

Overview of 2 Year M.Sc. Programme in Physics.

The department of Physics offers two options to students. Either they get a regular MSc degree with a total of 80 credits or they get MSc with Departmental specialization with a total of 86 credits. We give the credit distribution for both the streams below:

Credit structure for regular MSc

Total Number of credits: 80

Core course component: 62

Programme electives: 12

Open Electives: 06

Credit structure for MSc with departmental specialization

The students need to pick up 12 credits for Departmental specialization. It is worked out by specifying two exclusively departmental courses explicitly (total credits) , and letting the student pick up the remaining six credits from the OE basket.

Number of credits: 86

Core course component: 62

Programme electives: 12

Open Electives: 06 (contributes to Departmental specialization)

Departmental Specialization: 06

List of Core Courses

The list below contains those courses which will be floated as electives by the Department, but will NOT be a part of the DS set. They have been lifted from the *courses of Study*. Please go through the list and advise if any of them may be removed either because (i) it has not been floated for a long time, or (ii) the new courses have made it superfluous.

1. Mathematical Physics
2. Classical Physics
3. Quantum Mechanics I
4. Quantum Mechanics II
5. Electrodynamics
6. Statistical Mechanics
7. Electronics
8. Applied Optics
9. Solid State Physics
10. Atomic and Molecular Physics
11. Nuclear and Particle Physics

List of MSc Electives for Departmental specialization

The Department has identified three broad streams of specialization, (i) Photonics, (ii) Condensed Matter Physics, and (iii) Theoretical Physics. The list below gives the basket of courses in each stream. The lists are not completely mutually exclusive since some courses can fit in more than one stream.

1 Photonics

1. Laser physics (PHL655)
2. Fiber and integrated optics (PHL650)
3. Photonic devices (PYL793)
4. Guided wave components and devices (PHL891)
5. Statistical optics (PHL762)
6. nonlinear optics (PHL747)
7. quantum optics (PHL748)
8. Ultrafast optics and applications (number to be assigned in applied optics M.Tech.)
9. Biophotonics (PHL760)
10. Laser spectroscopy (PHL659)
11. Liquid crystals (PHL761)
12. quantum information and computation (PHL749)

2 Condensed Matter Physics

1. Advanced Solid State Physics (PHL651)
2. Science and Technology of Thin Films (PHL702)
3. Quantum Heterostructure (PHL727)
4. Physics of Semiconductor Devices (PHL705)
5. Characterization of materials (PHL707)
6. Computational Techniques for Solid State Physics (PHL739)
7. Magnetism and spintronics (PHL652)
8. Energy Materials and Devices (PHL727)
9. Advanced condensed matter theory (PHL740)

3 Theoretical Physics

1. Nonequilibrium Statistical Mechanics (PHL746)
2. Advanced Statistical Mechanics (PHL745)
3. Group Theory and its Applications (PHL743)
4. Field theory and quantum electrodynamics (PHL741)
5. High Energy physics (PHL744)
6. General Relativity and Introductory Astrophysics(PHL742)
7. Quantum Information and Computation (PHL749)
8. Advanced Condensed Matter theory (PHL740)
9. Quantum Optics (PHL748)
10. Plasma Physics (PHL657)
11. Advanced Plasma Physics (PHL658)

List of Programme Electives that are not a part of the Departmental specialization (DS) list

The list below contains those courses which will be floated as electives by the Department, but will NOT be a part of the DS set.

1. PHL658 Miniproject
2. PHL653 Semiconductor electronics
3. PHL656 Microwaves
4. PHL723 Vacuum science and technology
5. PHL725 Physics of amorphous materials
6. PHL726 Nanostructured materials

sem	Courses										Credits			
I	PHL-551 Classical Mechanics (3-1-0)4		PHL-553 Mathematical Physics (3-1-0)4		PHL-555 Quantum Mechanics (3-1-0)4		PHL-557 Electronics (3-1-0)4		PHP-561 Laboratory I (0-0-8)4		20			
II	PHL-552 Electrodynamics (3-1-0)4		PHL-556 Quantum Mechanics II (3-0-0)3		PHL-558 Statistical Mechanics (3-1-0)4		PHL-560 Applied Optics (3-1-0)4		PHP-562 Laboratory II (0-0-8)4		PE-01 (3-0-0)3	22		
III	PHL-563 Solid State Physics (3-1-0)4		PHL-567 Atomic and Molecular Physics (3-0-0)3		PHL-569 Nuclear and Particle Physics (3-0-0)3		PHP-563 Adv. Lab. (0-0-8)4		PHD-561 Project I (0-0-6)3		PE-02 (3-0-0)3	OE-01 (3-0-0)3	DS-01 (3-0-0)3	23/26
IV	PHD-562 Project II (0-0-12)6		PE-03 (3-0-0)3		PE-04 (3-0-0)3		OE-02 (3-0-0)3		DS-02 (3-0-0)3				15/18	

COURSE TEMPLATE

(Please avoid changing the number of tables, rows and columns or text in dark black, but fill only the columns relevant to the template by editing the columns in grey letters or blank columns: this would help in automating the processing of template information for curricular use)

1.	Department/Centre/School proposing the course	PHYSICS	
2.	Course Title	Classical Mechanics	
3.	L-T-P structure	3-1-0	
4.	Credits	4	Non-graded Units
			Please fill appropriate details in S. No. 21
5.	Course number	PHL-551	
6.	Course Status (Course Category for Program) PG		
	Institute Core for all UG programs	No	
	Programme Linked Core for:	List of B.Tech. / Dual Degree Programs	
	Departmental Core for:	List of B.Tech. / Dual Degree Programs	
	Departmental Elective for:	List of B.Tech. / Dual Degree Programs	
	Minor Area / Interdisciplinary Specialization Core for:	Name of Minor Area / Specialization Program	
	Minor Area / Interdisciplinary Specialization Elective for:	Name of Minor Area / Specialization Program	
	Programme Core for:	M.Sc. Physics	
	Programme Elective for:	List of M.Tech. / Dual Degree Programs	
	Open category Elective for all other programs (No if Institute Core)	(Yes / No)	
7.	Pre-requisite(s)	NIL	
8.	Status vis-à-vis other courses		
8.1	List of courses precluded by taking this course (significant overlap)	(course number)	
	(a) Significant Overlap with any UG/PG course of the Dept./Centre/ School	NIL	
	(b) Significant Overlap with any UG/PG course of other Dept./Centre/ School	NIL	
8.2	Supersedes any existing course	NIL	
9.	Not allowed for	NIL	

10.	Frequency of offering (check one box)	☐ Every semester ☒ I sem ☐ II sem ☐ Either semester
------------	---	--

11.	Faculty who will teach the course Ajit Kumar, Sujeet Chaudhary, Shantanu Ghosh, Sankalp Ghosh, Varsha Banerjee, Amruta Mishra, Sujin Babu, Rahul Marathe, V Ravishankar
------------	--

12.	Will the course require any visiting faculty?	No
------------	--	----

13.	Course objectives "On successful completion of this course, a student should be able to understand the basics of Classical Mechanics and its formal aspects thoroughly"
------------	--

14.	Course contents: constraints, generalized coordinates, action principle, symmetries and conservation laws, Hamilton's equations, poisson brackets, canonical transformations, central potentials, small oscillations, normal modes, rigid body dynamics.
------------	---

15. Lecture Outline(with topics and number of lectures)

Module no.	Topic	No. of hours
1	Constraints, Principle of virtual work, D'Alembert's Principle and generalized coordinates, Examples.	4
2	Principle of stationary action, Lagrange's equations in generalized coordinates, Lagrange's equation with undetermined multipliers, Velocity-dependent potentials, Dissipation function, Applications of Lagrange's formulation.	6
3	Symmetry of the Lagrangian, Noether's theorem and conserved currents, Spatial translations, temporal translation, and spatial rotations and the related conservation laws, Examples.	4
4	Canonical equations of motion (Hamilton's equations), cyclic coordinates and conservation laws, Poisson bracket formalism, Canonical transformations, Examples of canonical transformation, Symplectic approach to canonical transformations, Action-angle variables in systems in one dimension and for separable systems, Phase space, Liouville's equation.	8
5	Motion in a central Field, Equivalent one-dimensional problem and the classification of orbits, Virial theorem, Equation for the orbit, stability and the condition for closed orbits, Kepler's problem, Integrable power-law potentials, scattering in a central field.	6
6	Coupled oscillators, small oscillations, normal modes, characteristic frequencies, forced	6

	oscillations, parametric resonance.	
7	Rigid body motion, Euler's angles and Euler's theorem, Angular momentum and the kinetic energy about a point, Moment of inertia tensor, Eigenvalues of the inertia tensor and the principal axis transformation, Solution of problems with Euler's equations, Symmetrical top.	8
Total Lecture hours (14 times 'L')		

16. Brief description of tutorial activities:

Module no.	Description	No. of hours
	Problem sessions and clarification of doubts.	
Total Tutorial hours (14 times 'T')		

17. Brief description of Practical / Practice activities

Module no.	Description	No. of hours
Total Practical / Practice hours (14 times 'P')		

18. Brief description of module-wise activities pertaining to self-learning component (Only for 700 / 800 level courses) (Include topics that the students would do self-learning from books / resource materials: Do not Include assignments / term papers etc.)

Module no.	Description

(The volume of self-learning component in a 700-800 level course should typically be 25-30% of the volume covered in classroom contact)

19. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. "Classical Mechanics" (*Addison Wesley, Third Edition*) - H. Goldstein, C. Poole and J. Safko.
2. "Mechanics (Theoretical Physics Vol. 1) - L. Landau and E. Lifschitz.

20. Resources required for the course (itemized student access requirements, if any)

20.1	Software	Name of software, number of licenses, etc.
20.2	Hardware	Nature of hardware, number of access points, etc.
20.3	Teaching aids (videos, etc.)	Description, Source , etc. Projection System
20.4	Laboratory	Type of facility required, number of students etc.
20.5	Equipment	Type of equipment required, number of access points, etc.
20.6	Classroom infrastructure	Type of facility required, number of students etc. Yes
20.7	Site visits	Type of Industry/ Site, typical number of visits, number of students etc.
20.8	Others (please specify)	

21. Design content of the course (Percent of student time with examples, if possible)

21.1	Design-type problems	Eg. 25% of student time of practical / practice hours: sample Circuit Design exercises from industry
21.2	Open-ended problems	
21.3	Project-type activity	
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: (Signature of the Head of the Department/ Centre / School)

Date of Approval of Template by Senate	
---	--

The information on this template is as on the date of its approval, and is likely to evolve with time.

COURSE TEMPLATE

(Please avoid changing the number of tables, rows and columns or text in dark black, but fill only the columns relevant to the template by editing the columns in grey letters or blank columns: this would help in automating the processing of template information for curricular use)

1.	Department/Centre/School proposing the course	Physics	
2.	Course Title	Electrodynamics	
3.	L-T-P structure	3-1-0	
4.	Credits	4	Non-graded Units
			Please fill appropriate details in S. No. 21
5.	Course number	PHL-552	
6.	Course Status (Course Category for Program) PG		
	Institute Core for all UG programs		(Yes / No)
	Programme Linked Core for:		List of B.Tech. / Dual Degree Programs
	Departmental Core for:		List of B.Tech. / Dual Degree Programs
	Departmental Elective for:		List of B.Tech. / Dual Degree Programs
	Minor Area / Interdisciplinary Specialization Core for:		Name of Minor Area / Specialization Program
	Minor Area / Interdisciplinary Specialization Elective for:		Name of Minor Area / Specialization Program
	Programme Core for:		Msc. Physics
	Programme Elective for:		List of M.Tech. / Dual Degree Programs
	Open category Elective for all other programs (No if Institute Core)		(Yes / No)
7.	Pre-requisite(s)	NIL	
8.	Status vis-à-vis other courses		
8.1	List of courses precluded by taking this course (significant overlap)		(course number)
	(a)	Significant Overlap with any UG/PG course of the Dept./Centre/ School	NIL
	(b)	Significant Overlap with any UG/PG course of other Dept./Centre/ School	NIL
8.2	Supersedes any existing course		NIL
9.	Not allowed for	NIL	

10.	Frequency of offering (check one box)	☐ Every semester ☐ I sem ☒ II sem ☐ Either semester
------------	---	--

11.	Faculty who will teach the course H.K.Malik, Ajit Kumar, Amruta Mishra, V. Ravishankar.
------------	--

12.	Will the course require any visiting faculty?	NO
------------	--	----

13.	Course objectives "On successful completion of this course, a student should be able to understand basic electrodynamics and it's applications to various phenomena."
------------	--

14.	Course contents: Electrostatics, conductors, dielectrics, magnetostatics, boundary conditions, time dependent fields, waves in a medium, relativistic formulations of maxwell's equations, radiation from accelerating charges, scattering of electromagnetic waves.
------------	---

15. Lecture Outline(with topics and number of lectures)

Module no.	Topic	No. of hours
1	Electrostatics in free space The static limit of Maxwell's equations, Coulomb law, continuum limit, Gauss's law, field produced by a charge distribution, multipole expansion for the electrostatic potential, electric dipole and quadrupole, energy density of a charge distribution.	3
2	Electrostatics of conductors Microscopic and macroscopic fields, electrostatic field of conductors, Capacitance matrix, Poisson and Laplace's equations, boundary value problems, Green's functions, method of images.	4
3	Electrostatics of dielectrics Dielectric permittivity, conductors as a limiting case, electrostatic energy of a dielectric, sign of permittivity, brief discussion of dielectric permittivity for crystals and piezo-electrics, boundary conditions at interfaces.	4

4	Magnetostatics Biot-Savart Law; Ampere's law; vector potential; magnetic fields produced by current distributions; magnetic dipole moment; magnetic permeability of a medium; magnetization; boundary conditions on B and H fields; diamagnetic and paramagnetic materials; permanent magnets; hysteresis; Ohm's law and conductivity tensor; Hall effect.	5
5	Time dependent fields in media Quasi time dependent fields, Maxwell's equations for slowly varying fields, law of induction, inductance, inductance of a long straight wire and a circular loop, eddy currents, skin effect, complex resistance.	5
6	Electromagnetic waves in a medium Constitutive Maxwell's equations, Fresnel's laws of reflection and refraction, surface impedance of metals, wave propagation in plasmas, electromagnetic waves in wave guides, anomalous dispersion and negative refractive index, metamaterials and applications.	8
7	Relativistic formulation of Maxwell's equations Brief review of relativity, 4-vectors, Maxwell's equations in covariant form, transformation formula for electric and magnetic fields, Invariants of fields, field produced by a uniformly moving charged particle.	5
8	Accelerating charges and radiation Field of an accelerating charged particle, Lienard -Wiechert potentials, radiation from a dipole, Larmor formula, synchrotron radiation, radiation losses, radiation reaction, Abraham-Dirac-Lorentz equation.	5
9	Scattering of electromagnetic waves Rayleigh scattering, Mie scattering, colour of the sky and clouds, critical opalescence.	3
Total Lecture hours (14 times 'L')		

16. Brief description of tutorial activities:

Module no.	Description	No. of hours
	Problem solving sessions and clarifications of doubts.	
Total Tutorial hours (14 times 'T')		

17. Brief description of Practical / Practice activities

Module no.	Description	No. of hours
------------	-------------	--------------

Total Practical / Practice hours (14 times 'P')		

18. Brief description of module-wise activities pertaining to self-learning component (Only for 700 / 800 level courses) (Include topics that the students would do self-learning from books / resource materials: Do not Include assignments / term papers etc.)

Module no.	Description
(The volume of self-learning component in a 700-800 level course should typically be 25-30% of the volume covered in classroom contact)	

19. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

J.D.Jackson, Classical Electrodynamics.
L.D. Landau and E.M. Lifschitz, The classical theory of fields, Vol.-2.
D.J.Griffiths, Introduction to Electrodynamics.

20. Resources required for the course (itemized student access requirements, if any)

20.1	Software	Name of software, number of licenses, etc.
20.2	Hardware	Nature of hardware, number of access points, etc.
20.3	Teaching aids (videos, etc.)	Description, Source , etc. Projection System
20.4	Laboratory	Type of facility required, number of students etc.
20.5	Equipment	Type of equipment required, number of access points, etc.
20.6	Classroom infrastructure	Type of facility required, number of students etc.
20.7	Site visits	Type of Industry/ Site, typical number of visits, number of students etc.
20.8	Others (please specify)	

--	--	--

21. Design content of the course (Percent of student time with examples, if possible)

21.1	Design-type problems	Eg. 25% of student time of practical / practice hours: sample Circuit Design exercises from industry
21.2	Open-ended problems	
21.3	Project-type activity	
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: (Signature of the Head of the Department/ Centre / School)

Date of Approval of Template by Senate	
---	--

The information on this template is as on the date of its approval, and is likely to evolve with time.

