Detailed Syllabus
Lecture-wise Breakup

Course Code	19M21PH211	**Semester: Even**	**Semester: III Session** 2020 -2021 **Month from: July to December**
Course Name	Nuclear and Particle Physics		
Credits	4	**Contact Hours**	3+1
Faculty (Names)	**Coordinator**	Manoj Tripathi	
	Teacher	Manoj Tripathi	

COURSE OUTCOMES		**COGNITIVE LEVELS**
CO1	Recall the basic nuclear properties and laws of nuclear and particle physics.	Remembering (C1)
CO2	Understand different phenomenon and concepts of nuclear and particle physics along with their interpretation.	Understanding (C2)
CO3	Apply the concept and principles to solve problems related to nuclear and particle physics.	Applying (C3)
CO4	Analyze and examine thesolutions of the problems of nuclear and particle physics using physical and mathematical tools involved.	Analyzing (C4)

Module No.	**Title of the Module**	**Topics in the Module**	**No. of Lectures for the module**
1.	**Nucleus properties and nuclear models**	Basic nuclear properties – size, shape and charge distribution, nuclear energy levels, nuclear angular momentum, parity, isospin, statistics, and nuclear magnetic dipole moment. Binding energy, semi-empirical formula, Liquid drop model, Magic Numbers, Shell model and collective nuclear model.	8
2.	**Nuclear decay and nuclear reaction**	Alpha decay, Gamow's theory of alpha decay, Beta decay, Fermi's theory of beta decay, Fermi-Kurie plot, decay rates, Fermi and Gamow Teller selection rules, Gamma decay, Angular correlation in successive gamma emissions. Fission and Fusion, Nuclear reactions, reaction mechanism, compound nuclei and direct reactions.	8
3.	**Nuclear forces**	Classification of fundamental forces, Nature of nuclear force, form of nucleon-nucleon potential, charge independence and charge-symmetry of nuclear forces. Deuteron problem – properties of deuteron, ground state of deuteron, excited state, magnetic quadrupole moment of deuteron.	9
4.	**Elementary particles and relativistic kinematics**	Classification of elementary particles and their quantum numbers (charge, spin, parity, isospin, strangeness, etc.), Gellmann-Nishijima formula, Lepton & Hadrons, Classification of Hadron in baryons and mesons, Okubo mass formula for octet and decaplet Hadrons, Quark model,. C, P, and T invariance. Elementary particle	15

		symmetries, SU(2) and SU(3) groups, Their representations. Application of symmetry arguments to particle reactions. Parity non-conservation in weak interaction.	
		Total number of Lectures	**40**

Evaluation Criteria

Components	**Maximum Marks**
T1	20
T2	20
End Semester Examination	35
TA	25 [2 Quiz (7 M), Attendance (7 M) and A mini-project and class performance (6 M) and class performance (5M)]
Total	**100**

Recommended Reading material: Author(s), Title, Edition, Publisher, Year of Publication etc. (Text books, Reference Books, Journals, Reports, Websites etc. in the IEEE format)

1.	K. S. Krane, Introducing nuclear physics, Wieley India (2008).
2.	D. C. Tayal, Nuclear Physics. Himalya Publication House, Bombay (2015).
3.	Irving Kaplan, Nuclear Physics, Narosa Publication (2002).
4.	D. Griffiths, Introduction to elementary particles, 2^{nd} Ed, Academic Press (2008).
5.	S. N. Ghoshal, Nuclear and Particle Physics, S. Chand Limited (2008).

