Minor Degree in Electrical and Electronics Engineering
(offered to other branches students)

Course Code	Course Name	Level	L	T	P	C	CIE	SEE	Total	Pre-requisite
2501EE55	Operation &Control of Electric Machines	FC	2			2	50	50	100	BEEE
2501EE56	Fundamentals of Power Electronics	FC	2			2	50	50	100	BEEE
2501EE13	Electrical Measurements & Instrumentation	FC	2	1	1	4	50	50	100	ENA-1/BEEE
2501EE53	Electric Power Generation, Transmission & Distribution Systems	IC	3			3	50	50	100	ENA-1/BEEE
2501EE34 2501EE27	Alternative Energy Sources (or) Utilization of Electrical Energy	IC	3			3	50	50	100	EPGDS / BEEE/ ISM
2501EE37 2501EE35	Hybrid Electric Vehicles (or) Special Electric machines	AC	3			3	50	50	100	FPE/ OCEM
2501EE43 2501EE30	Electrical Safety (or) Methods & Algorithms for Intelligent Control	AC	3			3	50	50	100	EPGDS/PSA
	Total		18	1	1	20				

Electric Power Generation, Transmission & Distribution Systems

Course Code: 2501EE53

L	T	P	C
3	0	0	3

Course Outcomes:

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

CO1:	Identify the different components of various power plants.
CO2:	Analyze the performance of short, medium and long transmission lines.
CO3:	Identify various factors related to sag and corona.
CO4:	Distinguish between AC/ DC distribution systems and also estimate voltage drops of distribution systems.
CO5:	Analyze the different economic factors of power generation and tariffs.

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO 11
CO1	3	1	-	-	-	2	-	-	-	-	-
CO2	2	3	1	-	-	-	-	-	-	-	-
CO3	2	1	3	-	-	1	-	-	-	-	-
CO4	2	3	1	-	-	1	-	-	-	-	-
CO5	2	3	1	-	-	-	-	-	-	-	-

UNIT – I

Power Stations: Principle of power generation, site selection and layout of Thermal, Nuclear, Hydro power plant, Components of Thermal and Nuclear power plant

UNIT – II

Performance of Transmission Lines: Classification of Transmission Lines –Short, medium, long and their model representations –End condenser method, Nominal-T–Nominal-Pie, and A, B, C, D Constants, Surge Impedance and SIL of Long Lines.

UNIT – III

Corona and Sag: Corona – Description of the phenomenon–Factors affecting corona–Critical voltages and power loss –Radio Interference. Sag and Tension calculations with equal and unequal heights of towers–Effect of Wind and Ice on weight of Conductor

UNIT – IV

Distribution Systems: Classification of distribution systems, design features of distribution systems, radial distribution, ring main distribution, voltage drop calculations: DC distributors for following cases - radial DC distributor fed at one end and at both ends (equal / unequal voltages), ring main distributor, stepped distributor and AC distribution, comparison of DC and AC distribution.

UNIT – V

Economic Aspects of Power Generation and Tariff Methods: Types of load, Load curve, load duration and integrated load duration curves, Important terms and factors in Load Curve. Costs of Generation and their division into Fixed, Semi-fixed and Running Costs, Characteristics and types of Tariff.

Text Books:

1. A Text Book on Power System Engineering by M. L. Soni, P. V. Gupta, U. S. Bhatnagar &, A. Chakrabarti, Dhanpat Rai & Co. Pvt. Ltd (ISBN: 978817700207).
2. Generation, Distribution & Utilization of Electric Energy by C. L. Wadhawa, Newage International (P) Limited, Publishers (ISBN: 9789393159175).

Reference Books:

1. Principles of Power System by V. K. Mehta & Rohit Mehta, S Chand & Company Limited, Publishers (ISBN: 9788121924962).
2. Electrical Power Distribution Systems by V. Kamaraju, Tata McGraw Hill, New Delhi (ISBN: 978070151413).

Web Links:

1. https://www.slideshare.net/ntpc-project-korbasuper-themal-power-plant
2. https://www.euronuclear.org/1-information/energy-uses.html
3. https://www.slideshare.net/9anku/electrical-distribution-system

Operation & Control of Electric Machines

	L	T	P	C
Course Code:2501EE55	**2**	**0**	**0**	**2**

Course Outcomes:

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

- **CO1** Explain the concepts of electromechanical energy conversion & operation of the DC machines.
- **CO2** Analyze starting methods & speed control of DC machines.
- **CO3** Analyze the performance of DC machines by conducting various tests on DC machines.
- **CO4** Analyze the performance of synchronous generator.
- **CO5** Analyze the Parallel operation of synchronous generators.

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	3	2	-	-	-	-	-	-	1	1	-
CO2	2	3	2	-	-	-	-	-	1	1	-
CO3	3	2	2	-	-	-	-	-	1	1	-
CO4	3	2		-	-	-	-	-	1	1	-
CO5	2	3	2	-	-	-	-	-	1	1	-

UNIT – I

Electromechanical Energy Conversion & introduction to DC machines: Principles of Energy Conversion, singly excited & multi excited systems, torque production in rotating machines & general analysis of the electromechanical system.
DC Generator: Construction - the principle of operation - EMF equation – Types – Armature reaction - Characteristics – Applications.

UNIT – II

DC Motors: Principle of operation - Types- Back EMF - Torque equation – Characteristics – Losses - Efficiency – Commutation – Applications - 3 point starter - 4 point starter – Speed control methods.

UNIT – III

Single-phase Transformers: Types - constructional details – principle of operation – EMF equation – operation on no load & on load – lagging, leading & unity power factors loads – phasor diagrams of transformers – equivalent circuit.

UNIT – IV

Synchronous generator: Operation – Construction - type – Types of Armature windings – Distribution– Pitch & winding factors – E.M.F equation - armature reaction – Voltage regulation by synchronous impedance method– MMF method & Potier triangle method - Two reaction theory, Slip test.

UNIT – V

Parallel Operation of Synchronous Generators: Parallel operation with infinite bus & other alternators – Power flow equations - Synchronizing power – Load sharing– Control of real & reactive power.

Text Books:

1 Electrical Machinery by P.S. Bhimbra, R.C. Khanna & Vineet Khanna, 1st edition, 2021 (ISBN: 9788174091734).

2 Electrical Machines by R. K. Rajput, Lakshmi publications, 5th edition (ISBN: 9788131807460).

Reference Books:

1 Electrical Machines by D. P. Kothari, I. J. Nagarth, McGraw Hill Publications, 5th edition (ISBN: 978070699670).

2 Electrical Machinery by Abijith Chakrabarthi & Sudhipta Debnath, McGraw Hill, 1st edition (ISBN: 978125906456).

Web Links:

1 http://nptel.ac.in/courses/108106071

2 http://www.ncert.nic.in/html/learning_basket/electricity/electricity/machine/ma chi ne_content.htm

3 https://lecturenotes.in/subject/41/electrical-machine-1

Fundamentals of Power Electronics

	L	T	P	C
Course Code:2501EE56	**2**	**0**	**0**	**2**

Course Outcomes:

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

CO1 Explain the different types of power semiconductor devices & their Characteristics.
CO2 Evaluate the performance of rectifiers.
CO3 Design DC-DC& AC-AC converter with given characteristics.
CO4 Explain the operation of Inverters.
CO5 Explain the operation of three phase Inverters & application of PWM techniques.