COURSE TEMPLATE

(Please avoid changing the number of tables, rows and columns or text in dark black, but fill only the columns relevant to the template by editing the columns in grey letters or blank columns: this would help in automating the processing of template information for curricular use)

1.	Department/Centre/School proposing the course	PHYSICS	
2.	Course Title	Mathematical Physics	
3.	L-T-P structure	3-1-0	
4.	Credits	4	Non-graded Units
			Please fill appropriate details in S. No. 21
5.	Course number	PHL-553	
6.	Course Status (Course Category for Program) PG		
	Institute Core for all UG programs	No	
	Programme Linked Core for:	List of B.Tech. / Dual Degree Programs	
	Departmental Core for:	List of B.Tech. / Dual Degree Programs	
	Departmental Elective for:	List of B.Tech. / Dual Degree Programs	
	Minor Area / Interdisciplinary Specialization Core for:	Name of Minor Area / Specialization Program	
	Minor Area / Interdisciplinary Specialization Elective for:	Name of Minor Area / Specialization Program	
	Programme Core for:	List of M.Tech. / Dual Degree Programs: MSc. Physics	
	Programme Elective for:	List of M.Tech. / Dual Degree Programs	
	Open category Elective for all other programs (No if Institute Core)	(Yes / No)	
7.	Pre-requisite(s)	NIL	
8.	Status vis-à-vis other courses		
8.1	List of courses precluded by taking this course (significant overlap)	(course number)	
	(a) Significant Overlap with any UG/PG course of the Dept./Centre/ School	NIL	
	(b) Significant Overlap with any UG/PG course of other Dept./Centre/ School	NIL	
8.2	Supersedes any existing course	NIL	
9.	Not allowed for	NIL	

10.	Frequency of offering (check one box)	☐ Every semester ☒ I sem ☐ II sem ☐ Either semester
------------	---	--

11.	Faculty who will teach the course	Rahul Marathe, Amruta Mishra, Sankalpa Ghosh, Ajit Kumar, Saswata Bhattacharya, Sujin Babu, Varsha Banerjee, V. Ravishankar.
------------	--	--

12.	Will the course require any visiting faculty?	No
------------	--	----

13.	Course objectives	about 50 words. "On successful completion of this course, a student should be able to have requisite mathematical skills required by every physicist."
------------	--------------------------	--

14.	Course contents	(about 100 words; Topics to appear as course contents in the Courses of Study booklet) (Include Practical / Practice activities): Linear Algebra, complex analysis, Fourier transforms and delta function, Sturm-Liouville's theorem and orthogonal functions, ordinary differential equations, Green Functions.
------------	------------------------	--

15. Lecture Outline(with topics and number of lectures)

Module no.	Topic	No. of hours (not exceeding 5h per topic)
1	Linear Algebra- Vector spaces, metric spaces, linear operators and their algebra, eigen values and eigen vectors, N-dimensional vector spaces, matrix algebra.	10
2	Complex analysis – analytic functions, conformal transformations, series of analytic functions, calculus of residues, multivalued functions, Reimann surfaces, integrals of complex functions, dispersion relations, analytic continuation, method of steepest descent, gamma functions.	8
3	Fourier transforms (FTs), Dirac delta functions, properties of FTs, convolution and deconvolution, correlation functions and energy spectra, Parseval's theorem, applications.	6
4	Sturm-Liouville (SL) theory	6

	SL operators, expansions in orthogonal functions, Rodrigues formula, recurrence relations, differential equations satisfied by classical polynomials (Bessel, Legendre, Hermite, Jacobi, etc.)	
5	Ordinary differential equations : The Hypergeometric equation, functions related to the Hypergeometric function (Bessel, Legendre, Hermite, Jacobi, etc.).	6
6	Green's function (GF) for solutions of differential equations-eigen functions method, method of images, integral transforms.	6
Total Lecture hours (14 times 'L')		

16. Brief description of tutorial activities:

Module no.	Description	No. of hours
	Problem solving sessions and clarification of doubts.	
Total Tutorial hours (14 times 'T')		

17. Brief description of Practical / Practice activities

Module no.	Description	No. of hours
Total Practical / Practice hours (14 times 'P')		

18. Brief description of module-wise activities pertaining to self-learning component (Only for 700 / 800 level courses) (Include topics that the students would do self-learning from books / resource materials: Do not Include assignments / term papers etc.)

Module no.	Description

(The volume of self-learning component in a 700-800 level course should typically be 25-30% of the volume covered in classroom contact)	

19. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

Mathematics for Physicists : Dennery and Krzywicki, Dover Publications.

Mathematical Methods for Physics and Engineers : Riley, Hobson and Bence, Cambridge University Press.

Mathematical Methods of Physics : Mathews and Walker, Addison-Wesley Publishing Company.

Mathematical Methods in the Physical Sciences M. L. Boas, Wiley.

Mathematical Methods for Physicists : Arfken, Academic Press.

Methods of Theoretical Physics I and II : P. M. Morse and H. Feshback, McGraw Hill.

Complex Analysis : L. Ahlfors, McGraw Hill.

20. Resources required for the course (itemized student access requirements, if any)

20.1	Software	Name of software, number of licenses, etc.
20.2	Hardware	Nature of hardware, number of access points, etc.
20.3	Teaching aids (videos, etc.)	Description, Source , etc.: Projector
20.4	Laboratory	Type of facility required, number of students etc.
20.5	Equipment	Type of equipment required, number of access points, etc.
20.6	Classroom infrastructure	Type of facility required, number of students etc. Yes
20.7	Site visits	Type of Industry/ Site, typical number of visits, number of students etc.
20.8	Others (please specify)	

21. Design content of the course (Percent of student time with examples, if possible)

21.1	Design-type problems	Eg. 25% of student time of practical / practice hours: sample Circuit Design exercises from industry
21.2	Open-ended problems	
21.3	Project-type activity	
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: (Signature of the Head of the Department/ Centre / School)

Date of Approval of Template by Senate	
---	--

The information on this template is as on the date of its approval, and is likely to evolve with time.

COURSE TEMPLATE

1.	Department /Centre proposing the course	Physics
2.	Course Title (<i>< 45 characters</i>)	QUANTUM MECHANICS I
3.	L-T-P structure	3 - 1 - 0
4.	Credits	4
5.	Course number	PHL555
6.	Status (<i>category for program</i>)	M Sc.

7.	Pre-requisites (course no./title)	
----	---	--

8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	
8.2	Overlap with any UG/PG course of other Dept./Centre	NONE
8.3	Supercedes any existing course	PHL555

9.	Not allowed for (indicate program names)	
----	--	--

10.	Frequency of offering	☐ Every sem ☒ 1 st sem ☐ 2 nd sem ☐ Either sem
-----	------------------------------	---

11.	Faculty who will teach the course Sankalpa Ghosh, V Ravishankar, Amruta Mishra, Joyee Ghosh, Ajit Kumar and other members of the theory group.	
12.	Will the course require any visiting faculty?	NO

13.	Course objective (<i>about 50 words</i>): FAMILIARIZING STUDENTS WITH THE THEORETICAL FRAMEWORK OF NON RELATIVISTIC QUANTUM MECHANICS AND ITS APPLICATIONS TO SIMPLE PROBLEMS	
-----	---	--

14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Introduction, quantum mechanical wave function, Born interpretation, basic formalism (Dirac bra-ket formalism), state vectors, operators and their representation, review of one dimensional examples, one dimensional harmonic oscillator, creation and annihilation operators, Landau problem, symmetries in quantum mechanics, hydrogen atom, entanglement	
-----	--	--

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Introduction: Problems with classical physics: double-slit experiment: quantum mechanical wave function and Born interpretation	3
2	Basic formalism: Dirac's bra-ket formalism, matrix representation of vectors and operators, postulates of quantum mechanics in bra-ket language. Schrodinger Equation.	10
3	One dimensional examples: A brief review of problems involving Schrodinger equation in one dimension (box potential, potential barrier and tunneling, potential well)	2
4	1-D Harmonic Oscillator: creation and annihilation and number operators and construction of stationary wave functions.	5
5	Landau problem: Quantum Mechanics of a charged particle in a uniform magnetic field.	3
6	Symmetries in quantum mechanics : Translations, rotations and parity.	4
7	Quantum theory of angular momentum: Raising and lowering operators, eigenvalues and eigenfunctions, Spin angular momentum, addition of angular momenta and Clebsch-Gordan coefficients	7
8	Hydrogen atom: Schroedinger equation for a particle moving in a central force field, hydrogen atom, energy levels and eigenvalues, bound states. The full electronic wavefunction in co-ordinate and spin-space and Pauli formalism.	5
9	Entanglement: nonlocality of quantum mechanics, EPR correlations, Bell's Inequalities, entangled states	4
10		
11		
12		
COURSE TOTAL (14 times 'L')		

16. Brief description of tutorial activities

Problems will be solved in tutorials to understand the concepts better. Any difficulties in lecture will be addressed.

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1	###	
2		
3		
4		
5		
6		
7		
8		
9		
10		
COURSE TOTAL (14 times 'P')		####

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

Principles of Quantum Mechanics, R Shankar, Springer (Indian Edition), Second Edition
 Lectures on Quantum Mechanics, Ashoke Das, Hindustan Book Agency, 2003
 Modern Quantum Mechanics, J. J. Sakurai, Pearson Education (LPE),

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	
19.2	Hardware	
19.3	Teaching aides (videos, etc.)	
19.4	Laboratory	
19.5	Equipment	
19.6	Classroom infrastructure	
19.7	Site visits	

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	
20.2	Open-ended problems	
20.3	Project-type activity	
20.4	Open-ended laboratory work	
20.5	Others (please specify)	

Date:

(Signature of the Head of the Department)

COURSE TEMPLATE

(Please avoid changing the number of tables, rows and columns or text in dark black, but fill only the columns relevant to the template by editing the columns in grey letters or blank columns: this would help in automating the processing of template information for curricular use)

1.	Department/Centre/School proposing the course	PHYSICS	
2.	Course Title	Quantum Mechanics II	
3.	L-T-P structure	3-0-0	
4.	Credits	3	Non-graded Units
			Please fill appropriate details in S. No. 21
5.	Course number	PHL-556	
6.	Course Status (Course Category for Program) PG		
	Institute Core for all UG programs	NO	
	Programme Linked Core for:	List of B.Tech. / Dual Degree Programs	
	Departmental Core for:	List of B.Tech. / Dual Degree Programs	
	Departmental Elective for:	List of B.Tech. / Dual Degree Programs	
	Minor Area / Interdisciplinary Specialization Core for:	Name of Minor Area / Specialization Program	
	Minor Area / Interdisciplinary Specialization Elective for:	Name of Minor Area / Specialization Program	
	Programme Core for:	MSc. Physics	
	Programme Elective for:	List of M.Tech. / Dual Degree Programs	
	Open category Elective for all other programs (No if Institute Core)	(Yes / No)	
7.	Pre-requisite(s)	PHL-555	
8.	Status vis-à-vis other courses		
8.1	List of courses precluded by taking this course (significant overlap)	(course number)	
	(a) Significant Overlap with any UG/PG course of the Dept./Centre/ School	NIL	
	(b) Significant Overlap with any UG/PG course of other Dept./Centre/ School	NIL	
8.2	Supersedes any existing course	NIL	
9.	Not allowed for	NIL	

10. Frequency of offering (check one box)	☐ Every semester ☐ I sem ☒ II sem ☐ Either semester
---	--

11. Faculty who will teach the course	Ajit Kumar, Snkalpa Ghosh, Amruta Mishra, Shantanu Ghosh, Joyee Ghosh, V. Ravishankar.
--	--

12. Will the course require any visiting faculty?	NO
--	----

13. Course objectives	“On successful completion of this course, a student should be conversant with perturbation techniques, scattering theory and relativistic quantum mechanics.”
------------------------------	---

14. Course contents	(about 100 words; Topics to appear as course contents in the Courses of Study booklet) (Include Practical / Practice activities): Time independent perturbation theory, time dependent perturbation theory, approximation techniques, identical particles, interaction of atoms with radiation, relativistic particles.
----------------------------	---

15. Lecture Outline(with topics and number of lectures)

Module no.	Topic	No. of hours (not exceeding 5h per topic)
1	Time independent perturbation theory: Rayleigh Schrodinger perturbation theory for degenerate and non-degenerate cases, applications to bound state problems such as anharmonic oscillator, The Zeeman effects, Stark effect, second order perturbation, susceptibility and non-linear effects, limitations of Rayleigh-Schrodinger perturbation theory, variational techniques, generic properties of variational wave functions for energy eigenstates, simple examples and application to Helium atom.	9
2	Time dependent perturbation Theory: Schrodinger, Heisenberg and interaction representations, application to time dependent external potentials, NMR, rotating wave approximation, Rabi oscillations, Energy-time uncertainty relation, Schwinger-Dyson expansion, concept of S-matrix, Moller operators, scattering cross-section	9

3	Identical particles: Concept of identity and permutation symmetry, symmetric and antisymmetric states, exclusion principle, the periodic table, scattering of identical particles.	4
4	Approximation Techniques: Born approximation, Rutherford scattering, WKB approximation and expansion in powers of $\hbar$, application to tunneling and bound state problems, Adiabatic and sudden approximations with examples, Hartree and Hartree-Fock approximations, Slater determinants and application to atomic systems.	7
5	Interaction of atoms with radiation: Semiclassical treatment of interaction with radiation, multipole expansions, the dipole approximation, photoelectric effect, atomic transitions, selection rules.	5
6	Relativistic Particles: The Klein-Gordon Equation, Klein paradox, The Dirac equation, standard solutions, interaction with electromagnetic field, reduction to Pauli equation, spin and g-factor of the electron, negative energy solutions, antiparticles, Dirac and Feynman-Stueckelberg interpretations.	8
Total Lecture hours (14 times 'L')		

16. Brief description of tutorial activities:

Module no.	Description	No. of hours
Total Tutorial hours (14 times 'T')		

17. Brief description of Practical / Practice activities

Module no.	Description	No. of hours
Total Practical / Practice hours (14 times 'P')		

18. Brief description of module-wise activities pertaining to self-learning component (Only for 700 / 800 level courses) (Include topics that the students would do self-learning from books / resource materials: Do not Include assignments / term papers etc.)

Module no.	Description

(The volume of self-learning component in a 700-800 level course should typically be 25-30% of the volume covered in classroom contact)

19. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

R. Shankar, Principles of Quantum Mechanics.
 J.J.Sakurai, Modern Quantum Mechanics.
 W. Griener, Quantum Mechanics and Introduction.
 W.Griener, Relativistic Quantum Mechanics.

20. Resources required for the course (itemized student access requirements, if any)

20.1	Software	Name of software, number of licenses, etc.
20.2	Hardware	Nature of hardware, number of access points, etc.
20.3	Teaching aids (videos, etc.)	Description, Source , etc. Pojection System
20.4	Laboratory	Type of facility required, number of students etc.
20.5	Equipment	Type of equipment required, number of access points, etc.
20.6	Classroom infrastructure	Type of facility required, number of students etc. Yes
20.7	Site visits	Type of Industry/ Site, typical number of visits, number of students etc.
20.8	Others (please specify)	

21. Design content of the course (Percent of student time with examples, if possible)

21.1	Design-type problems	Eg. 25% of student time of practical / practice hours: sample Circuit Design exercises from industry
21.2	Open-ended problems	

21.3	Project-type activity	
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: (Signature of the Head of the Department/ Centre / School)

Date of Approval of Template by Senate	
---	--

The information on this template is as on the date of its approval, and is likely to evolve with time.