Detailed Syllabus

Lecture-wise Breakup

Course Code	19M21PH212	**Semester: Odd**	**Semester: 3^{rd} Session 2020-21** **Month from: July to December**
Course Name	**Advanced Quantum Mechanics**		
Credits	**4**	**Contact Hours**	**3L+1T**
Faculty (Names)	**Coordinator**	S P Purohit	
	Teacher	S P Purohit	

COURSE OUTCOMES		**COGNITIVE LEVELS**
CO1	Recall basic ideas of advanced quantum mechanics	Remembering (C1)
CO2	Explain various physical phenomena which can be explained only using advanced quantum mechanics	Understanding (C2)
CO3	Apply time-independent perturbation methods, time-dependent perturbation methods, quantum collision theory, quantum statistics and relativistic quantum mechanics for quantum mechanical systems.	Applying (C3)
CO4	Analyze advanced quantum mechanical problems.	Analyzing (C4)

Module No.	**Title of the Module**	**Topics in the Module**	**No. of Lectures for the module**
1.	**Approximation methods for time-dependent problems**	Time-dependent perturbation theory, General features, Fermi's golden rule, periodic perturbation, the adiabatic approximation and application to some atomic systems.	8
2.	**Quantum collision theory**	Scattering experiments and cross-sections, non-relativistic scattering theory, scattering by central potential, phase shift analysis, optical theorem, method of partial waves, scattering by a square well potential, the Born approximation, some applications of quantum collision theory.	8
3.	**Quantum statistics**	The density matrix, the density matrix for a spin-1/2 system, polarisation, the equation of motion of the density matrix, quantum mechanical ensembeles, applications to single-particle systems, systems of non-interacting particles, consequences of particle statistics, ideal quantum gases, Bose-Einstein condensation in atomic gases.	6
4.	**Relativistic quantum mechanics**	The Klein-Gordon equation, the Dirac equation, physical implementation and applications, covariant formulation of the Dirac theory, plane wave solutions of the Dirac equation.	6

5.	**Quantization of Wave Fields**	Classical and quantum field equations, coordinates of the field, time derivatives, classical Lagrangian and Hamiltonian equations, quantum equations for the field, fields with more than one components, quantisation of the non-relativistic Schrodinger equation, creation, destruction and number operators, anticommutation relations and operators, electromagnetic field in vacuum, interaction between charged particles and electromagnetic field.	8
6.	**Some applications of quantum mechanics (only qualitative discussion)**	The van der Waals interaction, electrons in solids, the decay of K-mesons, semiconductor quantum devices, quantum communication	4
		Total number of Lectures	**40**

Evaluation Criteria

Components	**Maximum Marks**
T1	20
T2	20
End Semester Examination	35
TA	25 [2 Quiz (7 M), Attendance (7 M) and A mini-project and class performance (6 M) and class performance (5M)]
Total	**100**

Recommended Reading material: Author(s), Title, Edition, Publisher, Year of Publication etc. (Text books, Reference Books, Journals, Reports, Websites etc. in the IEEE format)

1.	Leonard I. Schiff, Quantum Mechanics, McGraw-Hill, Singapore, 1985
2.	B. H. Bransden and C. J. Joachain, Quantum Mechanics, Pearson Education Ltd., 2000
3.	J. J. Sakurai, Advanced Quantum Mechanics
4.	J. D. Bjorken & S. D. Drell, Relativistic Quantum Fields

Detailed Syllabus
Lecture-wise Breakup

Course Code	19M21PH213	**Semester:** Odd		**Semester: III** **Session** 2020 -2021 **Month from:** July-December
Course Name	Numerical Techniques and Computer Programming			
Credits	03		**Contact Hours**	03

Faculty (Names)	**Coordinator(s)**	A P S Chauhan
	Teacher(s) (Alphabetically)	A P S Chauhan

COURSE OUTCOMES		**COGNITIVE LEVELS**
CO1	Define key concepts used in programming, data structures, Numerical methods.	Remember Level (C1)
CO2	Explain basics of programming, data structures, numerical analysis, parallel programming.	Understand Level (C2)
CO3	Create programs using C to implement various problems in numerical analysis.	Apply Level (C3)
CO4	Create programs using Mathematica and Matlab to solve various problems in numerical physics.	Apply level (C3)