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	3	2	1	-	-	-	-	-	1	1	-
CO2	2	3	2	-	-	-	-	-	1	1	-
CO3	3	2	2	-	-	-	-	-	1	1	-
CO4	2	3	2	-	-	-	-	-	1	1	-
CO5	3	2	2	-	-	-	-	-	1	1	-

UNIT – I

Introduction to Power Electronics devices:
Concept of power electronics, applications, types of power converters, operation & characteristics of Power IGBT, SCR, TRIAC, static & dynamic characteristics of SCR, protection of SCR, turn on methods of SCR & commutation of SCR, Thyristor Firing Circuits.

UNIT – II

Phase Controlled Converters: Principles of single-phase fully-controlled converter with R, RL, & RLE load, effect of freewheeling diode, Principles of single-phase half-controlled converter with RL & RLE load.

UNIT – III
DC-DC Converters: Introduction, Basic principles of step-down & step-up operation, chopper classification study of Buck, Boost & Buck-Boost regulators.
AC-AC converters: AC Voltage Controllers: Introduction, principle of operation of single-phase voltage controllers for R-L, R-L-E loads.

UNIT – IV

Inverters: Introduction, principle of operation, single phase bridge inverters with R, RL & RLC loads,

UNIT – V

3-phase bridge inverters: 180- & 120-degrees mode of operation, Voltage control of single-phase inverters –single pulse width modulation, multiple pulse width modulation, sinusoidal pulse width modulation.

Text Books:

1 Power Electronics – by P. S. Bhimbra, Khanna Publishers (ISBN:9788174092793).

2 Power Electronics: Circuits, Devices & Applications – by M.H Rashid, Prentice Hall of India, 3rd edition (ISBN: 9788120345317).

Reference Books:

1 Power Electronics: Essentials & Applications by L. Umanand, Wiley, Pvt. Limited, India (ISBN: 9788126519453).

2 Power Electronics, M. D. Singh & K. B. Kanchandhani, Tata McGraw – Hill Publishing Company, 2nd Edition (ISBN: 978074633694).

Web Links:

1 https://nptel.ac.in/courses/108/101/10811038/

2 https://nptel.ac.in/courses/108/102/108102145/

3 https://nptel.ac.in/courses/108/102/108102145/

Electrical Measurements & Instrumentation

	L	T	P	C
Course Code:2501EE13	**2**	**1**	**1**	**4**

Course Outcomes:

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

CO1 Explain different types of instruments for measuring AC & DC quantities.
CO2 Explain different types of instruments for measurement of power & power factor.
CO3 Identify suitable bridges for measurement of R, L, & C
CO4 Analyze the effectiveness of Transducers.
CO5 Illustrate the principle of different types of Digital Meters.

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	3	2	1	-	-	-	-	-	-	-	-
CO2	3	2	1	-	-	-	-	-	-	-	-
CO3	3	2	1	-	-	-	-	-	-	-	-
CO4	2	3	1	-	-	-	-	-	-	-	-
CO5	3	2	1	-	-	-	-	-	-	-	-

UNIT – I

Analog Ammeter & Voltmeters: Classification – deflecting - control & damping torques – PMMC - Moving Iron type & Electrostatic Instruments - Construction - Torque equation - Range extension - Errors & compensations. Instrument transformers – Current & Potential transformers- Construction-Working.

UNIT – II

Analog Wattmeters & Power Factor Meters: Electrodynamometer type wattmeter (LPF & UPF) - Power factor meters: Dynamometer & M.I type (Single phase & Three phase) - Single phase induction type energy meters- Construction - theory - torque equation - advantages & disadvantages. Measurement of active & reactive power in single phase & in three phase with balanced loads.
Potentiometers: Introduction to DC & AC Potentiometers – Construction-working.

Practice:
1. Calibration & Testing of single phase energy Meter.
2. Calibration of dynamometer wattmeter using phantom loading.
3. Calibration of PMMC ammeter & voltmeter using Crompton D.C. Potentiometer.

4. Measurement of 3 phase reactive power with single phase wattmeter for balanced Loading.
5. Measurement of 3 phase power with single wattmeter & using two C.Ts.
6. Calibration of LPF wattmeter by direct loading.

UNIT – III

Measurements of Electrical parameters: DC Bridges: Wheat stone's bridge - Kelvin's double bridge for measuring low resistance - Loss of charge method for measurement of high resistance - Megger – measurement of earth resistance.
AC Bridges: Measurement of inductance & quality factor: - Maxwell's bridge - Hay's bridge - &erson's bridge. Measurement of capacitance & loss angle - Desauty's bridge - Schering Bridge.

Practice:

1. Measurement of resistance & Determination of Tolerance using Kelvin's double Bridge.
2. Capacitance Measurement using Schering Bridge.
3. Inductance Measurement using &erson Bridge.

UNIT – IV

Transducers: Definition - Classification - Resistive - Inductive & Capacitive Transducer - LVDT - Strain Gauge - Thermistors - Thermocouples - Piezo electric & Photo Diode Transducers - Hall effect sensors.

Practice:

1. Determination of the characteristics of a LVDT.

UNIT – V

Digital meters : Digital Voltmeters – Successive approximation DVM - Ramp type DVM & Integrating type DVM – Digital frequency meter - Digital multimeter - Digital tachometer - Digital Energy Meter. CRO- measurement of phase difference & Frequency using lissajious patterns.

Additional practice:

1. Measurement of resistance using Wheatstone bridge.
2. Dielectric oil testing using H.T test Kit.
3. Measurement of Choke coil parameters & single-phase power using three voltmeter & three ammeter method.

Text Books:

1 Electrical Measurements & measuring Instruments by E.W. Golding & F.C.Widdis - 5th Edition - Wheeler Publishing (ISBN: 9780273402022).
2 Modern Electronic Instrumentation & Measurement Techniques by A.D. Helfrick & W.D. Cooper - 5th Edition, PHI (ISBN: 9788120307520).

Reference Books:

1 Electrical & Electronic Measurement & Instruments by A.K.Sawhney Dhanpat Rai & Co.Publications (ISBN: 978609578337).
2 Electrical & Electronic Measurements & instrumentation by R.K.Rajput (ISBN: 9788121929899).

Web Links:

1 Electrical Measurements by Buckingham & Price - Prentice – Hall
2 https://archive.nptel.ac.in/courses/108/105/108105153/
3 https://electricalbaba.com/different-types-of-transducers/

Alternative Energy Sources

	L	T	P	C
Course Code:2501EE34	**3**	**0**	**0**	**3**

Course Outcomes:

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

CO1	Describe the environmental aspects of Renewable Energy Resources.
CO2	Describe the use of Solar Energy & the various components used in the energy production.
CO3	Underst& the conversion principles of Wind & Biomass Energy Resources.
CO4	Acquire the basic knowledge of Ocean Thermal Energy
CO5	Acquire the basic knowledge of energy conversion & Hydrogen Energy.

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	3	3	2	-	-	2	-	-	-	-	-
CO2	3	3	2	-	-	2	-	-	-	-	-
CO3	3	3	2	-	-	2	-	-	-	-	-
CO4	3	3	2	-	-	2	-	-	-	-	-
CO5	3	3	2	-	-	2	-	-	-	-	-

UNIT – I

Introduction: Principles of renewable energy; energy & sustainable development, worldwide renewable energy availability, renewable energy availability in India, brief descriptions on solar energy, wind energy, tidal energy, wave energy, ocean thermal energy, biomass energy, geothermal energy, oil shale

UNIT – II

Solar Energy: Fundamentals; Solar Radiation; Estimation of solar radiation on horizontal & inclined surfaces; Solar radiation Measurements- Pyrheliometers, Pyrometer, Solar Thermal systems: Flat plate collector; Solar distillation; Solar Pond electric power plant. Photovoltaic system for electric power generation.