COURSE TEMPLATE

(Please avoid changing the number of tables, rows and columns or text in dark black, but fill only the columns relevant to the template by editing the columns in grey letters or blank columns: this would help in automating the processing of template information for curricular use)

1.	Department/Centre/School proposing the course	PHYSICS	
2.	Course Title	Electronics	
3.	L-T-P structure	(3-1-0)	
4.	Credits	4	Non-graded Units
			Please fill appropriate details in S. No. 21
5.	Course number	PHL557	
6.	Course Status (Course Category for Program) PG		
	Institute Core for all UG programs		No
	Programme Linked Core for:		
	Departmental Core for:		M.Sc (Physics) Programs
	Departmental Elective for:		
	Minor Area / Interdisciplinary Specialization Core for:		
	Minor Area / Interdisciplinary Specialization Elective for:		
	Programme Core for:		
	Programme Elective for:		
	Open category Elective for all other programs (No if Institute Core)		(Yes / No)
7.	Pre-requisite(s)		
8.	Status vis-à-vis other courses		
8.1	List of courses precluded by taking this course (significant overlap)		(course number)
	(a)	Significant Overlap with any UG/PG course of the Dept./Centre/ School	(course number)
	(b)	Significant Overlap with any UG/PG course of other Dept./Centre/ School	(course number)
8.2	Supersedes any existing course		(course number)

9.	Not allowed for	(indicate program names)
-----------	------------------------	--------------------------

10.	Frequency of offering (check one box)	☐ Every semester ☒ I sem ☐ II sem ☐ Either semester
------------	---	--

11.	Faculty who will teach the course	Mukesh Chander, J.P. Singh
------------	--	-----------------------------------

12.	Will the course require any visiting faculty?	No
------------	--	----

13.	Course objectives This core course is for M.Sc (Phy) students to make them familiar with basic and advanced analog and digital electronics used in circuit and instrument designing. To provide practical knowledge, electronics based design problems are included.
------------	--

14.	Course contents : Basics of semiconductor devices such as diode, transistor, FET and MOSFET; BJT and FET based amplifiers, oscillators, switches, circuit analysis by hybrid and r-parameters, operational amplifier and their applications, timer circuit, dc power supplies, filters and digital circuits, counters, registers, ADC and DAC and microprocessor.
------------	---

15. Lecture Outline(with topics and number of lectures)

Module no.	Topic	No. of hours (not exceeding 5h per topic)
1	Basics of p-n junction devices, transistor , FET and MOSFET devices	3
2	Small or large signal amplifiers, feedback amplifier, multistage amplifiers	4
3	Hybrid and r parameters, circuit analysis	3
4	JFET, MOSFET and their applications	4
5	DC differential amplifier, Operational amplifier	3
6	Circuits using op amp.: amplifiers, Schmitt trigger, clipping and clamping	3
7	Sample and hold circuit, Logarithmic and antilog amplifiers, multivibrators and oscillators, active RC filters	4
8	DC Power supplies and Regulators, Switching mode power supplies	4
9	Digital circuits: Logic gates, combinational logic, K-Map, flip flop	5
10	Shift register, counters, DAC and ADC converter	4
11	Microprocessor, controller, memory devices, I/O device	5
Total Lecture hours (14 times 'L')		42

16. Brief description of tutorial activities:

Module no.	Description	No. of hours
	Doubts will be clarified and problems posed in the lecture will be discussed.	
Total Tutorial hours (14 times 'T')		

17. Brief description of Practical / Practice activities

Module no.	Description	No. of hours
Total Practical / Practice hours (14 times 'P')		

18. Brief description of module-wise activities pertaining to self-learning component

(Only for 700 / 800 level courses) (Include topics that the students would do self-learning from books / resource materials: Do not Include assignments / term papers etc.)

Module no.	Description
(The volume of self-learning component in a 700-800 level course should typically be 25-30% of the volume covered in classroom contact)	

19. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. A.P. Malvino, Electronic Principles, McGraw Hill Publishers.
2. J. Millman and C.C. Halkias, Integrated electronics, Tata McGraw Hill.
3. R.L. Boylestad and L. Nashelsky, Electronic Devices and Circuit Theory (8th Ed.) Pearson Education Asia.

4. Malvino and Leech , Digital Electronics, Tata McGraw-Hill.

20. Resources required for the course (itemized student access requirements, if any)

20.1	Software	PSpice software for electronic circuit design on PC
20.2	Hardware	
20.3	Teaching aids (videos, etc.)	
20.4	Laboratory	
20.5	Equipment	
20.6	Classroom infrastructure	
20.7	Site visits	
20.8	Others (please specify)	

21. Design content of the course (Percent of student time with examples, if possible)

21.1	Design-type problems	30% time will be used on design problems and examples
21.2	Open-ended problems	
21.3	Project-type activity	
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: (Signature of the Head of the Department/ Centre / School)

Date of Approval of Template by Senate

The information on this template is as on the date of its approval, and is likely to evolve with time.

COURSE TEMPLATE

1.	Department/Centre/School proposing the course	Physics	
2.	Course Title	Statistical Mechanics	
3.	L-T-P structure	3-1-0	
4.	Credits	4	Non-graded Units Please fill appropriate details in S. No. 21
5.	Course number	PHL558	
6.	Course Status (Course Category for Program) (list program codes: eg., EE1, CS5, etc.)		
	Institute Core for all UG programs	No	
	Programme Linked Core for:	List of B.Tech. / Dual Degree Programs	
	Departmental Core for:	M. Sc. Physics Program	
	Departmental Elective for:	List of B.Tech. / Dual Degree Programs	
	Minor Area / Interdisciplinary Specialization Core for:	Name of Minor Area / Specialization Program	
	Minor Area / Interdisciplinary Specialization Elective for:	Name of Minor Area / Specialization Program	
	Programme Core for:	List of M.Tech. / Dual Degree Programs	
	Programme Elective for:	List of M.Tech. / Dual Degree Programs	
	Open category Elective for all other programs (No if Institute Core)	No	
7.	Pre-requisite(s)	combinations of courses: eg. (XYZ123 & XYW214) / XYZ234	
8.	Status vis-à-vis other courses		
	8.1 List of courses precluded by taking this course (significant overlap)		(course number)
	(a)	Significant Overlap with any UG/PG course of the Dept./Centre/ School	NO
	(b)	Significant Overlap with any UG/PG course of other Dept./Centre/ School	NO
	8.2	Supersedes any existing course	NO
9.	Not allowed for	UG	

10.	Frequency of offering (check one box)	☐ Every semester ☐ I sem ☒ II sem ☐ Either semester
------------	---	--

11.	Faculty who will teach the course (Minimum 2 names for core courses / 1 name for electives) Dr. Varsha Banerjee, Dr. Sujin B. Babu, Dr. Saswata Bhattacharya, Dr. Rahul Marathe, any other faculty in Statistical Mechanics, Condensed matter Physics Group.
------------	---

12.	Will the course require any visiting faculty?	No
------------	--	----

13.	Course objectives (about 50 words. "On successful completion of this course, a student should be able to..."): To introduce the students to the general notions of Statistical Mechanics viz. The Gibb's ensemble theory. Using this approach to calculate properties of classical systems. Density matrix approach for Quantum mechanical systems. Fermions, Bosons and their statistics. Introduction to phase transitions in classical spin systems like Ising model.
------------	--

14.	Course contents (about 100 words; Topics to appear as course contents in the Courses of Study booklet) (Include Practical / Practice activities): Introduction to statistical methods. Some basic notions of random walks, Poisson distribution, Gaussian distribution. statistical basis for thermodynamics: macrostates, microstates, Gibb's paradox. Gibb's ensemble theory: phase space perspective, Liouville's theorem, microcanonical, canonical and grand canonical ensembles, partition function, calculations of physical properties of classical systems using ensemble approach, thermodynamic relations. applications of ensemble theory, quantum statistical mechanics: density matrix approach, statistical mechanics of Bosons and Fermions, Bose-Einstein condensation, Pauli paramagnetism, Landau diamagnetism, quantum statistics of harmonic oscillators, non-ideal gases, virial expansion, brief introduction to phase transitions, critical phenomena, transfer matrix approach, application to 1-D Ising model.
------------	--

15. Lecture Outline(with topics and number of lectures)

Module no.	Topic	No. of hours (not exceeding 5h per topic)
1	Random walks and its properties	3
2	Basic notions of Probability theory	3
3	Phase Space and Liouville's theorem	2
4	Gibb's ensemble theory Micro-canonical, Canonical, Grand-Canonical ensembles and related topics.	7
5	Calculations of Physical properties using ensemble theory approach. Applications of Gibb's ensemble theory to classical prototype systems. Thermodynamic relations	9
6	Quantum statistical mechanics. Density matrix approach for Quantum mechanical systems, statistical mechanics of Bosons, Fermions. Bose-Einstein condensation. Paramagnetism, diamagnetism. Quantum statistics of Harmonic oscillators.	9

7	Non-ideal gases, virial expansion	3
8	Introduction to phase transitions, critical phenomena, classical spin models.	6
9		
10		
11		
Total Lecture hours (14 times 'L')		42

16. Brief description of tutorial activities:

Module no.	Description	No. of hours
1	Problem solving session on Lecture modules 1-2	2
2	Problem solving session on Lecture modules 3-5	5
3	Problem solving session on Lecture modules 6-7	4
4	Problem solving session on Lecture modules 8	3
Total Tutorial hours (14 times 'T')		14

17. Brief description of Practical / Practice activities

Module no.	Description	No. of hours
Total Practical / Practice hours (14 times 'P')		

Brief18. description of module-wise activities pertaining to self-learning component

(Only for 700 / 800 level courses) (Include topics that the students would do self-learning from books / resource materials: Do not Include assignments / term papers etc.)

Module no.	Description
(The volume of self-learning component in a 700-800 level course should typically be 25-30% of the volume covered in classroom contact)	

19. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

- 1) Pathria R. K., Statistical Mechanics, 2nd Edition, Elsevier (1996).
- 2) Huang K., Statistical Mechanics, 2nd Edition, Wiley (2008).
- 3) Landau L., Lifschitz E. M. Statistical Physics Part. 1, vol. 5 in course of Theoretical Physics, 3rd edition, Elsevier Science (1980).
- 4) Plischke M., Begersen B., Equilibrium statistical Physics, 2nd Edition, World Scientific (1994).

20. Resources required for the course (itemized student access requirements, if any)

20.1	Software	Name of software, number of licenses, etc.
20.2	Hardware	Nature of hardware, number of access points, etc.
20.3	Teaching aids (videos, etc.)	Description, Source , etc.
20.4	Laboratory	Type of facility required, number of students etc.
20.5	Equipment	Type of equipment required, number of access points, etc.
20.6	Classroom infrastructure	Type of facility required, number of students etc.
20.7	Site visits	Type of Industry/ Site, typical number of visits, number of students etc.
20.8	Others (please specify)	

21. Design content of the course (Percent of student time with examples, if possible)

21.1	Design-type problems	Eg. 25% of student time of practical / practice hours: sample Circuit Design exercises from industry
21.2	Open-ended problems	
21.3	Project-type activity	
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date:

(Signature of the Head of the Department/ Centre / School)

Date of Approval of Template by Senate	
---	--

The information on this template is as on the date of its approval, and is likely to evolve with time.

COURSE TEMPLATE

(Please avoid changing the number of tables, rows and columns or text in dark black, but fill only the columns relevant to the template by editing the columns in grey letters or blank columns: this would help in automating the processing of template information for curricular use)

1.	Department/Centre/School proposing the course	PHYSICS	
2.	Course Title	APPLIED OPTICS	
3.	L-T-P structure	3-1-0	
4.	Credits	4	Non-graded Units NIL
5.	Course number	PHL-560	
6.	Course Status (Course Category for Program) PC		
	Institute Core for all UG programs		No
	Programme Linked Core for:		No
	Departmental Core for:		PHS (M.Sc - Physics)
	Departmental Elective for:		List of B.Tech. / Dual Degree Programs
	Minor Area / Interdisciplinary Specialization Core for:		Name of Minor Area / Specialization Program
	Minor Area / Interdisciplinary Specialization Elective for:		Name of Minor Area / Specialization Program
	Programme Core for:		List of M.Tech. / Dual Degree Programs
	Programme Elective for:		List of M.Tech. / Dual Degree Programs
	Open category Elective for all other programs (No if Institute Core)		No
7.	Pre-requisite(s)	NIL	
8.	Status vis-à-vis other courses		
8.1	List of courses precluded by taking this course (significant overlap)		(course number)
	(a)	Significant Overlap with any UG/PG course of the Dept./Centre/ School	(course number)
	(b)	Significant Overlap with any UG/PG course of other Dept./Centre/ School	(course number)
8.2	Supersedes any existing course		PHL558
9.	Not allowed for	(indicate program names)	

10.	Frequency of offering (check one box)	☐ Every semester ☐ I sem ☐ II sem ☐ Either semester
------------	---	---

11.	Faculty who will teach the course Prof. R. K. Varshney, Prof. M. R. Shenoy, Prof. Arun Kumar, Prof. K Thyagarajan, Prof. Anurag Sharma, Prof. B. D. Gupta, Prof. Joby Joseph, Prof. Senthilkumaran, Dr. Kedar Khare
------------	--

12.	Will the course require any visiting faculty?	No
------------	--	----

13.	Course objectives: To provide foundations of advanced topics in Optics and some of the optical phenomena, and their applications in Science and Engineering. The course is at a level complementing an undergraduate course or a first course in Optics.
------------	---

14.	Course contents : Electromagnetic waves in a medium: review of Maxwell's equations and propagation of electromagnetic waves, Various states of polarization and their analysis. Anisotropic media, Plane waves in anisotropic media, Uniaxial crystals, some polarization devices. Diffraction: Scalar waves, The diffraction integral, Fresnel and Fraunhofer diffraction, Diffraction of a Gaussian beam, Diffraction grating. Fourier Optics and Holography: Spatial frequency and transmittance function, Fourier transform by diffraction and by lens, Spatial-frequency filtering, phase-contrast microscope. Holography: On-axis and off-axis hologram recording and reconstruction, Types of hologram and some applications. Coherence and Interferometry: Spatial and temporal coherence, fringe visibility, Michelson stellar interferometer, Optical beats, Multiple beam interference, Fourier transform spectroscopy. Guided Wave Optics: Modes of a planar waveguide, Optical fibers: Step-index and graded index fibers, Waveguide theory and Quantum Mechanics, Applications of optical fibers in Communication and Sensing.
------------	---

15. Lecture Outline(with topics and number of lectures)

Module no.	Topic	No. of hours
1	<u>E. M. Waves in a medium</u> : Review of Maxwell's equations and propagation of electromagnetic waves, reflection and refraction of electromagnetic waves, total internal reflection and evanescent waves. Various states of polarization and their analysis.	5
2	<u>Anisotropic media</u> , Plane waves in anisotropic media, Wave	4

	refractive index, Uniaxial crystals, some polarization devices.	
3	<u>Diffraction</u> : Scalar waves, The diffraction integral, Fresnel and Fraunhofer diffraction, Single-slit, Circular aperture, Resolving power, Diffraction of a Gaussian beam, Diffraction grating.	7
4	<u>Fourier Optics</u> : Basics of Fourier transform operation, Definition of spatial frequency and transmittance function, Fourier transform by diffraction and by lens, Spatial-frequency filtering, types of filters, Abbe-Porter experiments, phase-contrast microscope.	6
5	<u>Holography</u> : Principle of holography, On-axis and off-axis hologram recording and reconstruction, Types of hologram and some applications.	3
6	<u>Coherence and Interferometry</u> : Basics of coherence theory, spatial and temporal coherence, fringe visibility, Michelson stellar interferometer, Optical beats, Multiple beam interference, The Fabry-Perot interferometer, and its application to spectral analysis. Fourier transform spectroscopy, Laser speckles.	8
7	<u>Guided Wave Optics</u> : Guided wave structures, Ray analysis, Modes of a planar waveguide, Physical understanding of modes, Optical fibers: Guided modes of step-index and graded index fibers, Waveguide theory and Quantum Mechanics, Applications of optical fibers in Communication and Sensing.	9
Total Lecture hours (14 times 'L')		42

16. Brief description of tutorial activities:

Module no.	Description	No. of hours
1	Basic concepts, examples and numerical problems related to Reflection, refraction and polarization of EM waves	4
2	Gaussian beams and diffraction, basics examples and numericals	2
3	Fourier integral and its applications in spatial frequency filtering	2
4	Two beam and multiple beam interferometry and applications through examples and numericals	3

5	Basics of guided wave optics, examples, numericals, and applications	3
Total Tutorial hours (14 times 'T')		14

17. Brief description of Practical / Practice activities

Module no.	Description	No. of hours
Total Practical / Practice hours (14 times 'P')		

18. Brief description of module-wise activities pertaining to self-learning component (Only for 700 / 800 level courses) (Include topics that the students would do self-learning from books / resource materials: Do not Include assignments / term papers etc.)

Module no.	Description
(The volume of self-learning component in a 700-800 level course should typically be 25-30% of the volume covered in classroom contact)	

19. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

REFERENCE BOOKS:

1. Ajoy Ghatak, *Optics*, Tata McGraw Hill, New Delhi, (Fifth Edition) 2012
2. E. Hecht, *Optics*, Pearson Education Inc. (Fourth Edition) 2002.
3. Ajoy Ghatak and K. Thyagarajan, *Optical Electronics*, Cambridge University Press (1989).
4. J. W. Goodman, *Fourier Optics*, Viva Books Pvt. Ltd., New Delhi, (Third Edition) 2007.
5. Ajoy Ghatak and Arun Kumar, *Polarization of Light with Applications in Optical Fibers*, Tata McGraw Hill, New Delhi, 2012

--

20. Resources required for the course (itemized student access requirements, if any)

20.1	Software	Name of software, number of licenses, etc.
20.2	Hardware	Nature of hardware, number of access points, etc.
20.3	Teaching aids (videos, etc.)	Description, Source , etc.
20.4	Laboratory	Type of facility required, number of students etc.
20.5	Equipment	Type of equipment required, number of access points, etc.
20.6	Classroom infrastructure	Type of facility required, number of students etc.
20.7	Site visits	Type of Industry/ Site, typical number of visits, number of students etc.
20.8	Others (please specify)	

21. Design content of the course (Percent of student time with examples, if possible)

21.1	Design-type problems	Eg. 25% of student time of practical / practice hours: sample Circuit Design exercises from industry
21.2	Open-ended problems	
21.3	Project-type activity	
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: (Signature of the Head of the Department/ Centre / School)

Date of Approval of Template by Senate	
---	--

The information on this template is as on the date of its approval, and is likely to evolve with time.