Module No.	**Title of the Module**	**Topics in the Module**	**No. of Lectures for the module**
1.	Introduction to Programming	Fundamentals of Programming, high/low level languages, compilation and linking, Basic data types, Arithmetic operators, Elementary introduction to header files, print f, scan f and control functions of Turbo C/C++, Looping	10
2.	Data Structures	One and two dimensional arrays of various data types, Operations involving matrices and vectors, String of characters and related library functions, Functions and arrays, Structures, array of structures, unions and enumerations, Command line arguments. Dynamical memory allocation, Plotting simple geometric figures	15
3.	Numerical	Simple C programs covering some elementary topics in	10

	Techniques	numerical analysis such as root finding, interpolation, numerical differentiation and integration, numerical linear algebra, Euler and Runga-Kutta methods.	
4.	Approximation methods	Basic ideas of parallel computing and introduction to the software popularly used in Physics such as Mathematica and Matlab	05
		Total number of Lectures	**40**

Evaluation Criteria

Components	**Maximum Marks**
T1	20
T2	20
End Semester Examination	35
TA	25 [2 Quiz (7 M), Attendance (7 M) and A mini-project and class performance (6 M) and class performance (5M)]
Total	**100**

Recommended Reading material: Author(s), Title, Edition, Publisher, Year of Publication etc. (Text books, Reference Books, Journals, Reports, Websites etc. in the IEEE format)

1.	Greg Perry and Dean Miller, C Programming Absolute Beginner's Guide, Paperback, 2013.
2	Bjarne Stroustrup , C++ Programming Language, Paperback, 2013.
3	K. E. Atkinson, Numerical Analysis, John Wiley (Asia), 2004.
4	S. C. Chapra and R. P. Canale, Numerical Methods for Engineers, Tata McGraw Hill, 2002.
5	Stephen Wolfram ,The Mathematica Book, Fifth Edition , Wolfram Media, Inc., 2012.
6	A. Gilat, MATLAB An Introduction With Applications 4th Edition, John Wiley, 2013.

Detailed Syllabus

Lecture-wise Breakup

Course Code	19M21PH214	**Semester:** Odd	**Semester: III Session** 2020 -2021 **Month from:** July-December
Course Name	Advanced Condensed Matter Physics-1		
Credits	03	**Contact Hours**	03
Faculty (Names)	**Coordinator(s)**	Prof. R.K. Dwivedi	
	Teacher(s) (Alphabetically)	NA	

COURSE OUTCOMES		**COGNITIVE LEVELS**
CO1	Recall basic concepts related to magnetism, transport phenomena, phase transition and super conductivity	Remember Level (C1)
CO2	Explain the significance and value of condensed matter physics, both scientifically and in the wider community	Understand Level (C2)
CO3	Develop knowledge of conception or notion involved in various theories and models studied in this course	Apply Level (C3)
CO4	Make use of various methods and solve problems related to studied theories.	Apply level (C3)

Module No.	**Title of the Module**	**Topics in the Module**	**No. of Lectures for the module**
1.	Dielectrics and Ferroelectrics	Dielectrics, Maxwell Boltzmann equations, Polarization and macroscopic electric field, Local electric field of an atom, Lorentz field, Polarizabilty, Classius-Mossoti relation, Type of polarization and polarizabilities, Frequency dependence of polarizabilities. Ferroelectric crystals and structural phase transitions, Order-disorder phase transition, Displacive and soft mode transition, LST relation, Landau Theory of Phase transition, First order and second order phase transition, Anti-ferroelectricity, Ferroelectric domains (90^o and 180^o), Piezoelectricity and piezoelectric relations	12
2.	Magnetism	Magnetiztion and magnetic susceptibilty, Langevin theory of diamagnetism and Van Vleck paramagnetism, Quantum theory of Paramagnetism, Curie Brillouin law. Curie-Weiss ferromagnets, Magnons, Curie temperature and susceptibility of Ferrimagnets, Néel temperature and Anti-ferromagnetic order, Brags-Willium theory, Heisenberg model, Ising model; Elements of magnetic properties of metals, Landau diamagnetism, Pauli paramagnetism, Stoner	12

		ferromagnetism; Magnetic resonance; NMR and EPR.	
3.	Transport Properties	Boltzmann equation; Relaxation time approximation; General transport coefficients; Electronic conduction in metals; Thermoelectric effects; Transport phenomena in magnetic field; Magnetoresistance; Hall effect and Quantum Hall effect.	10
4.	Superconductivity	Cooper pairing and BCS theory; Ginzburg Landau theory; Flux quantization; Supercurrent tunneling; DC and AC Josephson effects; High-Tc superconductors.	6
		Total number of Lectures	**40**

