deepak Jain	-	DDU College
11.	Dr. Sanju	-	Miranda House
12.	Dr. Savinder Kaur	-	SGTB Khalsha College
13.	Dr. Ashok Kumar	-	Ramjas College
14.	Dr. Mamta	-	Shivaji College
15.	Dr. Sonia Lumb	-	Rajdhani College
16.	Dr. Sangeeta Sachdeva	-	St. Stephen's College
17.	Dr. Pradeep Kumar	-	Hans Raj College
18.	Dr. Seema Rawat	-	Zakir Hussain College
19.	Dr. Yogesh Kumar	-	Hansraj College
20.	Dr. Niti Agrawal	-	Shyam Lal College
21.	Dr. N. Santakrus Singh	-	Hindu College
22.	Dr. Vivek Verma	-	Hindu College
23.	Dr. Bilasini Devi Naorem	-	Miranda House
24.	Dr.Yogesh Kumar	-	ARSD College
25.	Dr. Agam Jha	-	Kirori Mal College
26.	Dr. Mamta Dahiya	-	SGTB Khalsa College
27.	Dr. Harish Kumar	–	St. Stephen's College
28.	Dr. Nimmi Singh	-	SGTB Khalsa College
29.	Dr. Chetana Jain	-	Hans Raj College
30.	Dr. Supreeti Das	-	Gargi College
31.	Dr. Ramlal Awasthi	-	Sri Venkateswara College
32.	Dr. Pushpa Bindal	-	Kalindi
33.	Dr. Jasmeet Singh	-	Keshav Mahavidhalaya
34.	Dr. Pankaj Narang	-	ARSD College
35.	Dr. Sushil Singh	-	SGTB Khalsa
36.	Dr. Sonam	-	Miranda House
37.	Dr. Sanjay Kumar	-	St. Stephens
38.	Dr. Geetanjali Sethi	-	St. Stephens

प्रो. देबज्योति चौधरी/Prof. Debajyoti Choudhury
Head of the Department
विभागाध्यक्ष/Head
भौतिकी एवं खगोल भौतिकी विभाग
Department of Physics & Astrophysics
दिल्ली विश्वविद्यालय/University of Delhi
दिल्ली–110 007/Delhi-110007

DEPARTMENT OF PHYSICS & ASTROPHYSICS
UNIVERSITY OF DELHI DELHI -110 007
INDIA

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Admn. Office Ph.:
+ 91-11-27666796
e-mail:
head@physics.du.ac.in,
head.physics.du@gmail.com

Ref. No...PDH/DC/2024/

Date: 08.03.2024

NOTIFICATION

The following faculty members have been appointed as a member of the Sub-Committee of the combined Committee of Courses in Physics and Moderation Committee (to appoint the examiners/paper-setter etc./ for moderation of question papers) for the UG examinations – 2024:

Combine Sub-Committee of the Committee of Courses Members:

1.	Prof. D.N. Gupta	-	Department
2.	Prof. Ajit Mahapatro	-	Department
3.	Dr. Arun Kumar	-	Department
4.	Dr. Mangilal Choudhury	-	Department
5.	Dr. Jagjiwan Balai	–	Dyal Singh College
6.	Dr. Sangeeta Gadre	-	Kirori Mal College
7.	Dr. Arijit Chowdhuri	-	AND College
8.	Dr. Naveen Gaur	-	Dyal Singh College
9.	Dr. Subhash Kumar	-	AND College
10.	Dr. Deepak Jain	-	DDU College
11.	Dr. Sanju	-	Miranda House
12.	Dr. Savinder Kaur	-	SGTB Khalsha College
13.	Dr. Ashok Kumar	-	Ramjas College
14.	Dr. Mamta	-	Shivaji College
15.	Dr. Sonia Lumb	-	Rajdhani College
16.	Dr. Sangeeta Sachdeva	-	St. Stephen's College
17.	Dr. Pradeep Kumar	-	Hans Raj College
18.	Dr. Seema Rawat	-	Zakir Hussain College
19.	Dr. Yogesh Kumar	-	Hansraj College
20.	Dr. Niti Agrawal	-	Shyam Lal College
21.	Dr. N. Santakrus Singh	-	Hindu College
22.	Dr. Vivek Verma	-	Hindu College
23.	Dr. Bilasini Devi Naorem	-	Miranda House
24.	Dr.Yogesh Kumar	-	ARSD College
25.	Dr. Agam Jha	-	Kirori Mal College
26.	Dr. Mamta Dahiya	-	SGTB Khalsa College
27.	Dr. Harish Kumar	–	St. Stephen's College
28.	Dr. Nimmi Singh	-	SGTB Khalsa College
29.	Dr. Chetana Jain	-	Hans Raj College
30.	Dr. Supreeti Das	-	Gargi College
31.	Dr. Ramlal Awasthi	-	Sri Venkateswara College
32.	Dr. Pushpa Bindal	-	Kalindi
33.	Dr. Jasmeet Singh	-	Keshav Mahavidhalaya
34.	Dr. Pankaj Narang	-	ARSD College
35.	Dr. Sushil Singh	-	SGTB Khalsa
36.	Dr. Sonam	-	Miranda House
37.	Dr. Sanjay Kumar	-	St. Stephens
38.	Dr. Geetanjali Sethi	-	St. Stephens