COURSE TEMPLATE

1.	Department /Centre proposing the course	PHYSICS
2.	Course Title (<i>< 45 characters</i>)	SOLID STATE PHYSICS
3.	L-T-P structure	3 - 1 - 0
4.	Credits	4
5.	Course number	PHL - 563
6.	Status (<i>category for program</i>)	Program Core (PC)

7.	Pre-requisites (course no./title)	None
----	---	------

8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	No
8.2	Overlap with any UG/PG course of other Dept./Centre	No
8.3	Supercedes any existing course	PHL554

9.	Not allowed for (indicate program names)	
----	--	--

10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
-----	------------------------------	---

11.	Faculty who will teach the course Pankaj Srivastava, Neeraj Khare, Ratnamala Chatterjee, Sankalpa Ghosh, Sujeet Chaudhary, BR Mehta, Pinto Das	
12.	Will the course require any visiting faculty?	No

13.	Course objective (<i>about 50 words</i>):	
-----	--	--

14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Crystal lattices, Reciprocal lattice, Equivalence of Bragg and Laue formulations, Ewald Construction, Bonding & packing in crystals. Free electron theory: Drude and Sommerfield's model of conductivity. Electrons in a Periodic Potential, Bloch Theorem in lattice and reciprocal space, origin of band gap in a weak periodic potential, Kronig-Penney Model, Band structures, Metal, Insulator Semiconductor, Concepts of Effective mass, light and heavy holes in semiconductor, optical properties of semiconductors. Wannier functions, Tight binding model and Calculation of Band structure, Fermi Surfaces.	
-----	---	--

	Thermal Properties: Classical & Quantum Theory of Harmonic Crystal in one-, two-, & three dimensions, Specific Heat at high and low temperatures, Normal Modes & phonons, Einstein & Debye models of specific heat. Special class of Dielectrics & Polarizability, Ferroelectric, Piezoelectric. Magnetism: Diamagnetism, Paramagnetism, Hunds Rule, Curie's Law, Cooling by Diamagnetism, Pauli Paramagnetism, Curie's weiss Law Ferromagnetism and Antiferromagnetic ordering, Domains. Superconductivity: Basic Phenomenology, Meissner effect, London penetration depth, coherence length, Flux quantization,
--	---

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Crystal lattices, Reciprocal lattice, Equivalence of Bragg and Laue formulations, Ewald Construction, Bonding & packing in crystals.	7
2	Free electron theory: Drude and Sommerfield's model of conductivity.	3
3	Electrons in a Periodic Potential, Bloch Theorem in lattice and reciprocal space, origin of band gap in a weak periodic potential, Kronig-Penney Model, Band structures, Metal, Insulator Semiconductor, Concepts of Effective mass, light and heavy holes in semiconductor, optical properties of semiconductors.	7
4	Wannier functions, Tight binding model and Calculation of Band structure, Fermi Surfaces.	5
5	Thermal Properties: Classical & Quantum Theory of Harmonic Crystal in one-, two-, & three dimensions, Specific Heat at high and low temperatures, Normal Modes & phonons, Einstein & Debye models of specific heat.	5
6	Special class of Dielectrics & Polarizability, Ferroelectric, Piezoelectric.	3
7	Magnetism: Diamagnetism, Paramagnetism, Hund's Rule, Curie's Law, Cooling by Diamagnetism, Pauli Paramagnetism, Curie's Weiss Law Ferromagnetism and Antiferromagnetic ordering, Domains.	6
8	Superconductivity: Basic Phenomenology, Meissner effect, London penetration depth, coherence length, Flux quantization, Type I, Type II, BCS theory, Energy gap, Josephson effect & SQUID.	6
9	###	
10		
11	##	
12		
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

Problem sessions will be incorporated in the lectures. Also, term papers on various topics will be given as a self study component.

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1	###	
2		
3		
4		
5		
6		
7		
8		
9		
10		
COURSE TOTAL (14 times 'P')		####

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

(i)

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	
19.2	Hardware	
19.3	Teaching aides (videos, etc.)	Projection System
19.4	Laboratory	
19.5	Equipment	
19.6	Classroom infrastructure	YES
19.7	Site visits	

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	
20.2	Open-ended problems	
20.3	Project-type activity	
20.4	Open-ended laboratory work	
20.5	Others (please specify)	

Date:

(Signature of the Head of the Department)

COURSE TEMPLATE

(Please avoid changing the number of tables, rows and columns or text in dark black, but fill only the columns relevant to the template by editing the columns in grey letters or blank columns: this would help in automating the processing of template information for curricular use)

1.	Department/Centre/School proposing the course	Physics Department		
2.	Course Title	Atomic and Molecular Physics		
3.	L-T-P structure	3-0-0		
4.	Credits	3	Non-graded Units	Nil
5.	Course number	PHL567		
6.	Course Status (Course Category for Program) PHL			
	Institute Core for all UG programs		No	
	Programme Linked Core for:		No	
	Departmental Core for:		No	
	Departmental Elective for:		Physics	
	Minor Area / Interdisciplinary Specialization Core for:		No	
	Minor Area / Interdisciplinary Specialization Elective for:		No	
	Programme Core for:		No	
	Programme Elective for:		M.Sc. (Physics)	
	Open category Elective for all other programs (No if Institute Core)		No	
7.	Pre-requisite(s)	No		
8.	Status vis-à-vis other courses			
	8.1	List of courses precluded by taking this course (significant overlap)	Nil	
	(a)	Significant Overlap with any UG/PG course of the Dept./Centre/ School	Nil	
	(b)	Significant Overlap with any UG/PG course of other Dept./Centre/ School	Nil	
	8.2	Supersedes any existing course	Nil	
9.	Not allowed for	(indicate program names)		

10.	Frequency of offering (check one box)	Either semester
------------	---	-----------------

11.	Faculty who will teach the course : R.K. Soni, Sujeet Choudhary, A.K. Shukla, Amartya Sengupta, Rajendra S. Dakha
------------	--

12.	Will the course require any visiting faculty?	No
------------	--	----

13.	Course objectives To provide a detailed understanding of the structure of atoms and molecules and an understanding of the interactions between electromagnetic radiation and matter and their applications.
------------	---

14.	Course contents: Hydrogen and alkali metals, double fine structure of atoms, two electron atom, Zeeman and Paschen-back effect, X-ray spectra, general factors influencing spectral line width (Collision, Doppler effect, Heisenberg) and line intensities (transition probability, population of states, Beer- Lambert law), Molecular symmetry, irreducible representations, Rotational and vibrational spectra of diatomic molecules, FTIR and Laser Raman spectroscopy, electronic spectra, Franck-Condon principle, bond dissociation energies, Molecular orbital and models, laser cooling of atom.
------------	--

15. Lecture Outline(with topics and number of lectures)

Module no.	Topic	No. of hours (not exceeding 5h per topic)
1	Theory of atoms Hydrogen atom, the quantization of energy, Alkali atom, Energy level diagram, Effective quantum number and quantum defect, Lamb shift, Two electron atom, LS and JJ coupling, X-ray spectra: energy levels, Emission and absorption spectra.	9
2	Interaction of atoms with electric and magnetic field Magnetic effects, Precessional motion, Spin-orbit interaction, fine structure, Influence of external magnetic field: Zeeman and Paschen-back effects in one and two electron atom, g-factor.	6
3.	Line width and broadening General factors influencing spectral line widths (collisional, Doppler Heisenberg), transition probability, population of states, Beer- Lambert law	4
4	Molecular Physics Molecular symmetry, irreducible representation Rotational Spectra of diatomic molecule, intensity of spectral lines, Effect of isotope substitutions, non-rigid rotator, Vibrational spectra of diatomic molecules, harmonic and anharmonic Vibrator-rotational spectra Pure rotational Raman spectra, linear and symmetric top molecules, vibrational Raman spectra, rotational fine structure, selection rule, overtone spectra,	9
5	Electronic properties of molecules	7

	Electronic spectra of diatomic molecules: Born-Oppenheimer approximation, Franck-Condon principle, Dissociation energy and dissociation products, rotational fine structures, pre-dissociation of molecules	
6	Orbital theory of molecules Molecular orbital theory, shape of molecular orbitals, classification of states, spectrum of hydrogen molecules	5
7	Laser cooling of atoms	2
Total Lecture hours (14 times 'L')		42

16. Brief description of tutorial activities: Nil

Module no.	Description	No. of hours
Total Tutorial hours (14 times 'T')		

17. Brief description of Practical / Practice activities: Nil

Module no.	Description	No. of hours
Total Practical / Practice hours (14 times 'P')		

18. Brief description of module-wise activities pertaining to self-learning component (Only for 700 / 800 level courses) (Include topics that the students would do self-learning from books / resource materials: Do not Include assignments / term papers etc.): Nil

Module no.	Description
(The volume of self-learning component in a 700-800 level course should typically be 25-30% of the volume covered in classroom contact)	

19. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. Introduction to Atomic Spectra, H.E.White, McGraw Hill, 1934
2. Basic Atomic and Molecular Spectroscopy- Basic Aspects and Practical Applications, Svanberg Sune, Springer, 4th edition., 2004
3. Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles, Robert Eisenberg and Robert Resnick, 2nd Ed, John Wiley & Sons, 2004.
4. Fundamental of Molecular Spectroscopy, Colin N. Banwell and Elaine M. McCash, 4th edition, 2004

20. Resources required for the course (itemized student access requirements, if any) : Nil

20.1	Software	Name of software, number of licenses, etc.
20.2	Hardware	Nature of hardware, number of access points, etc.
20.3	Teaching aids (videos, etc.)	Description, Source , etc.
20.4	Laboratory	Type of facility required, number of students etc.
20.5	Equipment	Type of equipment required, number of access points, etc.
20.6	Classroom infrastructure	Type of facility required, number of students etc.
20.7	Site visits	Type of Industry/ Site, typical number of visits, number of students etc.
20.8	Others (please specify)	

21. Design content of the course (Percent of student time with examples, if possible): Nil

21.1	Design-type problems	Eg. 25% of student time of practical / practice hours: sample Circuit Design exercises from industry
21.2	Open-ended problems	
21.3	Project-type activity	
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date:

(Signature of the Head of the Department/ Centre / School)

Date of Approval of Template by Senate

The information on this template is as on the date of its approval, and is likely to evolve with time.

COURSE TEMPLATE

(Please avoid changing the number of tables, rows and columns or text in dark black, but fill only the columns relevant to the template by editing the columns in grey letters or blank columns: this would help in automating the processing of template information for curricular use)

1.	Department/Centre/School proposing the course	PHYSICS	
2.	Course Title	Nuclear And Particle Physics	
3.	L-T-P structure	3-0-0	
4.	Credits	3	Non-graded Units
			Please fill appropriate details in S. No. 21
5.	Course number	PHL-569	
6.	Course Status (Course Category for Program) PG		
	Institute Core for all UG programs	No	
	Programme Linked Core for:	List of B.Tech. / Dual Degree Programs	
	Departmental Core for:	List of B.Tech. / Dual Degree Programs	
	Departmental Elective for:	List of B.Tech. / Dual Degree Programs	
	Minor Area / Interdisciplinary Specialization Core for:	Name of Minor Area / Specialization Program	
	Minor Area / Interdisciplinary Specialization Elective for:	Name of Minor Area / Specialization Program	
	Programme Core for:	MSc. Physics.	
	Programme Elective for:	List of M.Tech. / Dual Degree Programs	
	Open category Elective for all other programs (No if Institute Core)	(Yes / No)	
7.	Pre-requisite(s)	NIL	
8.	Status vis-à-vis other courses		
8.1	List of courses precluded by taking this course (significant overlap)	(course number)	
	(a) Significant Overlap with any UG/PG course of the Dept./Centre/ School	NIL	
	(b) Significant Overlap with any UG/PG course of other Dept./Centre/ School	NIL	
8.2	Supersedes any existing course	NIL	
9.	Not allowed for	(indicate program names)	

10.	Frequency of offering (check one box)	☐ Every semester ☒ I sem ☐ II sem ☐ Either semester
------------	---	--

11.	Faculty who will teach the course Amruta Mishra, A.K.Shukla, Shantanu Ghosh, V. Ravishankar.
------------	---

12.	Will the course require any visiting faculty?	No
------------	--	----

13.	Course objectives To introduce the student to basic aspects of nuclear and sub-nuclear physics.
------------	--

14.	Course contents (about 100 words; Topics to appear as course contents in the Courses of Study booklet) (Include Practical / Practice activities): N-N interaction, iso-spin symmetry, nuclear models, beta decay, detectors and particle accelerators, quark model, deep inelastic scattering, nuclear astrophysics, fundamental particles.
------------	--

15. Lecture Outline(with topics and number of lectures)

Module no.	Topic	No. of hours (not exceeding 5h per topic)
1	Basic properties of Nucleons and Nuclei A quick review of masses, radii, spins and magnetic momenta of the nucleons and nuclei, the Weizacker Mass formula, stable and unstable nuclei.	3
2	The nucleon- nucleon (N - N) interaction The deuteron and its properties, non-central nature of nuclear force, absence of proton-proton and neutron-neutron bound states, Isospin, Nucleon-Nucleon scattering, consequences of isospin symmetry and experimental evidence in N-N and pi- N scattering, realistic potentials.	5
3	Nuclear models Thomas Fermi; nuclear shell model, magnetic moments and spin parity of nuclei, the magic numbers; The collective model and application to even-even nuclei,	5

	their spectrum and selection rules for radiation.	
4	Beta Decay Fermi's theory of Beta decay, the Curie plot, mass of the neutrino, Fermi and Gamow Teller transitions, allowed and forbidden transitions. parity violation in beta decay and its experimental evidence.	4
5	Detectors and Particle Accelerators Particle detectors and accelerators, simple applications to material science and medicine	3
6	Nucleon Structure I Strongly interacting particles, hadrons baryons and mesons, Hagedorn temperature, degeneracy in Baryon and meson spectra, SU(3) symmetry, strangeness, Gellmann-quark model, color quantum number.	6
7	Nucleon Structure II Brief review of Rutherford scattering, electron-nucleon elastic scattering, form factors, charge and current distributions, inelastic scattering, deep inelastic scattering, structure functions, scaling laws, quark-parton model, evidence for colour, need for gluons and experimental evidence. Introduction to QCD. Some open problems.	7
8	Nuclear Astrophysics Stellar structure, Nuclear burning stages, hydrogen and helium burning, core collapse, Chandrasekhar limit, supernova, white dwarf, neutron stars, pulsars and black holes; synthesis of nuclei in stars.	5
9	Fundamental Particles Fundamental interactions and their properties, strengths and ranges, leptons and baryon generations, Gauge bosons and the Higgs, conservation laws, the particle zoo.	4
Total Lecture hours (14 times 'L')		

16. Brief description of tutorial activities: Nil

Module no.	Description	No. of hours
Total Tutorial hours (14 times 'T')		

17. Brief description of Practical / Practice activities

Module no.	Description	No. of hours
Total Practical / Practice hours (14 times 'P')		

18. Brief description of module-wise activities pertaining to self-learning component (Only for 700 / 800 level courses) (Include topics that the students would do self-learning from books / resource materials: Do not Include assignments / term papers etc.)

Module no.	Description
(The volume of self-learning component in a 700-800 level course should typically be 25-30% of the volume covered in classroom contact)	

19. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

A.Das and T.Ferbel, Introduction to nuclear and particle physics, World Scientific.
F. Halzen and A.D.Martin, Quarks and Leptons, John Wiley & Sons.
I.J.R.Aitchison and A.J.G.Hey, Gauge Theories in Particle Physics, Taylor and Francis.
M.G.Bowler, Femto Physics: A short course on particle physics, Pergamon Press.

20. Resources required for the course (itemized student access requirements, if any)

20.1	Software	Name of software, number of licenses, etc.
20.2	Hardware	Nature of hardware, number of access points, etc.
20.3	Teaching aids (videos, etc.)	Description, Source, etc. Projector Systems
20.4	Laboratory	Type of facility required, number of students etc.
20.5	Equipment	Type of equipment required, number of access points, etc.
20.6	Classroom infrastructure	Type of facility required, number of students etc. Yes

20.7	Site visits	Type of Industry/ Site, typical number of visits, number of students etc.
20.8	Others (please specify)	

21. Design content of the course (Percent of student time with examples, if possible)

21.1	Design-type problems	Eg. 25% of student time of practical / practice hours: sample Circuit Design exercises from industry
21.2	Open-ended problems	
21.3	Project-type activity	
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: (Signature of the Head of the Department/ Centre / School)

Date of Approval of Template by Senate	
---	--

The information on this template is as on the date of its approval, and is likely to evolve with time.