UNIT – III

Wind Energy: Wind velocity & power from wind; major problems associated with wind power, Basic components of wind energy conversion system (WECS); Classification of

WECS- Horizontal axis- single, double & multiblade system. Vertical axis- Savonius &darrieus types.
Biomass Energy: Biomass Resources; Biomass conversion technologies-fixed dome; Urban waste to energy conversion.

UNIT – IV

Tidal Power: Tides energy suppliers & their mechanics; fundamental characteristics of tidal power, harnessing tidal energy, advantages & limitations.
Ocean Thermal Energy Conversion: Principle of working, OTEC power stations in the world, problems as

UNIT – V

Green Energy: Introduction, Fuel cells: Classification of fuel cells – H2; Operating principles, Zero energy Concepts. Benefits of hydrogen energy, hydrogen production technologies (electrolysis method only), hydrogen energy storage, applications of hydrogen energy (contemporary cases).

Text Books:

1 Non-Conventional energy resources, Khan B.H, Tata Mc-Graw hill, New Delhi, 3rd edition (ISBN: 9789352601882).
2 Non-conventional Energy Sources, G.D.Rai, Khanna Publications, New Delhi, 4th edition (ISBN: 9788174090737).

Reference Books:

1 Renewable energy resources, Twidell, J.W. & Weir, A., BSP Books Pvt.Ltd, UK, 2nd edition (ISBN: 9780415584388).
2 Renewable Energy Technologies, R.Ramesh, Uday kumar, Narosa Publishing House, New Delhi, 1st edition (ISBN:9788173190674).

Utilization of Electrical Energy

	L	T	P	C
Course Code:2501EE27	**3**	**0**	**0**	**3**

Course Outcomes:

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

CO1	Identify various illumination methods produced by different illuminating sources.
CO2	Identify a suitable motor for electric drives & industrial applications
CO3	Identify most appropriate heating & welding techniques for suitable applications.
CO4	Distinguish various traction systems & determine the tractive effort & specific energy consumption.
CO5	Explain the necessity & usage of different energy storage schemes for different applications & comparisons.

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	3	2	1	-	-	-	-	-	-	-	-
CO2	3	2	1	-	-	-	-	-	-	-	-
CO3	3	2	1	-	-	-	-	-	-	-	-
CO4	3	2	1	-	-	-	-	-	-	-	-
CO5	3	2	1	-	-	-	-	-	-	-	-

UNIT – I

Illumination fundamentals & Methods: Illumination fundamentals Introduction - terms used in illumination–Laws of illumination–Polar curves–Integrating sphere–Lux meter Sources of light. Various Illumination Methods Discharge lamps - MV & SV lamps – Comparison between tungsten filament lamps & fluorescent tubes Basic principles of light control– Types & design of lighting & flood lighting–LED lighting - Energy conservation.

UNIT – II

Selection of Motors: Choice of Motor - Type of Electric Drives - Starting & Running Characteristics – Speed Control–Temperature Rise – Applications of Electric Drives–Types of Industrial Loads–Continuous Intermittent & Variable Loads–Load Equalization - Introduction To Energy Efficient Motors.

UNIT – III

Electric Heating & Welding: Advantages & methods of electric heating–Resistance heating induction heating & di electric heating. Electric Welding. Electric welding–Resistance & arc welding–Electric welding equipment–Comparison between AC & DC Welding.

UNIT – IV

Electric Traction: Traction & electrification– Special features of traction motor– Mechanics of train movement, Speed-time curves, tractive effort, Specific energy consumption, acceleration & retardation–Adhesive weight, coefficient of adhesion.

UNIT – V

Introduction to Energy Storage Systems: Need For Energy Storage - Types of Energy Storage-Thermal - Electrical - Magnetic & Chemical Storage Systems - Comparison of Energy Storage Technologies Applications.

Text Books:

1 Utilization of Electric Power – by Er.R.K Rajput – Lakshmi publications Third edition 2023(ISBN: 9788131808290).

2 Utilisation of Electric Power : Including Electric Drives & Electric Traction – by Suryanarayana N.V, New Age International (P) Limited - Publishers – Third edition 2024 (ISBN: 9788122405460).

Reference Books:

1 Utilization Of Electric Energy: Including Electric Drives & Electric Traction -by Tarlok singh(ISBN: 978938027845).

2 Utilization of Electric power & Electric Traction -by J.B.Gupta S.K.Kataria & Sons (ISBN: 9789350142585).

Web Links:

1 https://nptel.ac.in/courses/108105060

2 https://onlinecourses.nptel.ac.in/noc23_ag06/preview

Special Electrical Machines

	L	T	P	C
Course Code:2501EE35	**3**	**0**	**0**	**3**

Course Outcomes:

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

CO1	Explain the operation & control of Stepper Motor.
CO2	Describe theory of operation & control of Switched Reluctance Motor.
CO3	Explain the operation & control of Synchronous Reluctance Motor.
CO4	Describe theory of operation & control of Permanent Magnet Brushless D.C. Motors
CO5	Explicate the theory of PMSM & LIM & its applications.

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	3	2	1	-	-	-	-	-	-	-	-
CO2	3	2	1	-	-	-	-	-	-	-	-
CO3	3	2	1	-	-	-	-	-	-	-	-
CO4	3	2	1	-	-	-	-	-	-	-	-
CO5	3	2	1	-	-	-	-	-	-	-	-

UNIT – I

Stepper Motors: Constructional features – Types of Stepper Motors - permanent magnet (PM) type - Hybrid type Stepper Motor - Variable Reluctance Motor (VRM) - Single stack & multiple stack VRM – Characteristics, Modes of Operation & Applications of Stepper Motor.

UNIT – II

Switched Reluctance Motors: Constructional features, Principle of operation, Torque production, Power Converters & their controllers, Methods of Rotor position sensing, Sensor less operation, Closed loop control of SRM, Characteristics.

UNIT – III

Synchronous Reluctance Motor: Construction, Working, Torque Equation, control, Advantages & Applications Synchronous Reluctance Motor

UNIT – IV

Brushless D.C. Motors: Principle of Operation, Types, EMF & torque equations, Commutation, Motor characteristics & control, Torque/speed characteristics.

UNIT – V

Permanent Magnet Synchronous Motors: Construction, Principle of Operation, EMF Equation of PMSM, Torque Equation, Comparison of Conventional & PM Synchronous Motors, Application of PMSM

Linear Induction Motors

Linear Induction Motors (LIM)- Construction– principle of operation— Development of one-sided LIM with back iron equivalent circuit of LIM-Applications

Text Books:

1	Brushless Permanent magnet & reluctance motor drives, by T.J.E.Miller, Clarenden press, Oxford (ISBN:9780198593690).
2	Special electrical Machines, by K. VenkataRatnam, University press, New Delhi (ISBN: 9781439806463)

Reference Books:

1	Special electrical machines, E.G. Janardhanan, PHI learning private limited (ISBN: 9788120348806).
2	Permanent Magnet & BLDC Motor Drives, by Krishnan R, CRC Press (ISBN:9780824753849).