Evaluation Criteria

Components	**Maximum Marks**
T1	20
T2	20
End Semester Examination	35
TA	25 [2 Quiz (7 M), Attendance (7 M) and A mini-project and class performance (6 M) and class performance (5M)]
Total	**100**

Recommended Reading material: Author(s), Title, Edition, Publisher, Year of Publication etc. (Text books, Reference Books, Journals, Reports, Websites etc. in the IEEE format)

1.	Kittel C, “Introduction to Solid State Physics”, 8th Ed. Wiley eastern Ltd
2	Ashcroft N W and Mermin N D, “Solid State Physics”, Holt-Saunders
3	Chaikin P M and Lubensky T C, “Principles of Condensed Matter Physics”, Cambridge University Press
4	Harrison P, “Quantum Wells, Wires and Dots”, Wiley & Sons Ltd.
5	B. D. Cullity and C. D. Graham, “Introduction to magnetic materials” John Wily & Sons, Inc, 2011
6	K. H. J. Buschow and F. R. de Boer, “Physics of Magnetism and Magnetic Materials” Kluwer Academic Publishers, 2003
7	Stephen Blundell, “Magnetism in Condensed Matter” Oxford University Press (2001)
8	M. Tinkham, “Introduction to superconductivity” McGrawHill, New York. (1996); Dover Books (2004)
9	P. G. de Gennes, “Superconductivity of metals and alloys” W. A. Benjamin, New York (1966); Perseus Books (1999)
10	A. A. Abrikosov, “Fundamentals of the theory of metals” North Holland, Amsterdam (1998)

<u>**Detailed Syllabus**</u>

Lecture-wise Breakup

Course Code	19M21PH215	**Semester: Odd**	**Semester: III** **Session** 2020 -2021 **Month from: July to December**
Course Name	Optoelectronics		
Credits	3	**Contact Hours**	3

Faculty (Names)	**Coordinator**	Navneet K Sharma
	Teacher	Navneet K Sharma

COURSE OUTCOMES		**COGNITIVE LEVELS**
CO1	Recall the fundamentals of semiconductor physics, LEDs, Injection Laser diodes	Remembering (C1)
CO2	Explain basic principle of Optoelectronic detection: photodiodes, photoconducting detectors; Modulators	Understanding (C2)
CO3	Apply concepts of fibers: step index, graded index, Numerical aperture; Modes: single mode and multimode; V Parameter; evanescent modes; losses in fibers; dispersion in fibers	Applying (C3)
CO4	Analyze semiconductor optical amplifiers; Erbium-doped fiber amplifiers; Fiber Raman amplifiers	Analyzing (C4)

Module No.	**Title of the Module**	**Topics in the Module**	**No. of Lectures for the module**
1.	Optoelectronic Sources	Fundamental aspects of semiconductor physics: p-n junction, Heterojunction; LEDs; Types of LEDs: surface and edge emitting; Injection Laser diodes.	8
2.	Optoelectronic Detectors	Basic principle of Optoelectronic detection: Types of photodiodes; Photoconducting detectors.	6
3.	Optoelectronic Modulators	Review of basic principles of modulators; Electro-optic, Acousto-optic, Magneto-optic modulators.	8
4.	Optical Fiber-Theory	Classification of fibers: step index and graded index; numerical aperture; modes in optical fiber: single mode and multimode; V parameter; evanescent modes; losses in fibers: bending and coupling; dispersion in fibers: dispersion compensated, dispersion flattened and dispersion shifted; Fiber bragg grating.	12
5.	Optical Amplifiers	Semiconductor optical amplifiers; Erbium-doped fiber amplifiers; Fiber Raman amplifiers.	6
		Total number of Lectures	**40**
Evaluation Criteria			