COURSE TEMPLATE

1.	Department/Centre proposing the course	PHYSICS
2.	Course Title (<i>< 45 characters</i>)	FIBER AND INTEGRATED OPTICS
3.	L-T-P structure	3-0-0
4.	Credits	3
5.	Course number	PYL650
6.	Status (<i>category for program</i>)	PE

7.	Pre-requisites (course no./title)	
----	---	--

8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	PYL791
8.2	Overlap with any UG/PG course of other Dept./Centre	NO
8.3	Supercedes any existing course	No

9.	Not allowed for (indicate program names)	
----	--	--

10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
-----	------------------------------	---

11.	Faculty who will teach the course Prof. R.K. Varshney, Prof. M.R. Shenoy, Prof. K. Thyagarajan, Prof. Arun Kumar, Prof. Anurag Sharma	
12.	Will the course require any visiting faculty?	No

13.	Course objective (<i>about 50 words</i>): Fiber and Integrated Optics has important applications in the area of optical communications and sensing. The objective of this course is to introduce the basic concepts and the principles underlying the study and analysis of optical waveguides and devices. Propagation characteristics of both fiber and integrated optical waveguides will be discussed.	
-----	--	--

14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Modes in planar optical waveguides: TE and TM modes. Modal analysis of a parabolic index medium. Modes in channel waveguides: Effective index method, Perturbation method and Variational method. Modes in multilayered waveguides: Matrix method. Directional coupler: coupled mode theory, Integrated Optical devices: Prism Coupling, optical switching, modulators and wavelength filters, etc. Step Index and graded index fibers, Attenuation in optical fibers, LP Guided	
-----	--	--

	Modes of a step-index fiber, Single-mode fibers, Gaussian approximation and splice losses. Dispersion in optical fibers, Pulse dispersion, Dispersion management. Fabrication and characterization of optical waveguides. Fiber optic components and devices. Optical fiber sensors; basic principles and applications.
--	--

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Modes in planar optical waveguides: TE and TM modes, Parabolic index medium, WKB Method.	7
2	Modes in channel waveguides: Effective index method, Perturbation method and variational method	5
3	Directional coupler: coupled mode theory, Some integrated Optical devices: optical switching and wavelength filtering, modulators, etc,	7
4	Step index and graded index fibers, Attenuation in optical fibers, LP Guided Modes of a step-index fiber	5
5	Single-mode fibers, Gaussian approximation and splice losses	3
6	Dispersion in optical fibers, Pulse dispersion, Dispersion management	5
7	Fabrication and characterization of optical waveguides, the prism-coupling technique	4
8	Fiber optic components and devices	3
9	Optical fiber sensors; basic principles and applications	3
10		
11		
12		
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

--

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. A.K.Ghatak and K.Thyagarajan, "Optical Electronics", Cambridge University Press (1989),
2. A.K.Ghatak and K.Thyagarajan, "Introduction to Fiber Optics", Cambridge University Press (1998).
3. G. Keiser, "Optical Fiber Communications", McGraw-Hill, Inc. (2012) .
4. K Okamoto, "Fundamentals of optical waveguides", Academic Press (2006)
5. A. Yariv and P. Yeh, "Photonics", Oxford University Press (2007).

--

19. Resources required for the course (*itemized & student access requirements, if any*)

19.1	Software	Matlab
19.2	Hardware	
19.3	Teaching aides (videos, etc.)	LCD Projection facility
19.4	Laboratory	
19.5	Equipment	
19.6	Classroom infrastructure	
19.7	Site visits	

20. Design content of the course (*Percent of student time with examples, if possible*)

20.1	Design-type problems	10%
20.2	Open-ended problems	10%
20.3	Project-type activity	
20.4	Open-ended laboratory work	
20.5	Others (please specify)	

Date:

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	PHYSICS	
2.	Course Title (<i>< 45 characters</i>)	ADVANCED SOLID STATE PHYSICS	
3.	L-T-P structure	3 - 0 - 0	
4.	Credits	3	
5.	Course number	PHL - 651	
6.	Status (<i>category for program</i>)	Program Elective (PE)	

7.	Pre-requisites (<i>course no./title</i>)	Solid State Physics-I	
----	--	-----------------------	--

8.	Status vis-à-vis other courses (<i>give course number/title</i>)		
8.1	Overlap with any UG/PG course of the Dept./Centre	No	
8.2	Overlap with any UG/PG course of other Dept./Centre	No	
8.3	Supercedes any existing course	PHL554	

9.	Not allowed for (<i>indicate program names</i>)		
----	---	--	--

10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem	
-----	------------------------------	---	--

11.	Faculty who will teach the course Pankaj Srivastava, Neeraj Khare, Ratnamala Chatterjee, Sankalpa Ghosh, Sujeet Chaudhary, B. R. Mehta, Pintu Das, Rajendra Singh Dhaka		
12.	Will the course require any visiting faculty?	No	

13.	Course objective (<i>about 50 words</i>): The overall objective of the course is to give exposure to students to understand electron transport behavior as well as magnetic and superconducting properties of solids. Discussions on various topics will include experimental aspects, enabling students to pursue higher studies both in theoretical as well as experimental condensed matter physics.		
-----	---	--	--

14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Semiclassical model of electron dynamics, electrons in static electric and magnetic field, DC and AC electrical conductivity in metals, Sources of electron scattering, Boltzmann equation, Temperature dependence of electronic conductivity, Dielectric properties of insulators, Pizeoelectric, Ferroelectric, Pyroelectric, Optical properties of solids, Electrons in magnetic fields, Landau Levels, Cylotron resonance, density of states in magnetic field, De-Haas Van Alfen effect, Quantum Hall effect, Models for ferromagnetism,		
-----	---	--	--

	Magnetic phase transition, Properties of Superconductors, Ginzburg-Landau theory, Josephson effect, Squid Microscopic Theory of superconductivity: Cooper pairs, BCS theory.
--	--

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Semiclassical model of electron dynamics, General features, Consequences of semiclassical model, Electrons in static electric and magnetic fields.	4
2	Sources of electron scattering, Scattering probability and relaxation times, Scattering at defects, scattering by phonons, Normal and Umklapp processes, Temperature dependence of electrical conductivity of metals, Matthiessen's rules	4
3	Bloch electrons in a uniform magnetic field, cyclotron resonance, Landau levels, density of states in magnetic field, De-Haas van Alfen effect, Measurement of Fermi surface	4
4	Dielectric Properties of insulators, Local Fields, Polarizability, Piezoelectric, Ferroelectric, Pyroelectric.	4
5	Optical properties of solids: Complex dielectric function and complex optical conductivity, Absorption of light in solids, Impurities and excitons, Luminescence and photoconductivity, optical study of lattice vibrations	5
6	Anharmonic effects in crystals, equation of state, thermal expansion of a crystal, Grueneisen parameter, lattice thermal conductivity, heat conduction by phonons	5
7	Crystal fields, origin of crystal fields, Exchange interaction, origin of exchange, direct exchange, indirect exchange in ionic solids and in metals, double exchange, Landau theory of ferromagnetism, Heisenberg and Ising models, Spin excitation, Magnons.	8
8	Superconductivity: Properties of superconductors, Ginzburg-Landau Theory: Order Parameter, Boundary conditions, Coherence length, London penetration depth, Flux quantization, Josephson Effect, SQUID, Microscopic Theory of Superconductivity: Cooper pairs, BCS theory, Ground state of superconducting electron gas, excited states. High Temperature Superconductors	8
9	###	
10		
11	##	
12		
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

Term papers on various topics will be given as a self study component.
--

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1	###	
2		
3		
4		
5		
6		
7		

8		
9		
10		
COURSE TOTAL (14 times 'P')		####

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

- i) N. W. Aschcroft and N. D. Mermin, Solid State Physics, CBS Publishing Asia Ltd., 1976
- ii) H. Ibach and H. Lueth, Solid State Physics, An introduction to theory and experiment, Narosa Publishing House, 1992.
- iii) S. Blundell, Magnetism in Condensed Matter, 1st edition, Oxford University Press, 2001
- iv) J. Singleton, Band Theory and electronic properties of solids, 1st edition Oxford University Press, 2001.

19. Resources required for the course (*itemized & student access requirements, if any*)

19.1	Software	
19.2	Hardware	
19.3	Teaching aides (videos, etc.)	Projection System
19.4	Laboratory	
19.5	Equipment	
19.6	Classroom infrastructure	YES
19.7	Site visits	

20. Design content of the course (*Percent of student time with examples, if possible*)

20.1	Design-type problems	
20.2	Open-ended problems	
20.3	Project-type activity	
20.4	Open-ended laboratory work	
20.5	Others (please specify)	

Date:

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	PHYSICS
2.	Course Title (<i>< 45 characters</i>)	MAGNETISM AND SPINTRONICS
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	PHL - 652
6.	Status (<i>category for program</i>)	Program Elective (PE)

7.	Pre-requisites (<i>course no./title</i>)	PHL554
----	--	--------

8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	EPL446, PHL724
8.2	Overlap with any UG/PG course of other Dept./Centre	No
8.3	Supercedes any existing course	No

9.	Not allowed for (<i>indicate program names</i>)	B. Tech. (Engineering Physics), M. Tech. (SSM)
----	---	--

10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☒ Either sem
-----	------------------------------	---

11.	Faculty who will teach the course Neeraj Khare, Ratnamala Chatterjee, Sujeet Chaudhary, Santanu Ghosh, Pintu Das, P. K. Muduli	
12.	Will the course require any visiting faculty?	No

13.	Course objective (<i>about 50 words</i>): Spintronics is a relatively recent extension of conventional charge transport based electronics wherein both the spin, in addition to the charge, of the electron are used as state-variables to store, process, and transport information. First part of this course will cover topics of advanced magnetism and the second part will cover the general principles underpinning various spintronic device functionalities, and provide an overview of the topic, from its beginnings in magnetic multilayer structures through to the present state-of-the-art.	
-----	--	--

14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Magnetism of metals, Spontaneous spin split bands, Magnetic Anisotropy, Competing interactions, One and two-dimensional magnets, Spin dependent transport in magnetic metals - Anisotropic Magnetoresistance, Giant Magnetoresistance, Spin dependent tunneling, Tunneling magnetoresistance,	
-----	---	--

	Spin-Orbit interaction and Hall effects –Spin Hall Effect and Inverse Spin Hall Effect; Spin injection phenomena - Spin Transfer Torque, Spin injection magnetization reversal; High frequency phenomena; Spin Transfer Torque.
--	---

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Magnetism in metals: Free electron model, Pauli paramagnetism, Spontaneously spin-split bands, Landau levels, Landau diamagnetism, Magnetism of the electron gas, Excitations in the electron gas, Spin-density waves, Kondo effect, The Hubbard model	7
2	Magnetic anisotropy: Shape anisotropy, Magnetocrystalline anisotropy and its origin, Induced anisotropy	5
3	Competing interactions and low dimensionality: Magnetic frustration, Spin glasses, Superparamagnetism, One and two-dimensional magnets, Spin chain, Spin-Peierl's transition, Spin ladders	6
4	Galvanomagnetic Effects in Ferromagnetic Materials: Spin-orbit interaction, Anomalous Hall Effect, Anisotropic Magnetoresistance, Mechanism of AMR, Magnetic multilayers, Giant Magnetoresistance, Mechanism of GMR, Colossal Magnetoresistance, Spin flip scattering	7
5	Spin tunneling, Tunnel Magnetoresistance (TMR), Effects of Fermi surface, Effect of interfacial states, diffusive tunneling, Spin flip tunneling, Bias voltage dependence of TMR, Magnetic tunnel Junctions (MTJ), Tunnel Junctions with Half Metals	8
6	Spin polarization, Spin Injection, Spin accumulation, Spin-transfer torque, Spin torque effects in magnetic systems, Spin injection magnetization switching, High frequency phenomena - Spin transfer oscillation, Spin Hall effect and Inverse Spin Hall effect	9
7		
8		
9	###	
10		
11	##	
12		
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

Term papers on various topics will be given as a self study component.
--

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1	###	
2		
3		
4		
5		
6		
7		
8		
9		
10		
COURSE TOTAL (14 times 'P')		####

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

- i) S. Blundell, Magnetism in Condensed Matter, 1st edition, Oxford University Press, 2001.
- ii) R. C. O'Handley, Modern Magnetic Materials, John Wiley & Sons, Inc., 2000.
- iii) T. Shinjo (Ed.) Nanomagnetism and Spintronics, 1st edition, Elsevier, 2009.
- iv) E. Y. Tsymbal and I Zutic, Handbook of Spin Transport and Magnetism, CRC Press, 2012.

19. Resources required for the course (*itemized & student access requirements, if any*)

19.1	Software	
19.2	Hardware	
19.3	Teaching aides (videos, etc.)	Projection System
19.4	Laboratory	
19.5	Equipment	
19.6	Classroom infrastructure	YES
19.7	Site visits	

20. Design content of the course (*Percent of student time with examples, if possible*)

20.1	Design-type problems	
20.2	Open-ended problems	
20.3	Project-type activity	
20.4	Open-ended laboratory work	
20.5	Others (please specify)	

Date:

(Signature of the Head of the Department)

COURSE TEMPLATE

(Please avoid changing the number of tables, rows and columns or text in dark black, but fill only the columns relevant to the template by editing the columns in grey letters or blank columns: this would help in automating the processing of template information for curricular use)

1.	Department/Centre/School proposing the course	PHYSICS	
2.	Course Title	ADVANCED PLASMA PHYSICS	
3.	L-T-P structure	3-0-0	
4.	Credits	3	Non-graded Units Please fill appropriate details in S. No. 21
5.	Course number	PHL-658	
6.	Course Status (Course Category for Program) (list program codes: eg., EE1, CS5, etc.)		
	Institute Core for all UG programs	(Yes / No)	
	Programme Linked Core for:	List of B.Tech. / Dual Degree Programs	
	Departmental Core for:	List of B.Tech. / Dual Degree Programs	
	Departmental Elective for:	MSc	
	Minor Area / Interdisciplinary Specialization Core for:	Name of Minor Area / Specialization Program	
	Minor Area / Interdisciplinary Specialization Elective for:	Name of Minor Area / Specialization Program	
	Programme Core for:	List of M.Tech. / Dual Degree Programs	
	Programme Elective for:	List of M.Tech. / Dual Degree Programs	
	Open category Elective for all other programs (No if Institute Core)	(Yes / No)	
7.	Pre-requisite(s)	NONE	
8.	Status vis-à-vis other courses		
8.1	List of courses precluded by taking this course (significant overlap)	NONE	
	(a) Significant Overlap with any UG/PG course of the Dept./Centre/ School	(course number)	
	(b) Significant Overlap with any UG/PG course of other Dept./Centre/ School	(course number)	
8.2	Supersedes any existing course	(course number)	
9.	Not allowed for	(UG students)	

10.	Frequency of offering (check one box)	☐ Every semester ☐ I sem ☐ II sem x Either semester
------------	---	---

11.	Faculty who will teach the course HITENDRA K MALIK, AJIT KUMAR, AMRUTA MISHRA, SANTANU GHOSH
------------	---

12.	Will the course require any visiting faculty?	(Yes/ No)
------------	--	-------------------

13.	Course objectives (about 50 words. "On successful completion of this course, a student should be able to..."): THIS COURSE WILL PROVIDE NEW ASPECTS OF PLASMAS CONCERNING NONLINEAR ELECTROSTATIC AND ELECTROMAGNETIC WAVES FOR THEIR DIVERSE APPLICATIONS IN COMMUNICATIONS, RADIATION GENERATION, SPACE VEHICLES, AND PARTICLE ACCELERATION. AFTER COMPLETING THIS COURSE THE STUDENT WILL BE IN THE POSITION TO START RESEARCH WORK IN ANY OF THESE FIELDS. THIS WILL ALSO HELP DEVELOPING THE UNDERSTANDING WITH REGARD TO ASTROPHYSICS.
------------	--

14.	Course contents (about 100 words; Topics to appear as course contents in the Courses of Study booklet) (Include Practical / Practice activities): NONLINEARITY AND DISPERSION, SOLITARY WAVES AND SOLITONS, KORTEWEG-DeVRIES (KdV) EQUATION, ELECTROMAGNETIC (EM) RADIATION FROM FREE CHARGES, ABSORPTION OF EM WAVES IN PLASMAS, RADIATION BY COULOMB COLLISIONS, PLASMA BASED TERAHERTZ RADIATION GENERATION, HALL THRUSTERS, RAYLEIGH-TAYLOR INSTABILITY, RESISTIVE INSTABILITY, ELECTRON TRANSPORT, WAVEGUIDE MODES IN THE PRESENCE OF PLASMA, PONDEROMOTIVE FORCE, WAKEFIELD, PARTICLE ACCELERATION, DUSTY PLASMA, CURRENT FLOW IN DUST GRAINS, WAVES IN DUSTY PLASMA
------------	--

15. Lecture Outline(with topics and number of lectures)

Module no.	Topic	No. of hours (not exceeding 5h per topic)
1.	Linear and nonlinear forces, Linear and nonlinear systems, Effects of nonlinearity, Dispersion: Frequency dependence of permittivity, Plasma: A nonlinear and dispersive medium.	03
2.	Stretched coordinates, Korteweg-deVries (KdV) equation and its solution, Solitons in uniform plasma, Solitons in nonuniform	07

	plasma, Solitons in magnetized plasma.	
3.	Electromagnetic (EM) radiation, EM radiation from free charges, Propagation of EM waves in a plasma, Absorption of EM waves in a plasma, Radiation spectrum, Radiation from collisions between charged particles, Bremsstrahlung: Radiation by Coulomb collisions, Scattering of radiation by plasma species, Plasma based Terahertz radiation generation schemes.	10
4.	Configuration of Hall thrusters (HTs), Instabilities in general and in HTs, Rayleigh-Taylor instability, Resistive instability, Potential profiles, Electron transport, Thrusters efficiency.	07
5.	Modes in plasma filled waveguides, Wakefield, Particle acceleration, Effect of ponderomotive force, Duct formation, Special density bunch / pattern formation.	08
6.	Dust grains, Electron and ion current flow to a dust grain, Dust charge, Dusty plasma parameter space, Dust acoustic waves, Dust ion acoustic waves, Crystallization of a dusty plasma.	07
Total Lecture hours (14 times 'L')		42

16. Brief description of tutorial activities:

Module no.	Description	No. of hours
Total Tutorial hours (14 times 'T')		ZERO

17. Brief description of Practical / Practice activities

Module no.	Description	No. of hours
Total Practical / Practice hours (14 times 'P')		ZERO

18. Brief description of module-wise activities pertaining to self-learning component (Only for 700 / 800 level courses) (Include topics that the students would do self-learning from books / resource materials: Do not Include assignments / term papers etc.)