Web Links:

1	https://nptel.ac.in/courses/108102156
2	https://www.monolithicpower.com/stepper-motors-basics-types-uses
3	https://epochautomation.com/synchronous-reluctance-motor-working/

Electrical Safety

	L	**T**	**P**	**C**
Course Code: 2501EE43	**3**	**0**	**0**	**3**

Course Outcomes:
At the end of the Course, Student will be able to:

CO 1: Describe electrical hazards & safety equipment.
CO 2: Analyze & apply various grounding & bonding techniques
CO 3: Select appropriate safety method for low, medium equipment's & high voltage equipment.
CO 4: Participate in a safety team & Carry out proper maintenance of electrical equipment by underst&ing various St&ards.
CO 5: Analyze the safety method for high voltage equipment's.

Mapping of course outcomes with program outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	3	2	1	-	-	-	-	-	-	-	-
CO2	3	2	1	-	-	-	-	-	-	-	-
CO3	3	2	1	-	-	-	-	-	-	-	-
CO4	3	2	2	-	-	-	-	-	-	-	-
CO5	1	3	1	-	-	-	-	-	-	-	-

UNIT-I:

Hazards of Electricity & Electrical Safety Equipment: Primary & secondary hazards-arc, blast, shocks causes & effects-safety equipment flash & thermal protection, head & eye protection-rubber insulating equipment, hot sticks, insulated tools, barriers & signs, safety tags, locking devices- voltage measuring instruments- proximity & contact testers-safety electrical one line diagram- electrician's safety kit.

UNIT-II:

Grounding of Electrical Systems & Equipment: General requirements for grounding & bonding- definitions grounding of electrical equipment-bonding of electrically conducting materials & other equipment connection of grounding & bonding equipment- system grounding- purpose of system grounding-grounding electrode system- grounding conductor connection to electrodes-use of grounded circuit conductor for grounding equipment-grounding of low voltage & high voltage systems.

UNIT-III:

Safety Procedures & Methods: The six step safety methods- pre job briefings - hot-work decision tree-safe switching of power system- lockout-tag out- flash hazard calculation & approach distances-calculating the required level of arc protection-safety equipment, procedure for low, medium & high voltage systems- the one-minute safety audit

UNIT-IV:

Safety Management & Organizing Structure: Electrical safety program structure, development- company safety team- safety policy program implementation- employee electrical safety teams- safety meetings- safety audit accident prevention- first aid- rescue techniques-accident investigation.

UNIT-V:

Electrical Maintenance & Legal Safety Requirements & St&ards: Safety related case for electrical maintenance- reliability centred maintenance (RCM) - eight step maintenance program- frequency of maintenance- maintenance requirement for specific equipment & location- regulatory bodies- national electrical safety code st&ard for electrical safety in work place- occupational safety & health administration st&ards, Indian Electricity Acts related to Electrical Safety

Text Books:

1. 'Electrical Safety Handbook' by John Cadick, Mary Capelli-Schellpfeffer, Dennis Neitzel, Al Winfield, McGraw-Hill Education, 4th Edition (ISBN: 978071745130)
2. "Electric Safety Practice & Standards", Khaled Ismail, CRC Press, Taylor & Francis (ISBN: 9781138073999).

Reference Books

1. 'Electrical Safety- a guide to the causes & prevention of electric hazards', Maxwell Adams.J, The Institution of Electric Engineers, IET (ISBN: 9780852968062).
2. 'Electrical Safety in the Workplace', Ray A. Jones, Jane G. Jones, Jones & Bartlett Learning (ISBN: 9780877655800).

Web Links:

1. http://nptel.ac.in/courses/103106071/5
2. https://www.electricalsafetyfirst.org.uk

Methods & Algorithms for Intelligent Control

	L	T	P	C
Course Code: 2501EE30	**3**	**0**	**0**	**3**

Course Outcomes:

At the end of the Course, Student will be able to:

CO1: Design feedback controllers for complex dynamic systems using ANN.
CO2: Design fuzzy logic-based controller for dynamic systems.
CO3: Construct TS fuzzy models for complex dynamic systems.
CO4: Formulate hybrid controllers by combining the concepts of Genetic Algorithm and BioInspired algorithms with ANN.
CO5: Formulate hybrid controllers by combining the concepts of Genetic Algorithm and BioInspired algorithms with Fuzzy logic.

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	2	2	3	1	2	-	-	-	-	-	-
CO2	2	2	3	1	2	-	-	-	-	-	-
CO3	2	2	3	1	2	-	-	-	-	-	-
CO4	2	2	3	1	2	-	-	-	-	-	-
CO5	2	2	3	1	2	-	-	-	-	-	-

UNIT – I

Introduction: Introduction to intelligent control, comparison study between conventional and intelligent control, intelligent supervisory control, intelligent adaptive control.

UNIT – II

Neural network based control: Introduction to Neural Network, theory of neural network for classification and function approximation, supervised and unsupervised learning rules, RBF neural network, Support vector machines, intelligent control using Neural Network, Approximation capabilities by feed-forward and recurrent neural network, Neuro-control based on back propagation algorithm, system identification with neural network.

UNIT – III

Fuzzy logic control: Introduction to fuzzy set theory and logic, application of fuzzy logic in control system, fuzzy quantization of knowledge, fuzzy controller design, Fuzzy T-S modelling for dynamic system and stability using Lyapunov theory.

UNIT – IV

Genetic algorithm and control: Basic theory and operations of Genetic algorithm, GA based control system, optimization problem using GA related to control and other engineering problems.

UNIT – V

Bio-inspired evolutionary algorithms: Bio-inspired evolutionary algorithms – like Particle swamp optimization (PSO), simulated annealing, Fire-fly optimization, bacterial foraging etc – only the concepts and case studies related control problems.

Text Books:

1. Neural Networks, Simon Haykin. Pearson Education Asia (ISBN: 978023527616).
2. "Genetic Algorithm in Search Optimization & Machine Learning", David E. Goldberg, Pearson Education (ISBN: 978021157673).

Reference Books:

1. Fuzzy logic (intelligence control and information), J. Yen and R. Langari, Pearson, first edition(ISBN: 9780135258170).
2. Methods and Applications of Intelligent Control, Spyros G. Tzafestas, Kluware academic publisher (ISBN: 97807923462501).

Web Links:

1. https://archive.nptel.ac.in/courses/108/104/108104049/
2. https://archive.nptel.ac.in/courses/106/106/106106126/

Minor Degree in Quantum Technologies

S.No.	Course Code	Course Name	L	T	P	C	Semester
Mandatory Courses							
1	251EC097	Survey of Quantum technologies and Application	3	0	0	3	IV
2	251EC098	Foundations of Quantum Technologies	3	0	0	3	V
3	251EC099	Basic Programming Lab (or)	1	0	2	3	V
	251EC100	Basic Laboratory Course for Quantum Technologies					
4	251EC101	Quantum Algorithms and Cryptography	12 week 3 Credit - NPTEL MOOC			3	VII/VIII
Any One course from the below							
5	251EC102	Introduction to Quantum Computation	3	0	0	3	VI
6	251EC103	Introduction to Quantum Communication	3	0	0	3	VI
7	251EC104	Introduction to Quantum Sensing	3	0	0	3	VI
8	251EC105	Introduction to Quantum Materials	3	0	0	3	VI
Any One course from the below							
9	251EC106	Engineering Foundations of Quantum Technologies	3	0	0	3	VII
10	251EC107	Solid State Physics for Quantum Technologies	3	0	0	3	VII
11	251EC108	Quantum Optics	3	0	0	3	VII
12	251EC109	Quantum Cybersecurity	3	0	0	3	VII
13	251EC110	Quantum Machine Learning	3	0	0	3	VII
Total			**18**	**0**	**0**	**18**	

Survey of Quantum Technologies and Applications

Course Code: 251EC097

L	**T**	**P**	**C**
3	**0**	**0**	**3**

Course Outcomes: At the end of the course, student will be able to:

CO1 Explain the core quantum mechanical principles relevant to qubits and quantum technologies.
CO2 Analyze and compare major qubit hardware platforms used in quantum computation.
CO3 Describe the principles and operating mechanisms of quantum sensing techniques.
CO4 Evaluate practical applications of quantum sensing in measurement and metrology.
CO5 Explain and assess quantum communication protocols over fibre-based and free-space channels.