प्रो. देबज्योति चौधरी/Prof. Debajyoti Choudhury
Head of the Department
विभागाध्यक्ष/Head
भौतिकी एवं खगोल भौतिकी विभाग
Department of Physics & Astrophysics
दिल्ली विश्वविद्यालय/University of Delhi
दिल्ली–110 007/Delhi-110007

Production Detail Report-II

FRESH /REPURPOSED MOOCS

1. Subject Expert :Dr. Sabina Kazmi
2. Primary Subject : History **Secondary Subject** : European History
3. Target Audience : UG
4. Life of Program : Multiple Telecast
5. Date of Preview :_____
6. **Keywords** : **Demographic Crisis, Climatic and Environmental Crisis Social and Cultural Crisis etc.**
7. **Synopsis:** In the module titled **'Extent of Seventeenth Century European Crisis: Economic, Demographic, Environmental & Social Dimensions'** describes the key developments of 17th century Europe, the demographic and environmental aspects of the crisis, the economic, monetary and fiscal dimensions of the crisis and the social and cultural features of the crisis.

Production Crew:

1. Producer : Chandan Kumar
2. Cameraman : Manmohan Singh
3. Sound : Manmohan Singh
4. Editor :_____
5. Graphics/Animation :_____
6. Date of Dispatch :_____

Signature of Producer & Produced by

Name of Media Centre : **EMRC**

Signature of Director

Name of Media Centre : **EMRC, Patiala**

PUBLIC POLICY

17TH - 21ST JULY 2023

The St. Stephen's Centre for Advanced Learning (SCAL) invites **applications** for a one week In-Person Certificate Course

- Course Timings : 5 - 7 : 30 pm
- Fee : Rs. 5,000 /- including registration kit, refreshments, and certificate
- Open for graduates and professionals only!

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Presents

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Open for graduates and professionals only!

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Tele: 20863821
Email: dirtrgahq-ncc@nic.in

REGISTERED
Directorate General NCC
Ministry of Defence
West Block-IV
RK Puram
New Delhi - 110 066

17101/Syllabus/DGNCC/Trg 'A'

31 Jul 2024

NCC Dte Delhi

REVIEW OF NCC SYLLABUS : JD/JW AND SD/SW

1. Reference HQ DGNCC/P&C (Coord) letter No 15314/HQ NCC/Coord dated 19 Jul 2024.

2. ANO Lt Rakhi Thareja, who is detailed for the above board vide Para 2(vi), to report to Presiding Officer (PO) at DGNCC Camp wef 29 Jul to 04 Aug 2024.