Module no.	Description

(The volume of self-learning component in a 700-800 level course should typically be 25-30% of the volume covered in classroom contact)

19. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

- 1) Solitons in Action by Karl E Lonngren and Alwyn Scott. Publisher: Academic Press (1978).
- 2) Terahertz Physics by R A Lewis. Publisher: Cambridge University Press (2012).
- 3) Wave Propagation / Book 2, INTECH Open Science, Croatia (2013).
<http://dx.doi.org/10.5772/52246>
- 4) Plasmas: The First State of Matter by Vinod Krishan. Publisher: Cambridge University Press (2014).
- 5) Fundamentals of Plasma Physics by Paul M. Bellan. Cambridge University Press (2006).

20. Resources required for the course (itemized student access requirements, if any)

20.1	Software	Name of software, number of licenses, etc.
20.2	Hardware	Nature of hardware, number of access points, etc.
20.3	Teaching aids (videos, etc.)	Description, Source , etc.
20.4	Laboratory	Type of facility required, number of students etc.
20.5	Equipment	Type of equipment required, number of access points, etc.
20.6	Classroom infrastructure	Type of facility required, number of students etc.
20.7	Site visits	Type of Industry/ Site, typical number of visits, number of students etc.
20.8	Others (please specify)	

21. Design content of the course (Percent of student time with examples, if possible)

21.1	Design-type problems	Eg. 25% of student time of practical / practice hours: sample Circuit Design exercises from industry
21.2	Open-ended problems	
21.3	Project-type activity	
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: (Signature of the Head of the Department/ Centre / School)

Date of Approval of Template by Senate	
---	--

The information on this template is as on the date of its approval, and is likely to evolve with time.

COURSE TEMPLATE

(Please avoid changing the number of tables, rows and columns or text in dark black, but fill only the columns relevant to the template by editing the columns in grey letters or blank columns: this would help in automating the processing of template information for curricular use)

1.	Department/Centre/School proposing the course	PHYSICS	
2.	Course Title	Laser Spectroscopy	
3.	L-T-P structure	3-0-0	
4.	Credits	3	Non-graded Units Please fill appropriate details in S. No. 21
5.	Course number	PHL-659	
6.	Course Status (Course Category for Program) (list program codes: eg., EE1, CS5, etc.)		
	Institute Core for all UG programs		(Yes / No)
	Programme Linked Core for:		List of B.Tech. / Dual Degree Programs
	Departmental Core for:		List of B.Tech. / Dual Degree Programs
	Departmental Elective for:		List of B.Tech. / Dual Degree Programs
	Minor Area / Interdisciplinary Specialization Core for:		Name of Minor Area / Specialization Program
	Minor Area / Interdisciplinary Specialization Elective for:		Name of Minor Area / Specialization Program
	Programme Core for:		List of M.Tech. / Dual Degree Programs
	Programme Elective for:		M. Sc. Physics
	Open category Elective for all other programs (No if Institute Core)		(Yes / No)
7.	Pre-requisite(s)	Atomic and Molecular Physics, Lasers	
8.	Status vis-à-vis other courses		
	8.1	List of courses precluded by taking this course (significant overlap)	(course number)
	(a)	Significant Overlap with any UG/PG course of the Dept./Centre/ School	(course number)
	(b)	Significant Overlap with any UG/PG course of other Dept./Centre/ School	(course number)
	8.2	Supersedes any existing course	(course number)
9.	Not allowed for	(indicate program names)	

10.	Frequency of offering (check one box)	☐ Every semester ☐ I sem ☐ II sem ☐ Either semester
------------	---	---

11.	Faculty who will teach the course: R.K. Soni, A.K. Shukla.
------------	---

12.	Will the course require any visiting faculty?	No (Yes/no)
------------	--	-------------

13.	Course objectives: This course will give basic knowledge on spectroscopic techniques that use lasers and theoretical background on the interaction between laser radiation and matter. The course will also discuss advance spectroscopy techniques such as nonlinear Raman spectroscopy, multi-photon spectroscopy and time-resolved spectroscopy and their applications.
------------	--

14.	Course contents: Review of lasers as spectroscopic source, Absorption spectroscopy, high sensitive methods, cavity ring down spectroscopy, Doppler limited spectroscopy: Photo-ionization and Photo-acoustic spectroscopy, Laser-induced breakdown spectroscopy (LIBS), Laser induced fluorescence spectroscopy, Nonlinear spectroscopy: linear and nonlinear absorption, saturation spectroscopy two-photon and multi-photon spectroscopy, Laser Raman spectroscopy: Stimulated Raman spectroscopy, Coherent anti-Stokes Raman spectroscopy (CARS), Time-resolved spectroscopy: short pulse generation and detection, life time measurements, pump-and-probe techniques, Time-resolved absorption, fluorescence and Raman spectroscopy, Applications of laser spectroscopy: single molecule detection, trace level detection of explosives and hazardous gases, LIDAR.
------------	---

15. Lecture Outline(with topics and number of lectures)

Module no.	Topic	No. of hours (not exceeding 5h per topic)
1	Review of lasers as spectroscopic source	4
2	Absorption spectroscopy, high sensitive methods, cavity ring down spectroscopy	4
3	Doppler limited spectroscopy: Photo-ionization and Photo-acoustic spectroscopy	4
4	Laser-induced breakdown spectroscopy (LIBS)	3
5	Laser induced fluorescence spectroscopy	3
6	Nonlinear spectroscopy: linear and nonlinear absorption, saturation spectroscopy two-photon and multi-photon spectroscopy	5
7	Laser Raman spectroscopy: Stimulated Raman spectroscopy, Coherent anti-Stokes Raman spectroscopy (CARS)	5
8	Time-resolved spectroscopy: short pulse generation and detection, life time measurements, pump-and-probe techniques	5
9	Time-resolved absorption, fluorescence and Raman spectroscopy	4
10	Applications of laser spectroscopy: single molecule detection, trace level detection of explosives and hazardous gases, LIDAR	5
Total Lecture hours (14 times 'L')		42

16. Brief description of tutorial activities:

Module no.	Description	No. of hours
Total Tutorial hours (14 times 'T')		

17. Brief description of Practical / Practice activities

Module no.	Description	No. of hours
Total Practical / Practice hours (14 times 'P')		

18. Brief description of module-wise activities pertaining to self-learning component (Only for 700 / 800 level courses) (Include topics that the students would do self-learning from books / resource materials: Do not Include assignments / term papers etc.)

Module no.	Description
(The volume of self-learning component in a 700-800 level course should typically be 25-30% of the volume covered in classroom contact)	

19. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. Demtröder W, Laser Spectroscopy: Basic Concepts and Instrumentation, 3rd ed, Springer (2004)
2. Radziemski L J, Solarz R W, Paisner J A, Laser Spectroscopy and its Applications, Maecel Dekker, (1087)
3. M. S. Feld and V. S. Lethokov, Non linear laser Spectroscopy, Springer(1980).
4. S. Stenholm, Foundations of laser spectroscopy, Wiley (1999).

20. Resources required for the course (itemized student access requirements, if any)

20.1	Software	Name of software, number of licenses, etc.
20.2	Hardware	Nature of hardware, number of access points, etc.
20.3	Teaching aids (videos, etc.)	Description, Source , etc.
20.4	Laboratory	Type of facility required, number of students etc.
20.5	Equipment	Type of equipment required, number of access points, etc.
20.6	Classroom infrastructure	Type of facility required, number of students etc.
20.7	Site visits	Type of Industry/ Site, typical number of visits, number of students etc.
20.8	Others (please specify)	

21. Design content of the course (Percent of student time with examples, if possible)

21.1	Design-type problems	Eg. 25% of student time of practical / practice hours: sample Circuit Design exercises from industry
21.2	Open-ended problems	
21.3	Project-type activity	
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: (Signature of the Head of the Department/ Centre / School)

Date of Approval of Template by Senate	
---	--

The information on this template is as on the date of its approval, and is likely to evolve with time.

COURSE TEMPLATE

(Please avoid changing the number of tables, rows and columns or text in dark black, but fill only the columns relevant to the template by editing the columns in grey letters or blank columns: this would help in automating the processing of template information for curricular use)

1.	Department/Centre/School proposing the course	PHYSICS	
2.	Course Title	CHARACTERIZATION OF MATERIALS	
3.	L-T-P structure	3-0-0	
4.	Credits	3	Non-graded Units Please fill appropriate details in S. No. 21
5.	Course number	PHL-707	
6.	Course Status (Course Category for Program) (list program codes: eg., EE1, CS5, etc.)		
	Institute Core for all UG programs		(Yes / No)
	Programme Linked Core for:		List of B.Tech. / Dual Degree Programs
	Departmental Core for:		List of B.Tech. / Dual Degree Programs
	Departmental Elective for:		MSc
	Minor Area / Interdisciplinary Specialization Core for:		Name of Minor Area / Specialization Program
	Minor Area / Interdisciplinary Specialization Elective for:		Name of Minor Area / Specialization Program
	Programme Core for:		List of M.Tech. / Dual Degree Programs
	Programme Elective for:		List of M.Tech. / Dual Degree Programs
	Open category Elective for all other programs (No if Institute Core)		(Yes / No)
7.	Pre-requisite(s)	combinations of courses: eg. (XYZ123 & XYW214) / XYZ234	
8.	Status vis-à-vis other courses		
8.1	List of courses precluded by taking this course (significant overlap)		(course number)
	(a)	Significant Overlap with any UG/PG course of the Dept./Centre/ School	(course number)
	(b)	Significant Overlap with any UG/PG course of other Dept./Centre/ School	(course number)
8.2	Supersedes any existing course		PHL654
9.	Not allowed for	(indicate program names)	

10.	Frequency of offering (check one box)	☐ Every semester ☒ I sem ☐ II sem ☐ Either semester
------------	---	--

11.	Faculty who will teach the course Santanu Ghosh, Pankaj Srivastava, Neeraj Khare, R.S.Dhaka
------------	--

12.	Will the course require any visiting faculty?	No
------------	--	----

13.	Course objectives On successful completion of this course, a student should be able to learn some fundamental concepts of experimental methods to characterize materials. This course also includes some state of the art experimental techniques to understand low dimensional physical systems.
------------	---

14.	Course contents): Structural studies: X-ray diffraction, Electron diffraction; Composition analysis: Backscattering spectrometry, secondary ion mass spectrometry, X-ray photoelectron spectroscopy, X-ray absorption; Morphological study: Electron microscopy, Scanning probe microscopy. Four probe resistivity method, Mobility and carrier concentration analysis, UV-visible spectrometry, Photoluminescence, Magnetometry, Thermal studies.
------------	---

15. Lecture Outline(with topics and number of lectures)

Module no.	Topic	No. of hours (not exceeding 5h per topic)
1.	XRD basics, geometry, instrumentation, Peak indexing and analysis of cubic and hexagonal system.	5
	Strain, crystallite size, precise lattice parameter and mixed phase analysis.	5
	Electron diffraction: Phase identification and cross sectional analysis.	4
2.	Rutherford backscattering spectrometry, secondary ion mass spectrometry identification of elements and depth profile.	4
	X-ray photoelectron spectroscopy, X-ray absorption	4
3.	Scanning probe microscopy: Scanning electron microscopy, scanning tunneling microscopy and atomic force microscopy	5
	Transmission electron microscopy, dark field, bright field imaging, high resolution mode.	4
4.	Electrical transport measurements	3
	Optical studies, UV-visible, photoluminescence, and Raman spectroetry	3
	Vibration sample and SQUID magnetometry	3
	Thermal studies: TGA.	2
Total Lecture hours (14 times 'L')		42

16. Brief description of tutorial activities:

Module no.	Description	No. of hours
	Problems related to above topics will be discussed during lecture classes.	
Total Tutorial hours (14 times 'T')		

17. Brief description of Practical / Practice activities

Module no.	Description	No. of hours
Total Practical / Practice hours (14 times 'P')		

18. Brief description of module-wise activities pertaining to self-learning component

(Only for 700 / 800 level courses) (Include topics that the students would do self-learning from books / resource materials: Do not Include assignments / term papers etc.)

Module no.	Description

(The volume of self-learning component in a 700-800 level course should typically be 25-30% of the volume covered in classroom contact)

19. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. Fundamentals of Nanoscale Film Analysis, Alford, Feldmen and Mayer, Springer, 2007.
2. Expeimental Techniques , Sam Zhang, CRC Press, 2009.

20. Resources required for the course (itemized student access requirements, if any)

20.1	Software	Name of software, number of licenses, etc.
20.2	Hardware	Nature of hardware, number of access points, etc.
20.3	Teaching aids (videos, etc.)	Description, Source , etc.
20.4	Laboratory	Type of facility required, number of students etc.
20.5	Equipment	Type of equipment required, number of access points, etc.
20.6	Classroom infrastructure	Type of facility required, number of students etc.
20.7	Site visits	Type of Industry/ Site, typical number of visits, number of students etc.
20.8	Others (please specify)	

21. Design content of the course (Percent of student time with examples, if possible)

21.1	Design-type problems	Eg. 25% of student time of practical / practice hours: sample Circuit Design exercises from industry
21.2	Open-ended problems	
21.3	Project-type activity	
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: (Signature of the Head of the Department/ Centre / School)

Date of Approval of Template by Senate	
---	--

The information on this template is as on the date of its approval, and is likely to evolve with time.