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	3	2									2
CO2	3	3		2	2						2
CO3	2	2		2	2						2
CO4	2	2		3	2	2					2
CO5	3	3		2	3	2	1				2

UNIT – 1: Quantum Technologies – four verticals: Motivation for Quantum Technologies A qualitative overview of salient aspects of quantum physics: Quantum States, Wavefunctions, Probabilistic interpretation, Physical observables, Hermitian operators, expectation values, Heisenberg uncertainty principle, Schrodinger equation, Time evolution; distinction from classical physics; Heuristic description of Superposition, Tunnelling and entanglement; No cloning theorem; Simulating classical systems – Feynman's idea of a quantum simulator and the birth of the field.

UNIT-II: Quantum Computation: Basics of qubits -- what is a qubit?, How is it different from a classical bit? – Review of classical logic gates; Di Vincenzo criteria for realising qubits; Basics of qubit gates and quantum circuits; Physical implementation of qubits (very qualitative description); Solid State Qubits: Semiconducting Qubits – quantum dots, spins, Superconducting Qubits – charge, flux and phase, Topological Qubits – proposals and advantages; Atoms and Ions: Trapped ions, Rydberg atoms, Neutral atoms; Photonic Qubits: Conventional linear optical setups, Integrated Photonics; NMR qubits: Conventional NMR qubits, NV centres Overview of applications and recent achievements: RSA and Shor's algorithm, Quantum Advantage; Long term goals and strategies being followed : Error correction

UNIT-III: Quantum Sensing: Basics of quantum sensing, Basics of Photon (single and entangled) generation and detection, Gravimetry, Atomic clock, Magnetometry, State of the art in Quantum Sensing

UNIT-IV: Quantum Communications: Basics of digital communication, Quantifying classical information – Shannon entropy, Basic ideas of quantum communication, security, eavesdropping, Overview of quantum communication achievements : Terrestrial – fibre-based, Free space, Satellite-based

UNIT-V: Introduction to Quantum Materials: What are quantum materials, Why are they important, Applications (quantum computing, spintronics, etc.)

Overview of Key Classes of Quantum Materials: Topological Insulators, Superconductors, Mott Insulators, 2D Materials and Quantum Spin Liquids.

Course References:

1. Quantum Information Science – Manenti R., Motta M., 1st Edition, Oxford University Press (2023)
2. Quantum computation and quantum information – Nielsen M. A., and Chuang I. L., 10th Anniversary edition, Cambridge University Press (2010)
3. Elements of Quantum Computation and Quantum Communication, A. Pathak, Boca Raton, CRC Press (2015)
4. An Introduction to Quantum Computing, Phillip Kaye, Raymond Laflamme, and Michele Mosca, Oxford University Press (2006)
5. Quantum computing explained, David McMahon, Wiley (2008)

Foundations of Quantum Technologies

Course Code: 251EC098

L	T	P	C
3	0	0	3

Course Outcomes: At the end of the course, student will be able to:

CO1 Apply mathematical tools to model and analyze classical and quantum physical systems.

CO2 Explain and apply the postulates of quantum mechanics to solve elementary quantum system problems.

CO3 Analyze statistical physics concepts and differentiate classical and quantum statistical distributions.

CO4 Explain and interpret information-theoretic concepts in classical and quantum information systems.

CO5 Analyze and compare classical and quantum computational complexity classes with reference to post-quantum cryptography.

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	3	2			1						2
CO2	3	3		2	1						2
CO3	3	2		2							2
CO4	2	2			2						2
CO5	2	3			1	1	1				2

UNIT-I: Brief overview of classical physics (This segment is meant for the student to understand what a Hamiltonian is, which will feature later in quantum mechanics) : Hamiltonian function and Hamilton's equations, Phase-space description of a system, Connection and Equivalence with Newton's laws for simple systems – free particle, particle moving in a conservative potential, examples of Harmonic oscillator, hydrogen atom. Historical evolution of quantum mechanics: Planck's quantum hypothesis, Photo electric effect, Atomic spectra, Bohr's quantisation principle, De Broglie's Wave particle duality

UNIT-II Postulates of Quantum Mechanics: State vectors and Hilbert Space, Dirac Bra-Ket notation, Measurables and Hermitian Operators, Unitary Transformations, Schrodinger. Equation and Time evolution of quantum states, Measurement Postulate, Schrodinger, Heisenberg and Interaction pictures, Eigen values, Expectation values and Matrix elements, Heisenberg's Uncertainty principle

UNIT-III:

Density operator formalism of quantum mechanics – pure and mixed states; Superposition and Entanglement in quantum mechanics; No cloning theorem; Applications of postulates – Particle in a box, Hydrogen atom, Harmonic Oscillator. Number states, ladder operators and Coherent states of a harmonic oscillator; Spin and Angular momentum – spin half particles; Rabi problem of a spin-half particle in a rotating magnetic field; Bosons and Fermions

UNIT-IV:

Statistical Physics: Quick review of first and second laws of thermodynamics, Thermal Equilibrium and Gibbs principle, Applying Gibbs principle to Classical and Quantum harmonic oscillators, Bosons and Fermions and Quantum statistics – Fermi-Dirac and Bose-Einstein distributions

UNIT - V: Information Science: Digital communication and information: Quantifying information in terms of Shannon entropy; Basic ideas of quantum information; Decoherence and noise; Introductory ideas of Kraus operators Brief overview of Computational Complexity: Qualitative ideas of a Turing machine: Types of Turing machines; Time and Space complexity – P vs NP, PSPACE; Quantum complexity classes – Q, EQP, BQP, BPP, QMA; Post Quantum Cryptography (PQC)

Course References:

1. Introduction to Quantum Mechanics, Griffiths D. J., 3rd Edition, Cambridge University Press (2024)
2. Introduction to Electrodynamics, Griffiths D. J., 4th edition, Cambridge University Press (2020)
3. Principles of Quantum Mechanics, Shankar, R., 2nd edition, Springer (2014)
4. Quantum Information Science – Manenti R., Motta M., 1st Edition, Oxford University Press (2023)
5. Quantum computation and quantum information – Nielsen M. A., and Chuang I. L., 10th Anniversary edition, Cambridge University Press (2010)
6. A Pathak, Elements of Quantum Computation and Quantum Communication, Boca Raton, CRC Press (2015)
7. Information Theory, Robert B. Ash, Dover Publications (2003)
8. Introduction to the Theory of Computation, Michael Sipser, 3rd edition, Cengage India Pvt. Ltd. (2014) Statistical Mechanics, Pathria R. K., Paul D. Beale, 4th edition, Academic Press, (2021)

Basic Programming Lab

Course Code: 251EC099

L	T	P	C
1	0	2	3

Course Outcomes: At the end of the course, student will be able to:

CO1 Apply basic programming concepts and object-oriented principles to develop scientific programs.
CO2 Implement and analyze simple algorithms and evaluate their computational performance.
CO3 Apply numerical methods to solve differential equations and linear algebra problems.
CO4 Analyze probabilistic and statistical data using numerical and simulation techniques.
CO5 Develop computational models for quantum mechanics and electromagnetism applications.