Components	Maximum Marks
T1	20
T2	20
End Semester Examination	35
TA	25 [2 Quiz (7 M), Attendance (7 M) and A mini-project and class performance (6 M) and class performance (5M)]
Total	**100**

Recommended Reading material: Author(s), Title, Edition, Publisher, Year of Publication etc. (Text books, Reference Books, Journals, Reports, Websites etc. in the IEEE format)	
1.	Fundamentals of Photonics – B. E. A. Saleh and M. C. Teich, wiley, 2nd edition.
2.	Principles of Optics - M. Born and E. Wolf , Cambridge university press, 7th edition.
3.	Optical Electronics - A.Ghatak and K.Thyagarajan, Cambridge university press.
4.	Optical Fiber communications: principles and practice – John M.Senior, Pearson Education, 3rd edition.

Detailed Syllabus
Lecture-wise Breakup

Course Code	19M25PH211	**Semester:** Odd	**Semester: III Session** 2020 -2021 **Month from:** Jan to June (Deferred)
Course Name	Laboratory-3 (Solid State Physics)		
Credits	04	**Contact Hours**	08

Faculty (Names)	**Coordinator(s)**	
	Teacher(s) (Alphabetically)	

COURSE OUTCOMES		**COGNITIVE LEVELS**
CO1	Explain the principal and working of experimental setup.	Understand Level (C2)
CO2	Plan the experiment and take measurements.	Apply Level (C3)
CO3	Analyze the data obtained and calculate the error.	Analyze level (C4)
CO4	Interpret and justify the results.	Evaluate Level (C5)

Module No.	**Title of the Module**	**Topics in the Module**	**CO**
1.	Structural characterization	1. Structural determination of given samples ($BaTiO_3$, $CoFe_2O_4$, ZnO etc) by X-ray diffraction technique. 2. Determination of structural parameters (lattice parameters, crystallite size etc) of given samples from XRD data.	2, 3, 4, 5
2.	Dielectric measurements	3. Temperature dependent dielectric measurements of given sample and their analysis. 4. Frequency dependent dielectric measurements of given sample and their analysis. 5. To measure the coercive field (Ec), Remanent Polarization (Pr), and Spontaneous Polarization (Ps) of Barium Titanate (BaTiO3) sample.	2, 3, 4, 5
3.	Spectroscopic measurements	6. Determination of optical band gap of prepared given sample by UV-Vis spectroscopy, 7. Analysis of various bonding in given samples by Infrared spectroscopy.	2, 3, 4, 5
4.	Transport Properties	8. To study the temperature dependence of Hall coefficient of N and P type semiconductors. 9. Electrical resistivity of high resistive material as a function of temperature using DC four probe method. 10. Determination of co-efficient of linear thermal expansion of polymer as a function of temperature. 11. To study C-V characteristics of various solid state	2, 3, 4, 5

		devices & materials. (like p-n junctions and ferroelectric capacitors)	

Evaluation Criteria

Components	**Maximum Marks**
Mid Term Viva	20
End Term Viva	20
Day To Day Evaluation	60
Total	**100**

Recommended Reading material: Author(s), Title, Edition, Publisher, Year of Publication etc. (Text books, Reference Books, Journals, Reports, Websites etc. in the IEEE format)

1.	Melissinos A.C. and Napolitano J, **"**Experiments in Modern Physics**",** Academic Press

<u>**Detailed Syllabus**</u>

Lecture-wise Breakup

Course Code	**19M25PH212**	**Semester: Odd**		**Semester: 3rd Session 2020-21** **Month from: Jan to June (Deferred)**
Course Name	**Laboratory-3 (Applied Optics)**			
Credits	**4**		**Contact Hours**	**08**
Faculty (Names)	**Coordinator**			
	Teacher			