COURSE TEMPLATE

(Please avoid changing the number of tables, rows and columns or text in dark black, but fill only the columns relevant to the template by editing the columns in grey letters or blank columns: this would help in automating the processing of template information for curricular use)

1.	Department/Centre/School proposing the course	PHYSICS	
2.	Course Title	Computational Techniques for Solid State Physics	
3.	L-T-P structure	3-0-0	
4.	Credits	3	Non-graded Units
			Please fill appropriate details in S. No. 21
5.	Course number	PHL-660	
6.	Course Status (Course Category for Program) (list program codes: eg., EE1, CS5, etc.)		
	Institute Core for all UG programs		(Yes / No)
	Programme Linked Core for:		List of B.Tech. / Dual Degree Programs
	Departmental Core for:		List of B.Tech. / Dual Degree Programs
	Departmental Elective for:		List of B.Tech. / Dual Degree Programs
	Minor Area / Interdisciplinary Specialization Core for:		Name of Minor Area / Specialization Program
	Minor Area / Interdisciplinary Specialization Elective for:		Name of Minor Area / Specialization Program
	Programme Core for:		List of M.Tech. / Dual Degree Programs
	Programme Elective for:		List of M.Tech. / Dual Degree Programs
	Open category Elective for all other programs (No if Institute Core)		(Yes / No)
7.	Pre-requisite(s)	Statistical Mechanics, Quantum Mechanics, Classical Mechanics, Mathematical Physics, Computer Programming	
8.	Status vis-à-vis other courses		
	8.1	List of courses precluded by taking this course (significant overlap)	NIL
	(a)	Significant Overlap with any UG/PG course of the Dept./Centre/ School	NIL
	(b)	Significant Overlap with any UG/PG course of other Dept./Centre/ School	NIL
	8.2	Supersedes any existing course	NIL
9.	Not allowed for	UG	

10.	Frequency of offering (check one box)	☐ Every semester ☐ I sem ☒ II sem ☐ Either semester
------------	---	--

11.	Faculty who will teach the course Dr. Varsha Banerjee, Dr. Sankalpa Ghosh, Dr. Sujin B. Babu, Dr. Rahul S. Marathe, Dr. Saswata Bhattacharya, any faculty in statistical mechanics condensed matter theory group.
------------	--

12.	Will the course require any visiting faculty?	NO
------------	--	----

13.	Course objectives (about 50 words. "On successful completion of this course, a student should be able to..."): This course is the introduction towards application of different state-of-the-art computational methods to predict materials property at different level of accuracy.
------------	---

14.	Course contents (about 100 words; Topics to appear as course contents in the Courses of Study booklet) (Include Practical / Practice activities): Equations of motion, Numerical solution of equations of motion, Pressure and temperature molecular dynamics (MD), Constraint dynamics, Time correlation function, Estimation of errors, Application of MD for continuous and discontinuous potentials, Basic notions of probability, Markov chains and master equations, Generation of pseudo-random numbers, Simple sampling MC methods: evaluations of multidimensional integrals, Boundary value problems, Percolation, Random walks, etc., Importance sampling methods for lattice systems: Single spin flip methods, Cluster flipping methods for Ising models, q-state Potts model, etc., MC simulations for non-equilibrium and irreversible systems: Driven diffusive models, Growth models such as Eden model, Diffusion-limited-aggregation, etc., Schrodinger Equation, The Born-Oppenheimer approximation, What the electronic ground state energy reveals, The Hydrogen atom, Pauli exclusion principle and Anti-symmetry, Wave-function based methods, Hartree Theory, Hartree-Fock Theory, Closed-Shell Hartree-Fock and the meaning of exchange, Hartree-Fock in a basis, Form of the exact wave function and Configuration Interaction, Density Functional Theory (DFT), Kohn-Sham equations, Hohenberg-Kohn Theorems, Exchange Correlation Functional, Self-interaction, Hybrid Functional, Excitations in DFT and HF.
------------	---

15. Lecture Outline(with topics and number of lectures)

Module no.	Topic	No. of hours (not exceeding 5h per topic)
1	Equations of motion, Numerical solution of equations of motion	2
2	Constant pressure and temperature molecular dynamics,	4

	Constraint dynamics	
3	Time correlation function, Estimation of errors	4
4	Application of MD for continuous and discontinuous potentials	4
5	Monte Carlo (MC) Methods	3
6	Simple sampling MC methods	3
7	Importance sampling methods for lattice systems	4
8	MC simulations for non-equilibrium and irreversible systems	4
9	The Schrodinger equation	4
10	Wave function based approaches	4
11	Density Functional Theory	6
Total Lecture hours (14 times 'L')		42

16. Brief description of tutorial activities:

Module no.	Description	No. of hours
Total Tutorial hours (14 times 'T')		

17. Brief description of Practical / Practice activities

Module no.	Description	No. of hours
Total Practical / Practice hours (14 times 'P')		

18. Brief description of module-wise activities pertaining to self-learning component (Only for 700 / 800 level courses) (Include topics that the students would do self-learning from books / resource materials: Do not Include assignments / term papers etc.)

Module no.	Description

(The volume of self-learning component in a 700-800 level course should typically be 25-30% of the volume covered in classroom contact)	

19. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. M P Allen And D J Tildesly, Computer simulation of liquids, Clarendon Press, Oxford, paperback edition, 1989
2. Daan Frenkel and Berend Smit Understanding molecular simulation from algorithm to application Academic Press second edition 2002.
3. David P. Landau and Kurt Binder, A guide to MC simulation in statistical physics, Cambridge University Press, fourth edition 2014.
4. Electronic Structure: Basic Theory and Practical Methods: by author Richard M. Martin, Published Cambridge University Press, first edition, 2004.

20. Resources required for the course (itemized student access requirements, if any)

20.1	Software	Name of software, number of licenses, etc.
20.2	Hardware	Nature of hardware, number of access points, etc.
20.3	Teaching aids (videos, etc.)	Description, Source , etc.
20.4	Laboratory	Type of facility required, number of students etc.
20.5	Equipment	Type of equipment required, number of access points, etc.
20.6	Classroom infrastructure	Type of facility required, number of students etc.
20.7	Site visits	Type of Industry/ Site, typical number of visits, number of students etc.
20.8	Others (please specify)	

21. Design content of the course (Percent of student time with examples, if possible)

21.1	Design-type problems	Eg. 25% of student time of practical / practice hours: sample Circuit Design exercises from industry
21.2	Open-ended problems	
21.3	Project-type activity	
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date:

(Signature of the Head of the Department/ Centre / School)

Date of Approval of Template by Senate	
---	--

The information on this template is as on the date of its approval, and is likely to evolve with time.

COURSE TEMPLATE

(Please avoid changing the number of tables, rows and columns or text in dark black, but fill only the columns relevant to the template by editing the columns in grey letters or blank columns: this would help in automating the processing of template information for curricular use)

1.	Department/Centre/School proposing the course	PHYSICS	
2.	Course Title	Advanced Condensed Matter Theory	
3.	L-T-P structure	3-0-0	
4.	Credits	3	Non-graded Units Please fill appropriate details in S. No. 21
5.	Course number	PHL-740	
6.	Course Status (Course Category for Program) (list program codes: eg., EE1, CS5, etc.)		
	Institute Core for all UG programs		(Yes / No)
	Programme Linked Core for:		List of B.Tech. / Dual Degree Programs
	Departmental Core for:		List of B.Tech. / Dual Degree Programs
	Departmental Elective for:		List of B.Tech. / Dual Degree Programs
	Minor Area / Interdisciplinary Specialization Core for:		Name of Minor Area / Specialization Program
	Minor Area / Interdisciplinary Specialization Elective for:		Name of Minor Area / Specialization Program
	Programme Core for:		List of M.Tech. / Dual Degree Programs
	Programme Elective for:		List of M.Tech. / Dual Degree Programs
	Open category Elective for all other programs (No if Institute Core)		(Yes / No)
7.	Pre-requisite(s)	Quantum mechanics I and II , Statistical Mechanics, Solid State Physics (both at PG and UG level)	
8.	Status vis-à-vis other courses		
8.1	List of courses precluded by taking this course (significant overlap)		NIL
	(a)	Significant Overlap with any UG/PG course of the Dept./Centre/ School	NIL
	(b)	Significant Overlap with any UG/PG course of other Dept./Centre/ School	NIL
8.2	Supersedes any existing course		NIL
9.	Not allowed for	Anybody who have not done the prerequisites	

10.	Frequency of offering (check one box)	☐ Every semester ☐ I sem ☒ II sem ☐ Either semester
------------	---	--

11.	Faculty who will teach the course , Sankalpa Ghosh, V. Ravishankar, Ajit Kumar, any faculty in condensed matter theory/quantum many body theory group.
------------	---

12.	Will the course require any visiting faculty?	NO
------------	--	----

13.	Course objectives (about 50 words. "On successful completion of this course, a student should be able to..."): To familiarize students with the basic tools of Quantum Many Body Theory so that they can perform calculation in real solid state systems.
------------	---

14.	Course contents (about 100 words; Topics to appear as course contents in the Courses of Study booklet) (Include Practical / Practice activities): . Quantum Fields and their roles in describing collective modes. Fields as particle creation and annihilation operator: Commutation relation for Bosons and Fermions. Second Quantization. Equivalence with the many body Schroedinger Equation. Identical Conserved particles in equilibrium and thermodynamic properties: Simple Examples of Second Quantization: Bosonic and Fermionic systems. The Cooper instability and BCS Hamiltonian: Mean field description of the BCS condensate: Quasiparticle excitation and Bogoliubov de Gennes theory. Phase transition and broken symmetry: Order parameter concept: Landau theory and Landau Ginzburg theory and some examples from condensed matter Spin systems and magnetism : Heitler London theory and Heisenberg model: Ferromagnets: Spin waves: Antiferromagnets: Spin-chains.
------------	---

15. Lecture Outline(with topics and number of lectures)

Module no.	Topic	No. of hours (not exceeding 5h per topic)
1	Introduction to Quantum Fields and their roles in describing collective modes. Fields as particle creation and annihilation operator: Commutation relation for Bosons and Fermions. Second Quantization. Vacuum and Many Body wavefunction: Equivalence with the many body Schroedinger Equation. Identical Conserved particles in equilibrium and thermodynamic properties:	10
2	. Simple Examples of Second Quantization: System of non-interacting fermions; System of non-interacting Bosons : Basics of Hubbard models: Basics of microscopic theory of superfluidity	10
3	. Superconductivity and BCS theory: The Cooper instability and BCS Hamiltonian: Mean field description of the condensate: Quasiparticle excitation	10

	and Bogoliubov de Gennes theory:	
4	Phase transition and broken symmetry: Order parameter concept: Landau theory and Landau Ginzburg theory and some examples from condensed matter	6
5	Spin systems and magnetism : Heitler London theory and Heisenberg model: Ferromagnets: Spin waves: Antiferromagnets: Spin-chains.	6
Total Lecture hours (14 times 'L')		42

16. Brief description of tutorial activities:

Module no.	Description	No. of hours
Total Tutorial hours (14 times 'T')		

17. Brief description of Practical / Practice activities

Module no.	Description	No. of hours
Total Practical / Practice hours (14 times 'P')		

18. Brief description of module-wise activities pertaining to self-learning component

(Only for 700 / 800 level courses) (Include topics that the students would do self-learning from books / resource materials: Do not Include assignments / term papers etc.)

Module no.	Description

(The volume of self-learning component in a 700-800 level course should typically be 25-30% of the volume covered in classroom contact)

19. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. M P Allen And D J Tildesly, Computer simulation of liquids, Clarendon Press, Oxford, paperback edition, 1989
2. Daan Frenkel and Berend Smit Understanding molecular simulation from algorithm to application Academic Press second edition 2002.
3. David P. Landau and Kurt Binder, A guide to MC simulation in statistical physics, Cambridge University Press, fourth edition 2014.
4. Electronic Structure: Basic Theory and Practical Methods: by author Richard M. Martin, Published Cambridge University Press, first edition, 2004.

20. Resources required for the course (itemized student access requirements, if any)

20.1	Software	Name of software, number of licenses, etc.
20.2	Hardware	Nature of hardware, number of access points, etc.
20.3	Teaching aids (videos, etc.)	Description, Source , etc.
20.4	Laboratory	Type of facility required, number of students etc.
20.5	Equipment	Type of equipment required, number of access points, etc.
20.6	Classroom infrastructure	Type of facility required, number of students etc.
20.7	Site visits	Type of Industry/ Site, typical number of visits, number of students etc.
20.8	Others (please specify)	

21. Design content of the course (Percent of student time with examples, if possible)

21.1	Design-type problems	Eg. 25% of student time of practical / practice hours: sample Circuit Design exercises from industry
21.2	Open-ended problems	
21.3	Project-type activity	
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: (Signature of the Head of the Department/ Centre / School)

Date of Approval of Template by Senate	
---	--

The information on this template is as on the date of its approval, and is likely to evolve with time.

COURSE TEMPLATE

(Please avoid changing the number of tables, rows and columns or text in dark black, but fill only the columns relevant to the template by editing the columns in grey letters or blank columns: this would help in automating the processing of template information for curricular use)

1.	Department/Centre/School proposing the course	PHYSICS	
2.	Course Title	Quantum Field Theory and Quantum Electrodynamics	
3.	L-T-P structure	3-0-0	
4.	Credits	3	Non-graded Units Please fill appropriate details in S. No. 21
5.	Course number	PHL-741	
6.	Course Status (Course Category for Program) (list program codes: eg., EE1, CS5, etc.)		
	Institute Core for all UG programs	(Yes / No)	
	Programme Linked Core for:	List of B.Tech. / Dual Degree Programs	
	Departmental Core for:	List of B.Tech. / Dual Degree Programs	
	Departmental Elective for:	List of B.Tech. / Dual Degree Programs	
	Minor Area / Interdisciplinary Specialization Core for:	Name of Minor Area / Specialization Program	
	Minor Area / Interdisciplinary Specialization Elective for:	Name of Minor Area / Specialization Program	
	Programme Core for:	List of M.Tech. / Dual Degree Programs	
	Programme Elective for:	List of M.Tech. / Dual Degree Programs	
	Open category Elective for all other programs (No if Institute Core)	(Yes / No)	
7.	Pre-requisite(s)	EPL-202 (for UG students) PHL-556 (for M.Sc. students) NONE for Ph.D.	
8.	Status vis-à-vis other courses		
8.1	List of courses precluded by taking this course (significant overlap)	(course number)	
	(a) Significant Overlap with any UG/PG course of the Dept./Centre/ School	(course number)	
	(b) Significant Overlap with any UG/PG course of other Dept./Centre/ School	(course number)	
8.2	Supersedes any existing course	PHL-744	
9.	Not allowed for	(indicate program names)	

10.	Frequency of offering (check one box)	☐ Every semester ☐ I sem ☐ II sem ☐ Either semester
------------	---	---

11.	Faculty who will teach the course: Amruta Mishra, Ajit Kumar, V. Ravishankar
------------	---

12.	Will the course require any visiting faculty?	(Yes/no)
------------	--	----------

13.	Course objectives : To introduce the students to quantum field theory and quantum electrodynamics.
------------	--

14.	Course contents: Quantization of free fields; discrete symmetries; gauge symmetries; QED; Elementary processes; higher order effects; renormalization; novel effects of QED.
------------	---

15. Lecture Outline(with topics and number of lectures)

Module no.	Topic	No. of hours
1	Preliminaries System of coupled oscillators, normal modes, infinite and continuum limits, concept of a field, review of Klein Gordon and Dirac equations.	2
2	Quantization of free bosonic fields Need for field quantization, Bohr-Rosenfeld argument, equal time canonical commutation relations, quantization of Klein Gordon and charged scalar fields including Fock space, energy momentum tensor, angular momentum tensor, microcausality, retarded, advanced and Feynman propagators.	6
3	Quantization of radiation field Maxwell's equations in terms of gauge potentials, gauge freedom	3

	and transformations, problems with quantization, Gupta-Bleuler method of indefinite metric, the propagators and coherent states in Fock space.	
4	Quantization of Dirac field Pauli exclusion principle, canonical anticommutation relations, quantization of Dirac field, the Dirac propagators.	3
5	Discrete symmetries C, P and T symmetries of free scalar, charged scalar, Maxwell and Dirac fields. Concept of intrinsic parity	2
6	Introduction to gauge theories Global gauge invariance of charged scalar and Dirac fields, conservation of charge, local gauge invariance, minimal coupling and current-current interaction of charged fields with the Maxwell field, basis for QED, anomalous magnetic moments and non-minimal Pauli coupling.	2
7	Quantum Electrodynamics Brief review of S-matrix and Schwinger-Dyson expansion, time ordered and normal ordered products, Wick's theorem, Feynman rules for perturbative QED, Feynman diagrams for elementary processes.	6
8	Elementary processes Lowest order calculations for Compton scattering, bremsstrahlung, Bhabha and Moller scatterings, pair production and annihilation. Spin sum and averaging techniques and Klein-Nishina formula.	5
9	Higher order contributions Higher order processes, symmetry factors, infrared and ultraviolet divergences, regularization schemes and power counting, Bloch-Nordsieck method for infrared divergence.	3
10	One loop radiative corrections Vacuum polarization tensor, charge renormalization, Lamb shift, electron propagator and self energy, mass renormalization, vertex function, Ward identity, form factors and g-2 corrections.	6
11	New effects Photon-photon scattering, Schwinger pair production, Casimir effect.	4
Total Lecture hours (14 times 'L')		

16. Brief description of tutorial activities:

Module no.	Description	No. of hours

Total Tutorial hours (14 times 'T')		

17. Brief description of Practical / Practice activities

Module no.	Description	No. of hours
Total Practical / Practice hours (14 times 'P')		

18. Brief description of module-wise activities pertaining to self-learning component (Only for 700 / 800 level courses) (Include topics that the students would do self-learning from books / resource materials: Do not Include assignments / term papers etc.)

Module no.	Description
(The volume of self-learning component in a 700-800 level course should typically be 25-30% of the volume covered in classroom contact)	

19. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

A. Das, Lectures on quantum field theory, World Scientific (singapore), (2008). S. Weinberg, The quantum theory of fields, Cambridge University Press, (2005). M.E. Perkins and D.V. Schroeder, An introduction to quantum field theory, Addison-Wesley publishing company, (1996). C. Itzykson and J.B. Zuber, Quantum field theory, Tata McGraw-Hill (New Delhi), (1980).