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	3	2			2						2
CO2	3	3			2						2
CO3	3	2		2	2						2
CO4	2	3		2	2						2
CO5	3	3	2	3	2	1		1			2

Course Content and syllabus:

- Basics of programming
  - Data structures, classes, Object-oriented programming
  - Data storage and retrieval, Memory allocation
  - Scientific plotting, documentation of codes
- Simple algorithms and benchmarking run time
  - Sorting
  - Searching
  - Arithmetic algorithms like GCD, Prime factorisation
- Numerical Integration and differential equations
  - Linear 2nd Order ODEs with constant coefficients
  - Linear 2nd order ODEs with variable coefficients
  - Boundary value problems
    - Poisson equation
    - Laplace equation
    - Wave equation
    - Diffusion Equation
- Numerical techniques in linear algebra

    - Matrix inverse
    - Eigenvalue problem
    - Diagonalisation of matrices
    - Singular value decomposition
- Numerical techniques in Probability and Statistics
    - (Pseudo) Random number generation
    - Computing statistical moments for data samples
    - Least Squares fitting
    - Error Analysis
    - Hypothesis Testing
    - Monte Carlo sampling
- Applications to Quantum Mechanics (can be done using openly available modules in languages like Python, Julia etc.)
    - Eigen energies of coupled two level systems
    - Eigen energies of two-level system coupled to oscillator (Jaynes-Cummings Model)
    - Driven two-level system – Rabi Problem
    - Driven damped oscillator — coherent states
- Applications to EM theory (e.g. magnetic field simulation)
    - Electrostatic charge distributions
    - Magnetostatic current distributions
    - Finite Element techniques for electromagnetic simulations

Course References:

Computational Physics, Nicholas Giordano, Hisao Nakanishi, 2nd edition, Pearson-Addison Wesley (2005)

Basic Laboratory Course for Quantum Technologies

	L	T	P	C
Course Code: 251EC100	1	0	2	3

Course Outcomes: At the end of the course, student will be able to:

CO1 Apply optical experimental techniques to measure wavelength, diffraction, polarization, and imaging parameters.

CO2 Analyze and characterize RLC circuits and resonators to determine quality factor and losses.

CO3 Implement and verify basic digital circuits using standard ICs and laboratory instruments.

CO4 Operate RF and microwave instruments to measure transmission, reflection, noise, and network parameters.

CO5 Acquire, process, and interpret experimental data using computer interfacing and quantum simulation tools.

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	3	2		2	2						2
CO2	3	3		2	2						2
CO3	3	2	2		2		1				2
CO4	3	3		2	2	1					2
CO5	3	3	2	2	2	1	1				2

Course Content and syllabus:

- Optics
  - Interferometry – wavelength measurements, intensity measurements
  - Diffraction – single slit, grating
  - Microscopy – magnification, aberration
  - Polarization optics – PBS, HWP, QWP
- RLC circuits
  - Series and parallel RLC circuits – Verifying the quality factor formulae
  - Extracting intrinsic losses
- Digital circuits
  - Adder, Multiplier
  - Encoder, Decoder
  - D flipflop, shift registers
  - How to use common Integrated Circuit chips
- Radio Frequency Technology:
  - Using Oscilloscope

        - Ring-up and ring-down time measurements of RLC circuits
        - Measurements of different pulse-shapes generated by a function generator
    - Using Vector Network Analyser
        - Transmission and reflection measurements of coaxial cable in open, short and matched termination
        - Voltage standing wave ratio measurement
        - Amplitude and Phase quadrature, In-phase and Out-of-phase quadrature plots and Quality factor measurement of RLC circuits
        - Characterising S-parameters, ABCD and Z matrices of common 2 port networks – coaxial cable, attenuator, low pass high pass bandpass filters etc.
        - Characterising 3 port networks – directional couplers, circulators, isolators
    - Using a spectrum analyser
        - Noise from a resistor at different temperatures

- Interfacing instruments with a computer
- Data acquisition
    - Signal demodulation – heterodyne vs Homodyne, Mixing of signals
    - Sampling, digitisation using ADCs – under-sampling and aliasing, oversampling and noise
    - Averaging and interpolation techniques
- Quantum Simulators
    - Running quantum protocols in a quantum simulator
    - Implementing simple quantum algorithms on cloud-based quantum computers (depending on availability of time on such machines)
- Running simple algorithms on cloud-based quantum processors (optional)

Course References:

1. Optics, Eugene Hecht, A. R. Ganesan, 5th edition, Pearson (2019)
2. Art of Electronics, Paul Horowitz and Winfield Hill, 3rd edition, Cambridge University Press (2015)
3. Digital Design, Morris Mano, Michael D. Cilletti, 6th edition, Pearson Education (2018)
4. Microwave Engineering, David Pozar, 4th edition, Wiley (2013)
5. Discrete-time signal processing, Alan V. Oppenheim and Ronald W. Shaffer, 4th edition, Pearson (2009)
6. Optical quantum information and quantum communication, A. Pathak and A. Banerjee, SPIE Spotlight Series, SPIE Press (2016)

Introduction to Quantum Computation

Course Code: 251EC102

L	T	P	C
3	**0**	**0**	**3**

Course Outcomes: At the end of the course, student will be able to:

CO1 Explain the principles of qubits and compare their physical realizations with classical bits.
CO2 Analyze quantum correlations, entanglement, and Bell-type inequalities in quantum systems.
CO3 Apply universal quantum gates and circuits to construct basic quantum computational models.
CO4 Analyze and explain the working of fundamental quantum algorithms such as Grover's and Shor's algorithms.
CO5 Explain quantum computational complexity, error correction techniques, and the limitations of NISQ-era processors.

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	3	2									2
CO2	3	3		2							2
CO3	3	2			2						2
CO4	3	3		2	2						2
CO5	2	3		2	2	2	1		1		2

Course Content and syllabus:

- Qubits versus classical bits
  - Spin-half systems and photon polarizations
  - Trapped atoms and ions
  - Artificial atoms using circuits
  - Semiconducting quantum dots
  - Single and Two qubit gates – Solovay - Kitaev Theorem
- Quantum correlations
  - Entanglement and Bell's theorems
- Review of Turing machines and classical computational complexity
  - Time and space complexity (P, NP, PSPACE)
- Reversible computation
- Universal quantum logic gates and circuits
- Quantum algorithms
  - Deutsch algorithm
  - Deutsch Josza algorithm
  - Bernstein - Vazirani algorithm
  - Simon's algorithm

- Database search
    - Grover's algorithm
- Quantum Fourier Transform and prime factorization
    - Shor's Algorithm.
- Quantum complexity classes – Q, EQP, BQP, BPP, QMA
- Additional Topics in Quantum Algorithms
    - Variational Quantum Eigensolver (VQE)
    - HHL
    - QAOA
- Introduction to Error correction
- Fault-tolerance
- Simple error correcting codes
- Survey of current status
    - NISQ era processors
    - Quantum advantage claims
    - Roadmap for future

Course References:

1. Quantum Information Science – Manenti R., Motta M., 1st Edition, Oxford University Press (2023)
2. Quantum computation and quantum information – Nielsen M. A., and Chuang I. L., 10th Anniversary edition, Cambridge University Press (2010)
3. A Pathak, Elements of Quantum Computation and Quantum Communication, Boca Raton, CRC Press (2015)
4. Quantum error correction and Fault tolerant computing, Frank Gaitan, 1st edition, CRC Press (2008)
5. Quantum computing explained, David McMahon, Wiley (2008)
6. Introduction to Quantum Computing: From a lay person to a programmer in 30 steps, Hui Yung Wong, 1st edition, Springer-Nature Switzerland AG (2022)

Introduction to Quantum Communication

	L	T	P	C
Course Code: 251EC103	**3**	**0**	**0**	**3**

Course Outcomes: At the end of the course, student will be able to:

CO1 Explain the principles of polarization optics and photodetection relevant to quantum communication systems.