3. For info and necessary action please.

(Harikrishnan N)
Col
Col Trg (A)
for DG NCC

Copy to :-

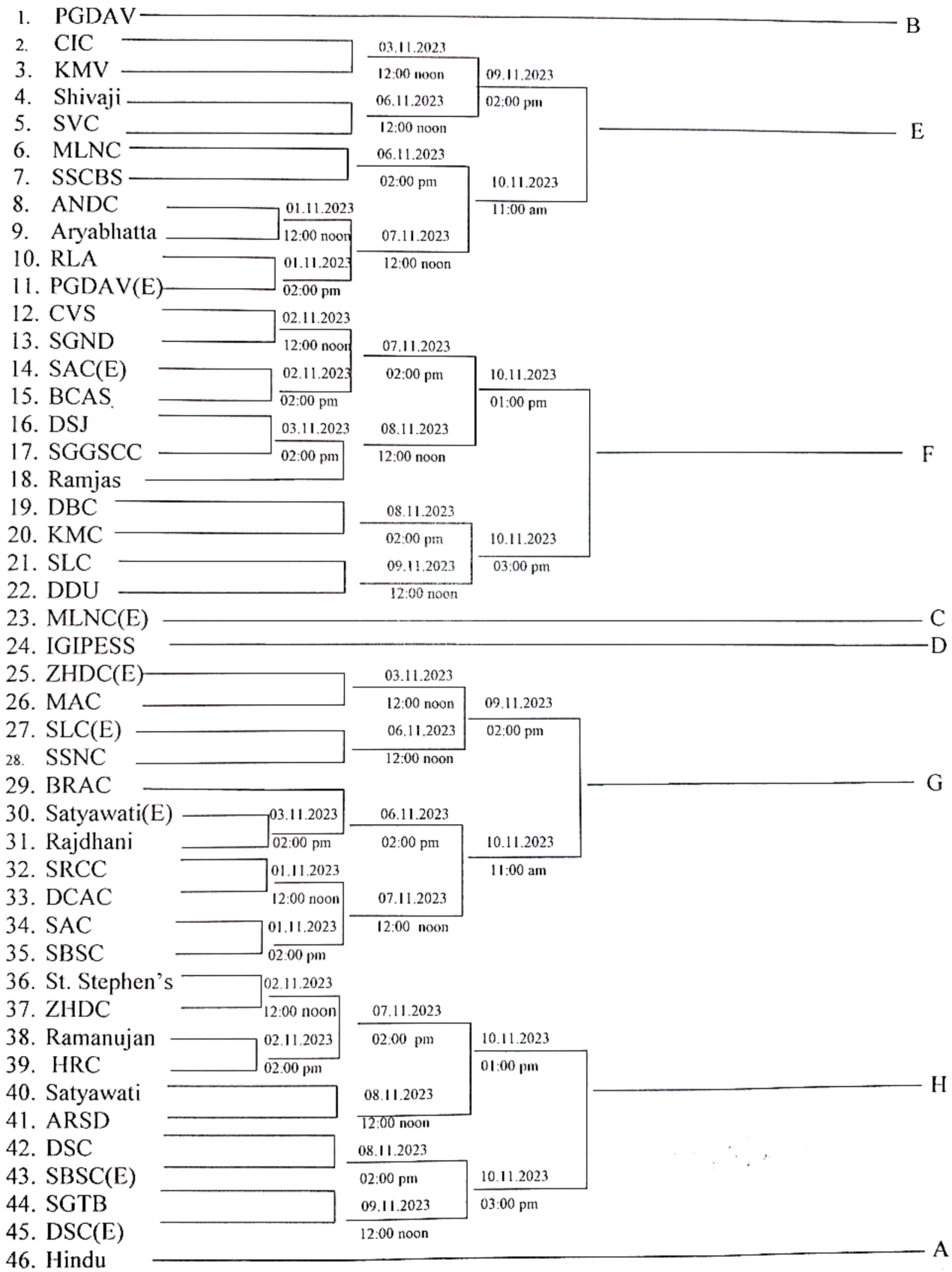
1 DGBN, NCC Dte Delhi.

ANO Lt Rakhi Thareja -

DUSC/IC (M)/2023/
26.10.2023

Delhi University Sports Council

Fixture of Delhi University Inter College Football (Men) Tournament 2023-24



Important:
Matches from serial no.02 to 22 to be played at **Shri Ram College of Commerce,** University of Delhi and serial no. 25 to 45 at **Rugby Stadium**, University of Delhi.

League Matches
Venue: **Rugby Stadium, University of Delhi**

Group – I	Timing	**15.11.2023**	**17.11.2023**	**20.11.2023**
(B,C,E,F)	**09:00 am**	B V/s E	B V/s F	E V/s F
	10:30 am	C V/s F	C V/s E	B V/s C
Group – II	**12:00 noon**	A V/s H	A V/s G	G V/s H
(A,D,H,G)	**01:30 pm**	D V/s G	D V/s H	A V/s D

22.11.2023	**Rugby Stadium, University of Delhi**
10:00 am	Winner of Groups- I V/s Runner of Group – II
12:00 noon	Winner of Groups-II V/s Runner of Group - I

24.11.2023	**Rugby Stadium, University of Delhi**
10:00 am	Third Place Match
12:00 noon	Final Match

Note: Convener should confirm the participation of Team before the Match. In case of non-availability of Team, walkover may be awarded by the Convener to the reporting Team.
1) Student should carry their College I-Cards and Eligibility Performa signed by the Head of the Institution / Competent Authority.
2) Team should be accompanied by the Manager.
3) If the Team scheduled to play do not report within half an hour of the given scheduled time of the Match, the opponent Team will be given walk over.
4) Delhi University team will be selected by the Selection Committee constituted as per the constitution of DUSC.
For Selection Trial, kindly contact the Convener for details.

Tournament/Selection Committee:
1. Chairman, DUSC
2. Director, DUSC
3. Dr. Pawan Dabas (9312219030) — Convener — PGDAV College
4. Dr. Sujay John — St. Stephen's College
5. Dr. Manoj Rathi — PGDAV College
6. Dr. C.S Datta — Hindu College
7. Expert to be nominated by the Chairman, DUSC

26/10/23
Dr. Anil Kumar Kalkal
Director, Physical Education & Sports