COURSE OUTCOMES		**COGNITIVE LEVELS**
CO1	Recall the principles of Optical Spectroscopy, optical fibers, optoelectronics and Lasers behind the experiments.	Remembering (C1)
CO2	Explain the experimental setup and the principles involved behind the experiments performed.	Understanding (C2)
CO3	Plan the experiment and set the apparatus and take measurements.	Applying (C3)
CO4	Analyze the data obtained and calculate the error.	Analyzing (C4)
CO5	Interpret and justify the results.	Evaluating (C5)

Module No.	**Title of the Module**	**Topics in the Module**	**CO**
1.	**Optical Spectroscopy**	**1.**Determination of size of Nano materials by uv-vis absorption spectrophotometer. **2.** Determination of optical band gap (Δε) of materials by uv-vis emission spectrophotometer. **3.** Determination of optical band gap (Δε) of materials by uv-vis absorption spectrophotometer. **4.** Determination of various nonlinear optical coefficients (first and second order hyperpolarizabilities) by FTIR spectrometry.	1-5
2.	**Optical Fibers**	**5.**To measure the power loss at a splice between two multimode fibers and study the variation of splice loss with transverse and longitudinal offsets. **6.**To couple the light from an optical source into the optical fiber and to measure its Numerical aperture (NA). **7.**To determine the mode field diameter (MFD) of the fundamental mode in given single mode fiber (SMF) by a measurement of its far field.	1-5
3.	**Laser and Applications**	**8.**Measurement of laser parameters using He-Ne laser. **9.**Determination of optical absorption coefficient and determination of refractive index of the liquids using He-Ne laser. **10.** Biasing characteristics of a Laser diode and spectral characterization using an Optical Spectrum Analyzer.	**1-5**

Evaluation Criteria

Components	**Maximum Marks**

Mid Term Viva (V1)	20
End Term Viva (V2)	20
D2D	60
Total	**100**

Recommended Reading material: Author(s), Title, Edition, Publisher, Year of Publication etc. (Text books, Reference Books, Journals, Reports, Websites etc. in the IEEE format)

1.	Experiment hand-outs.

Detailed Syllabus

Lecture-wise Breakup

Course Code	**20M22PH213**	**Semester:** ODD	**Semester: 3rd** **Session** 2020 -2021 **Month from** July to December
Course Name	**Semiconductor and Electronic Devices**:		
Credits	3	**Contact Hours**	3

Faculty (Names)	**Coordinator(s)**	Dinesh Tripathi
	Teacher(s) (Alphabetically)	Dinesh Tripathi

COURSE OUTCOMES		**COGNITIVE LEVELS**
CO1	Define terminology and concepts of semiconductors in correlation with semiconductor related electronic devices	Remember Level (Level 1)
CO2	Explain optical thermal and electronic properties of semiconductor and devices in equilibrium and steady state conditions	Understand Level (Level 2)
CO3	Apply mathematical equations and laws of semiconductor physics to solve related problems.	Apply Level (Level 3)
CO4	Analyze and compare different semiconductor and electronic devices for understanding their performances	Analyze Level (Level 4)

Module No.	**Title of the Module**	**Topics in the Module**	**No. of Lectures for the module**
1.	Semiconductors	Energy bands, direct and indirect semiconductors, charge carriers, mobility, drift of carriers in field, bonds and bands in semiconductors, intrinsic and extrinsic semiconductors, law of mass action, Hall effect and cyclotron resonance in semiconductors.	12
2.	Optical Injection	Carrier life time, direct and indirect recombination of electron and holes, steady state carrier generation, diffusion and drift of carriers, the continuity equation, steady state carrier injection, The Haynes-Shockley experiment.	8
3.	Junctions	Metal-Semiconductor contact: under equilibrium, and non-equilibrium conditions, the junction diode theory, tunnel diode, photodiode, LED, solar cell, Hetro-junctions and Laser diode.	10
4.	Devices	Bipolar Junction Transistors: Charge transport and amplification, minority carrier distribution and terminal currents switching behavior in bipolar transistor, FET and	10

		MOSFET: Ideal MOS capacitor, effect of work function and interface charge on threshold voltage.	
Total number of Lectures			**40**