CO2 Analyze classical and quantum information concepts including entropy, noise, and channel capacity.

CO3 Explain and analyze quantum correlations, Bell measurements, and fundamental quantum communication protocols.

CO4 Analyze the working of quantum communication protocols such as teleportation, dense coding, and quantum key distribution.

CO5 Evaluate quantum communication architectures, hardware implementations, and the concept of quantum networks and internet.

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	3	2									2
CO2	3	3			2						2
CO3	3	3		2							2
CO4	3	3		2	2		1		2		2
CO5	2	2		2	3	2	1		2		2

Course Content and syllabus:

- Basics of Polarization optics
  - Quarter and half-wave plates
  - Polarizing beam splitters
- Basics of linear and square-law detectors
  - Quadrature amplitude modulation
  - Heterodyne and Homodyne demodulation and linear detectors
  - Intensity measurements and square law detectors
  - Photomultipliers, Avalanche Photo diodes
- Digital communication – information theory (basics)
  - Information entropy
  - Noiseless channel encoding
  - Noisy channel encoding
- No cloning theorem
- Quantum Memories
- Quantum repeaters
- Entanglement and Bell Theorems
- Bell Measurements and Tests
- Quantum Teleportation protocol

- Quantum Dense coding
- Quantum Key Distribution protocols
  - BB84
  - E91
  - BBM92.
  - B92
  - COW
  - DPS
- Quantum Networks and Quantum Internet
- Survey of Hardware implementations
  - Free space communications
  - Satellite based communications
  - Fibre optics-based communications

Course References:

1. Quantum computation and quantum information – Nielsen and Chuang Cambridge University Press, Cambridge (2010)
2. A Pathak, Elements of Quantum Computation and Quantum Communication, Boca Raton, CRC Press (2015)

Introduction to Quantum Sensing

L	T	P	C
3	0	0	3

Course Code: 251EC104

Course Outcomes: At the end of the course, student will be able to:

- **CO1** Explain the principles of classical sensing, noise mechanisms, and measurement sensitivity limits.
- **CO2** Analyze quantum measurement processes including projective, weak, and non-demolition measurements.
- **CO3** Apply information-theoretic bounds to quantify and optimize quantum sensing performance.
- **CO4** Analyze quantum states of light and photodetection techniques used in precision measurements.
- **CO5** Evaluate photon-, entanglement-, atomic-, and spin-based quantum sensing applications.

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	3	2									2
CO2	3	3		2							2
CO3	3	3		2	2						2
CO4	3	3		2	2				2		2
CO5	2	3		3	2	2			2		2

Course Content and syllabus:

- Classical sensing
  - photo detection
- Classical Noise
  - Johnson Noise, Telegraph noise, flicker or 1/f noise
- Sensitivity of classical measurements
  - Classical Fisher information
  - Cramer - Rao bounds (information theory basics may be required here).
- Quantum measurements
  - projective/orthogonal measurements
  - Approximate/non-orthogonal measurements
  - Weak continuous measurements
  - Error-disturbance relations
  - Standard quantum limits
  - Quantum non-demolition measurements
- States of light
  - fock states
  - Coherent states

- Squeezed states
- Tomography
- Wigner quasi-probability distribution
- P-distribution
- Husimi Q function

- Quantum photo detection
  - Square-law detectors, Intensity measurements and Photo-detection
  - Linear Detectors and Quadrature Measurements
- Quantum Cramer-Rao bounds
- Single photon-based sensing applications
- Entanglement based sensing applications
- Atomic state-based sensing, solid-state spin-based sensing applications (gravimetry, magnetometry)

Course References:

1. Quantum Measurement and Control , Howard Wiseman and David Milburn, Cambridge University Press (2014)
2. Quantum Measurement , Vladimir Braginsky and Farid Ya Khalili, Cambridge University Press (1995)
3. Quantum Information Science – Manenti R., Motta M., 1st Edition, Oxford University Press (2023)

Introduction to Quantum Materials

	L	T	P	C
Course Code: 251EC105	**3**	**0**	**0**	**3**

Course Outcomes: At the end of the course, student will be able to:

CO1 Explain the fundamental concepts of band theory and electronic structure in solids.
CO2 Analyze correlated systems and magnetic phenomena using basic experimental and theoretical principles.
CO3 Explain the principles of superconductivity and the operation of superconducting devices.
CO4 Analyze the electronic and optical properties of two-dimensional materials such as graphene and TMDCs.
CO5 Explain topological phases of matter and assess material growth techniques relevant to quantum technologies.

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	3	2									2
CO2	3	3		2							2
CO3	3	2		2							2
CO4	3	3		2	2				2		2
CO5	2	2		2	2	2			2		2

Course Content and syllabus:

- Band theory basics
  - Metals, Semiconductors and Insulators
  - Band structure of solids
  - Survey of semiconducting devices for quantum technologies (electronic, quantum optical devices and principle of operation)
- Correlated systems
- Magnetism
  - Para, ferro magnetism basics
  - Magnetic measurements, hall effect, magnetoresistance
  - Faraday and Kerr effects
- Superconductivity
  - BCS theory
  - Ginzburg Landau
  - Josephson Effect – AC and DC Josephson effects
  - Survey of superconducting devices for quantum technologies
- 2D materials

    - Graphene and its properties – single and few layers
    - Transition Metal Dichalcogenides – Electronic and Optical Properties
- Topological Phases of matter
    - Basics of Topology
    - Geometric phases - Berry Phase
    - Aharonov Bohm effect
    - Topological phases of matter
- Survey of material growth techniques
    - Molecular beam epitaxy
    - Chemical vapor deposition, MOVPE
    - Pulsed laser deposition, etc.
    - Crystal growth techniques

Course References:

1. Condensed Matter Physics , M P Marder, 2nd Edition, John Wiley and Sons, 2010
2. Introduction to Superconductivity, Michael Tinkham, standard ed., Medtech (2017)

Engineering Foundations of Quantum Technologies

	L	T	P	C
Course Code: 251EC106	**3**	**0**	**0**	**3**

Course Outcomes: At the end of the course, student will be able to:

CO1 Apply principles of electrical networks and transmission lines to analyze resonant circuits and signal propagation.
CO2 Explain abstract models of computation and analyze algorithmic complexity using classical computation theory.
CO3 Analyze analog and digital communication techniques with respect to modulation, noise, and information capacity.
CO4 Apply noise analysis and signal conditioning principles to evaluate system performance and quantum noise limits.
CO5 Explain cryptographic principles and analyze classical and post-quantum cryptographic protocols.

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	3	2	2		2						2
CO2	3	3									2
CO3	3	3		2	2			2			2
CO4	3	3		2	2						2
CO5	2	3			2	2		2			2

Course Content and syllabus:

● Electrical Networks (4 hours)
  ○ Analog RLC circuits – resonances, impedances, quality factors
  ○ Transmission line basics (2 hours)
    ■ Telegrapher equations, wave impedance, impedance matching, transmission line resonators

● Computer Science (15 hours)
  ○ Basics of computer architecture (1 hour)

■ Arithmetic Logic Unit
■ Memory
  ○ Abstract models of computation (12 hours)
    ■ Finite State Machine
    ■ Turing Machines
    ■ Overview of Hierarchy of languages – Regular, Context-Free, Turing Decidable and Turing Recognisable
  ○ Complexity Theory (2 hours)
    ■ Time and Space complexity

        - P vs NP, NP-completeness
- Electrical Communications (1 hour)
    - Analog Communications (1 hour)
        - Quadrature amplitude modulation
        - Heterodyne and Homodyne demodulation
- Noise and Signals (6 hours)
    - Characterising Noise
    - Types of Noise
        - Shot Noise
        - Johnson-Nyquist Noise
        - Telegraphic noise or flicker or 1/f noise
- Signal conditioning and noise mitigation
- Amplification and Added Noise
        - Linear Amplifier theory
        - Signal-Noise Ratio, Added Noise, Noise Figure of amplification
        - Dynamic Range
        - Noise temperature
        - Quantum limits on noise in linear amplifiers
- Digital Communications (4 hours)
- Information entropy
- Noiseless channel encoding
- Noisy channel encoding
- Basics of cryptography (6 hours)
    - Basics of Number Theory
    - Random Number Generation
    - One time pad, Private key, public key, symmetric and asymmetric cryptography protocols
    - RSA and DH
    - Post Quantum Cryptography (PQC)

Course References:

1. Art of Electronics, Paul Horowitz and Winfield Hill, 3rd edition, Cambridge University Press (2015)
2. Digital Design, Morris Mano, Michael D. Cilletti, 6th edition, Pearson Education (2018)
3. Microwave Engineering, David Pozar, 4th edition, Wiley (2013)
4. Information Theory, Robert B. Ash, Dover Publications (2003)
5. Introduction to the Theory of Computation, Michael Sipser, 3rd edition, Cengage India Pvt. Ltd. (2014)
6. Protecting Information – From Classical error correction to quantum cryptography, Susan Loepp and William K. Wootters, Cambridge University Press (2006)

Solid State Physics for Quantum Technologies

	L	T	P	C
Course Code: 251EC107	**3**	**0**	**0**	**3**

Course Outcomes: At the end of the course, student will be able to:

CO1 Explain crystal structures, symmetry, diffraction principles, and bonding mechanisms in solids.
CO2 Analyze electronic properties of solids using free-electron, band theory, and tight-binding models.
CO3 Analyze lattice vibrations and phonon dynamics to explain vibrational and thermal properties of solids.
CO4 Explain and analyze magnetic phenomena in solids using classical and quantum models.
CO5 Explain superconducting phenomena and analyze superconducting materials and devices relevant to quantum technologies.

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	3	2									2
CO2	3	3		2							2
CO3	3	3		2							2
CO4	3	2		2							2
CO5	3	3		2	2	2					2

Course Content and syllabus:

- Structure of solids –
- ○ Symmetry, Bravais lattices
- ○ Laue equations and Bragg's law,
- ○ Brillouin Zones
- ○ Atomic scattering and structure factors.
- Characterisation of crystal structures – XRD etc.
- Bonding in solids –
- ○ van der Waals and Repulsive interactions,
- ○ Lennard Jones potential,
- ○ Madelung constant
- The Drude theory of metals –
  - DC & AC electrical conductivity of a metal;
  - Hall effect & magnetoresistance,
  - Density of states, Fermi-Dirac distribution, Specific heat of degenerate electron gases
  - Free electron model

- Beyond the Free electron model
  - Kronig-Penney Model
  - Periodic potential – Bloch Theorem
  - Band theory
  - Tight binding model
- Phonons in Solids
  - One dimensional monoatomic and diatomic chains
  - Normal modes and Phonons
  - Phonon spectrum
  - Long wavelength acoustic phonons and elastic constants
  - Vibrational Properties- normal modes, acoustic and optical phonons.
- Magnetism
  - Dia-, Para-, and Ferromagnetism
  - Langevin's theory of paramagnetism
  - Weiss Molecular theory
- Superconductivity:
  - Phenomenological description – Zero resistance, Meissner effect
  - London Theory
  - BCS theory
  - Ginzburg-Landau Theory
  - Type-I and type-II superconductors
  - Flux quantization
  - Josephson effect.
  - High Tc superconductivity

Course References:

1. Introduction to Solid State Physics, Charles Kittel, Wiley India Edition (2019)
2. Condensed Matter Physics, M P Marder, 2nd Edition, John Wiley and Sons (2010)
3. Introduction to Superconductivity, Michael Tinkham, standard edition, Medtech (2017)

Quantum Optics

	L	T	P	C
Course Code: 251EC108	**3**	**0**	**0**	**3**

Course Outcomes: At the end of the course, student will be able to:

CO1 Explain the quantization of the electromagnetic field and the properties of non-classical states of light.

CO2 Analyze optical coherence phenomena and interferometric techniques using quantum optical principles.

CO3 Analyze phase-space representations of quantum states of light to identify non-classical features.

CO4 Analyze classical, semi-classical, and quantum models of light–matter interaction in atomic systems.

CO5 Apply open quantum system models to describe decoherence and dissipation in quantum optical systems.

Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	3	2									2
CO2	3	3		2					1		2
CO3	3	3		2					1		2
CO4	3	3		2	2				1		2
CO5	3	3		2	2				1		2

Course Content and syllabus:

- Quantization of the electromagnetic field
  - Number states, coherent states, squeezed states
  - Hanbury-Brown and Twiss experiments – Photon bunching, Photon anti bunching
  - Hong-Ou-Mandel interference
- Theory of Optical coherence
  - Young's double slit experiment and first order coherence
  - Coherence functions of arbitrary order
  - Normal ordering, symmetric ordering and ani-normal ordering of operators
  - Interferometry
- Phase-space representations of states of light
  - Wigner distribution
  - P-function and the notion of non-classicality with some examples of nonclassical states like squeezed states and their applications
  - Husimi Q function
- Light-matter interaction
  - Classical model of light-matter interaction

  - Semi-classical model of light-matter interaction-
  - Quantum light-matter interaction
  - Rabi Model
  - Jayne's-cummings model
- Open quantum systems
  - Fermi golden rule
  - Born-Markov Lindblad Master Equation

Course References:

1. Introductory Quantum Optics, Christopher Gerry and Peter Knight, Cambridge University Press (2004)
2. Quantum Optics, D. F. Walls, Gerard J. Milburn, 2nd Edition, Springer (2008)
3. Quantum Optics: An introduction, Mark Fox, Oxford University Publishers (2006)
4. Quantum Optics for Beginners, Z. Ficek and M. R. Wahiddin, 1st edition, Jenny Stanford Publishing (2014)