Evaluation Criteria

Components	**Maximum Marks**
T1	20
T2	20
End Semester Examination	35
TA	25 [2 Quiz (7 M), Attendance (7 M) and A mini-project and class performance (6 M) and class performance (5M)]
Total	**100**

Recommended Reading material:	
1.	Donald A Neamen & Dhrubes Biswas, Semiconductor Physics and Devices, McGraw Hill Education
2.	S. M. Sze, Physics of Semiconductor devices, Wiley-Interscience
3.	Streetman and Banerjee, Solid State Electronic devices, PHI
4.	Umesh Mishra and Jasprit Singh, Semiconductor Device Physics and Design,

Detailed Syllabus

Lecture-wise Breakup

Course Code	20M22PH212	**Semester: Odd**		**Semester: 3rd Session 2020-21** **Month from: July to December**
Course Name	Quantum Optics			
Credits	3		**Contact Hours**	3
Faculty (Names)	**Coordinator**	Anirban Pathak		
	Teacher	Anirban Pathak		

COURSE OUTCOMES		**COGNITIVE LEVELS**
CO1	Recall basics of field quantization	Remembering (C1)
CO2	Explain various physical phenomena which fall under the domain of quantum optics	Understanding (C2)
CO3	Apply the witnesses of quantum ness of light on various quantum states to determine their non classical properties and applicability	Applying (C3)
CO4	Analyze complex problems related to matter field interaction using quantum treatment	Analyzing (C4)

Module No.	**Title of the Module**	**Topics in the Module**	**No. of Lectures for the module**
1.	**Introduction to quantum optics**	Classification of optics as classical, semi-classical and quantum optics; establish the need of field quantisation for the understanding of various optical phenomena; quantization of electromagnetic field (second quantization), normal ordering and field operators.	5
2.	**Coherent state and the notion of nonclassicality**	Coherent state as an eigenket of annihilation operator and other definitions of coherent state; properties of coherent state; notion of pure and mixed state; Glauber-Sudarshan P-representation and the nontion of nonclassical states.	5
3.	**Quantum (nonclassical) states of light their properties, witnesses and nonclassicality inducing operations**	Notion of squeezed state, antibunchied state, entangled states, states with sub-Poissonian photon statistics, etc, and their properties; Displacement operator, squeezing operator, and photon addition and subtraction operators, their roles in inducing nonclassicality. Operational criteria for witnessing nonclassicality with emphasis on correlation functions and quasi probability distributions like Wigner function and Q function.	8
4.	**Generation, evolution and**	Various physical process used to generate quantum (nonclassical) light e.g., SPDC and other nonlinear optical	14

	detection of quantum (nonlcassical) state of light	processes; mathematical methods and models used in quantum optics: Jayne-Cummings model, Rabi models, rotating wave approximation, Fokker-Planck equation and elementary idea of Master equation and open quantum system; Detection of quantum light by coincidence-counting and methods of phase-sensitive detection; Landmark experiments in quantum optics.	
5.	**Applications of Quantum Optics**	Precise measurement (with example of LIGO), laser cooling and BEC, ion trapping, CPT, EIT, slow light, applications in quantum communication, quantum computation and in quantum metrology with specific mention of quantum radar.	8
		Total number of Lectures	**40**

Evaluation Criteria

Components	**Maximum Marks**
T1	20
T2	20
End Semester Examination	35
TA	25 [2 Quiz (7 M), Attendance (7 M) and A mini-project and class performance (6 M) and class performance (5M)]
Total	**100**

Recommended Reading material: Author(s), Title, Edition, Publisher, Year of Publication etc. (Text books, Reference Books, Journals, Reports, Websites etc. in the IEEE format)

1.	M Fox, Quantum optics: An introduction, Oxford University Press, Oxford 2006
2.	Z Ficek and M R Wahiddin, Quantum Optics for Beginners , CRC Press, London2014
3.	G S Agarwal, Quantum Optics, Cambridge University Press, Cambridge, 2012