20. Resources required for the course (itemized student access requirements, if any)

20.1	Software	Name of software, number of licenses, etc.
20.2	Hardware	Nature of hardware, number of access points, etc.
20.3	Teaching aids (videos, etc.)	Description, Source , etc.
20.4	Laboratory	Type of facility required, number of students etc.
20.5	Equipment	Type of equipment required, number of access points, etc.
20.6	Classroom infrastructure	Type of facility required, number of students etc.
20.7	Site visits	Type of Industry/ Site, typical number of visits, number of students etc.
20.8	Others (please specify)	

21. Design content of the course (Percent of student time with examples, if possible)

21.1	Design-type problems	Eg. 25% of student time of practical / practice hours: sample Circuit Design exercises from industry
21.2	Open-ended problems	
21.3	Project-type activity	
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: (Signature of the Head of the Department/ Centre / School)

Date of Approval of Template by Senate	
---	--

The information on this template is as on the date of its approval, and is likely to evolve with time.

COURSE TEMPLATE

(Please avoid changing the number of tables, rows and columns or text in dark black, but fill only the columns relevant to the template by editing the columns in grey letters or blank columns: this would help in automating the processing of template information for curricular use)

1.	Department/Centre/School proposing the course	PHYSICS	
2.	Course Title	High Energy Physics	
3.	L-T-P structure	3-0-0	
4.	Credits	3	Non-graded Units
			Please fill appropriate details in S. No. 21
5.	Course number	PHL-744	
6.	Course Status (Course Category for Program) (list program codes: eg., EE1, CS5, etc.)		
	Institute Core for all UG programs		(Yes / No)
	Programme Linked Core for:		List of B.Tech. / Dual Degree Programs
	Departmental Core for:		List of B.Tech. / Dual Degree Programs
	Departmental Elective for:		List of B.Tech. / Dual Degree Programs
	Minor Area / Interdisciplinary Specialization Core for:		Name of Minor Area / Specialization Program
	Minor Area / Interdisciplinary Specialization Elective for:		Name of Minor Area / Specialization Program
	Programme Core for:		List of M.Tech. / Dual Degree Programs
	Programme Elective for:		List of M.Tech. / Dual Degree Programs
	Open category Elective for all other programs (No if Institute Core)		(Yes / No)
7.	Pre-requisite(s)	PHL-741 (for UG and M.Sc. students) NONE (for Ph.D. students)	
8.	Status vis-à-vis other courses		
8.1	List of courses precluded by taking this course (significant overlap)		NIL
	(a)	Significant Overlap with any UG/PG course of the Dept./Centre/ School	NIL
	(b)	Significant Overlap with any UG/PG course of other Dept./Centre/ School	NIL
8.2	Supersedes any existing course		NIL
9.	Not allowed for	NIL	

10.	Frequency of offering (check one box)	☐ Every semester ☐ I sem ☐ II sem ☐ Either semester
------------	---	---

11.	Faculty who will teach the course Ajit Kumar, Amruta Mishra, V. Ravishankar.
------------	---

12.	Will the course require any visiting faculty?	No
------------	--	----

13.	Course objectives : To bring the students up-to-date on current status of particle physics.
------------	---

14.	Course contents: Fundamental interactions; QED; QCD; Marshak-Sudarshan theory of weak interactions; parity violations; Higg's mechanism; Salam-Weinberg model; the standard model of particle physics; open problems.
------------	---

15. Lecture Outline(with topics and number of lectures)

Module no.	Topic	No. of hours (not exceeding 5h per topic)
1	The particle zoo - brief review Properties of fundamental interactions - strengths, ranges, and signs. Classification of elementary particles - quarks and leptons, gauge bosons and Higgs.	2
2	Brief review of relativistic equations Klein Gordon, Dirac and Maxwell's equations in second quantized form; symmetries and other basic properties	2
3	Quantum electrodynamics as a U(1) gauge theory Global gauge invariance and charge conservation; local gauge invariance and the principle of general relativity; Maxwell equations from minimal coupling; higher order corrections to reaction cross sections;	6

	divergences; renormalization and gauge invariance	
4	QCD I Color as a dynamical degree of freedom, introduction to nonabelian gauge theories, self interaction, Feynman rules; QCD as a SU(3) gauge theory; light cone analysis; operator product expansions; scaling laws; evidence for QCD from deep inelastic scattering.	8
5	QCD II quantum corrections to quark parton model; scaling violations; experimental evidence; RGE analysis, asymptotic freedom; low energy limit and quark confinement (brief discussion only)	4
6	Weak interactions - Fermi theory Brief review of Fermi theory; Marshak-Sudarshan V-A theory; parity violation, problems with Fermi theory; conflict between massive gauge bosons and renormalization	5
7	Higgs mechanism Basic ideas of spontaneous symmetry breaking (SSB); illustration with plasmons and magnetism; Goldstone modes - illustration with phonons; SSB with gauge interactions, Higgs mechanism and generation of masses.	4
8	Salam Weinberg Model Electroweak unification via a $U(1) \times SU(2)$ gauge theory; neutral current processes; Masses of W and Z; experimental evidence.	4
9	Mass matrices Flavour and Mass bases; Singular value decomposition; CKM matrix; evidence in neutrino oscillations, K- $\bar{K}$ and B- $\bar{B}$ systems; GIM mechanism for weak decays.	3
10	The Standard model Electroweak-strong interactions as $U(1) \times SU(2) \times SU(3)$ theory; current status of the standard model; discovery of the Higgs	3
11	Open problems Drawbacks of the standard model, brief ideas of grand unification and supersymmetry; problems in quantizing gravity; string theory and other approaches.	3
Total Lecture hours (14 times 'L')		

16. Brief description of tutorial activities:

Module no.	Description	No. of hours

Total Tutorial hours (14 times 'T')		

17. Brief description of Practical / Practice activities

Module no.	Description	No. of hours
Total Practical / Practice hours (14 times 'P')		

18. Brief description of module-wise activities pertaining to self-learning component (Only for 700 / 800 level courses) (Include topics that the students would do self-learning from books / resource materials: Do not Include assignments / term papers etc.)

Module no.	Description
(The volume of self-learning component in a 700-800 level course should typically be 25-30% of the volume covered in classroom contact)	

19. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

D.J. Griffiths, Introduction to elementary particles, John-Wiley and sons, (2008). I.J.R. Aitchison and A.J.G. Hey, Gauge theories in particle physics, vol-(1,2), CRC press, (2012) D.H.Perkins, Introduction to high energy physics, Cambridge University Press,(2000)
--

20. Resources required for the course (itemized student access requirements, if any)

20.1	Software	Name of software, number of licenses, etc.
20.2	Hardware	Nature of hardware, number of access points, etc.

20.3	Teaching aids (videos, etc.)	Description, Source , etc.
20.4	Laboratory	Type of facility required, number of students etc.
20.5	Equipment	Type of equipment required, number of access points, etc.
20.6	Classroom infrastructure	Type of facility required, number of students etc.
20.7	Site visits	Type of Industry/ Site, typical number of visits, number of students etc.
20.8	Others (please specify)	

21. Design content of the course (Percent of student time with examples, if possible)

21.1	Design-type problems	Eg. 25% of student time of practical / practice hours: sample Circuit Design exercises from industry
21.2	Open-ended problems	
21.3	Project-type activity	
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: (Signature of the Head of the Department/ Centre / School)

Date of Approval of Template by Senate	
---	--

The information on this template is as on the date of its approval, and is likely to evolve with time.

COURSE TEMPLATE

1.	Department/Centre proposing the course	PHYSICS
2.	Course Title (<i>< 45 characters</i>)	ADVANCED STATISTICAL MECHANICS
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	PHL - 745
6.	Status (<i>category for program</i>)	PG/Ph. D.

7.	Pre-requisites (<i>course no./title</i>)	PG: PHL556/STATISITCAL MECHANICS Ph. D. : NIL
----	--	--

8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	NIL
8.2	Overlap with any UG/PG course of other Dept./Centre	NIL
8.3	Supercedes any existing course	NIL

9.	Not allowed for (<i>indicate program names</i>)	UG
----	---	----

10.	Frequency of offering	☐ Every sem ☒ 1 st sem ☐ 2 nd sem ☐ Either sem
-----	------------------------------	---

11.	Faculty who will teach the course Sujin B. Babu, Versha Banerjee, Rahul Marathe	
12.	Will the course require any visiting faculty?	NO

13.	Course objective (<i>about 50 words</i>): To introduce students to more advanced level techniques of statistical mechanics, theory of phase transitions and critical phenomena, renormalization group and to related computational techniques.	
-----	--	--

14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Review of basic thermodynamics, thermodynamic potentials, equation of state. Theory of ensembles, density matrix. Thermodynamics of phase transitions, concept of thermodynamic stability, metastability and instability, Van der Waal equation of state, phase coexistence and Gibbs phase rule. Lattice models to describe phase transition e.g Ising model, Heisenberg model etc. Landau theory of second order phase transitions, scaling hypothesis, critical exponents and universality classes, spatial correlation, correlation length, importance of fluctuations near critical point. Mean Field theory, Transfer matrix method. Concept of renormalization group. Ising model, renormalization in one	
-----	--	--

	dimension. Related numerical methods, Monte-Carlo simulations of spin systems.
--	--

15. Lecture Outline (*with topics and number of lectures*)

Module no.	Topic	No. of hours
1	Review of Basic Thermodynamics	3
2	Thermodynamics of phase transition	4
3	Critical phenomena, lattice models	6
4	Landau Theory of phase transition	6
5	Scaling hypothesis, critical exponents	4
6	Mean Field theory and transfer matrix method	5
7	Computational techniques	8
8	Renormalization Group	6
9		
10		
11		
12		
COURSE TOTAL (14 times 'L')		

16. Brief description of tutorial activities

--

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

- 1) Pathria R. K., Statistical Mechanics, 3rd edition, Elsevier India Pvt. (2011).
- 2) Huang K, Statistical Mechanics, 2nd Edition, Wiley India Pvt. Ltd. (2008)
- 3) Goldenfeld N., Lectures on Phase Transitions and the Renormalization Group, 1st Edition, Sarat Book House (2005).
- 4) Kadanoff L., Statistical Physics: Statics, Dynamics and Renormalization, 1st edition, World Scientific (2000).
- 5) Plischke M., Begersen B., Equilibrium statistical Physics, 2nd Edition, World Scientific (1994).
- 6) Chaikin P. M., Lubensky T. C., Principles of Condensed Matter physics, Cambridge University Press, 4th edition (2000).
- 6) Binder K., Heermann D. W., A Guide to Monte Carlo Simulations in Statistical Physics, 3rd

Edition, Cambridge University Press (2013).

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	MATLAB
19.2	Hardware	
19.3	Teaching aides (videos, etc.)	
19.4	Laboratory	
19.5	Equipment	
19.6	Classroom infrastructure	
19.7	Site visits	

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	
20.2	Open-ended problems	
20.3	Project-type activity	
20.4	Open-ended laboratory work	
20.5	Others (please specify)	

Date: 27/03/2015

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department / Centre proposing the course	PHYSICS
2.	Course Title (<i>< 45 characters</i>)	NON-EQUILIBRIUM STATISTICAL MECHANICS WITH INTERDISCIPLINARY APPLICATIONS
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	PHL - 746
6.	Status (<i>category for program</i>)	UG/PG/Ph. D.

7.	Pre-requisites (<i>course no./title</i>)	UG: PYL202/STATISITCAL PHYSICS PG: PYL556/STATISTICAL MECHANICS Ph. D. : NIL
----	--	--

8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	NIL
8.2	Overlap with any UG/PG course of other Dept./Centre	NIL
8.3	Supercedes any existing course	NIL

9.	Not allowed for (<i>indicate program names</i>)	NIL
----	---	-----

10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☒ 2 nd sem ☐ Either sem
-----	------------------------------	---

11.	Faculty who will teach the course Sujin B. Babu, Versha Banerjee, Rahul Marathe	
12.	Will the course require any visiting faculty?	NO

13.	Course objective (<i>about 50 words</i>): To introduce students to advanced topics to study non equilibrium phenomena and their application to biological and soft-condensed matter systems.	
-----	--	--

14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Review of equilibrium systems. Systems out of equilibrium, kinetic theory of gases, Boltzman equation and its application to transport problems, Master equation and irreversibility. Time correlation functions, linear response theory, Kubo formula, Onsager relations. Random walks, Brownian motion and diffusion, Langevin equation, fluctuation dissipation theorem, Einstein relation, Fokker-Planck equation. Ratchets, driven diffusive systems. Fluctuation theorems, Jarzynski Equality. Percolation, polymers, soft condensed matter systems. Biological systems applications to Molecular motors, stochasticity in gene expression. Stochastic growth models. Monte-Carlo simulations of Random walks and their applications to polymers, percolation, diffusion limited	
-----	--	--

	aggregation and other growth models.
--	--------------------------------------

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Review of Equilibrium systems	2
2	Systems out of equilibrium, Boltzmann equation	4
3	Master equation, irreversibility	4
4	Linear Response theory, Kubo formula, Onsager relations	6
5	Random walks, Brownian motion, diffusion, Fokker-Planck equation, fluctuation dissipation theorem, Einstein relation.	8
6	A few topics from the following list will be discussed: Ratchets, driven diffusive systems. Stochastic growth models like Random Deposition, EW, KPZ, DLA etc. Jarzynski equality, fluctuation theorems, percolation, polymers. Applications to Soft condensed matter systems. Biological systems like molecular motors, stochastic gene expression etc.	12
7	Monte-Carlo simulations of Random walks, percolation, polymers, DLA and other growth models	6
8		
9		
10		
11		
12		
COURSE TOTAL (14 times 'L')		

16. Brief description of tutorial activities

--

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1) Balkrishnan V., Elements of non-equilibrium statistical mechanics, 1 st edition, Ane-book New Delhi (2008).
2) Van Kampen N. G., Stochastic processes in Physics and Chemistry, 2 nd Edition, Elsevier Science (2007).
3) Gardiner C. W., Handbook of Stochastic Methods, 4 th edition, Springer Science (2010)

- 4) Risken H., The Fokker Planck Equation, 2nd edition, Springer-Verlag (1996).
 5) Binder K., Heermann D. W., A Guide to Monte Carlo Simulations
 Statistical Physics, 3rd Edition, Cambridge University Press (2013).

19. Resources required for the course (*itemized & student access requirements, if any*)

19.1	Software	Matlab
19.2	Hardware	
19.3	Teaching aides (videos, etc.)	
19.4	Laboratory	
19.5	Equipment	
19.6	Classroom infrastructure	
19.7	Site visits	

20. Design content of the course (*Percent of student time with examples, if possible*)

20.1	Design-type problems	
20.2	Open-ended problems	
20.3	Project-type activity	
20.4	Open-ended laboratory work	
20.5	Others (please specify)	

Date: 27/03/2015

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	PHYSICS
2.	Course Title (<i>< 45 characters</i>)	NONLINEAR OPTICS
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	PHL - 747
6.	Status (<i>category for program</i>)	Programme Elective
7.	Pre-requisites (course no./title)	
8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	
8.2	Overlap with any UG/PG course of other Dept./Centre	
8.3	Supercedes any existing course	
9.	Not allowed for (indicate program names)	
10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☐ 2 nd sem ☐ Either sem
11.	Faculty who will teach the course K Thyagarajan, M R. Shenoy, Joyee Ghosh, Kedar Khare	
12.	Will the course require any visiting faculty?	
13.	Course objective (<i>about 50 words</i>): This course will detail the student about the field of Nonlinear Optics and its tremendous applications in generating new frequencies, modulating and manipulating a light signal, observing new effects possible due to material nonlinearities.	
14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): Wave propagation in anisotropic media. Origin of optical nonlinearity, Nonlinear optical polarization; Second order and third order processes; Nonlinear optical wave equation; Second order nonlinear processes; Second harmonic generation, difference and sum frequency generation, phase insensitive and phase sensitive optical parametric amplifiers, spontaneous parametric down conversion; Birefringence and quasi phase matching; optical parametric oscillators. Third order nonlinear processes; third harmonic generation, self phase modulation, cross phase modulation and four wave mixing; impact of nonlinear	

	effects in lightwave communication systems; supercontinuum generation; Phase conjugation and applications, Stimulated Raman and Brillouin scattering; applications of stimulated processes. Electro optic, photorefractive and acousto optic effects and their applications Ultrafast and intense field nonlinear optics. Special topics
--	---

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Review of wave propagation in anisotropic media.	3
2	Origin of optical nonlinearity, Nonlinear optical polarization; Second order and third order processes; Nonlinear optical wave equation;	2
3	Second order nonlinear processes; Second harmonic generation (SHG), Birefringence and quasi phase matching, Difference (DFG) and sum frequency generation (SFG), Optical parametric amplifiers (OPA) -- Phase insensitive and phase sensitive, Manley-Rowe Relations, Optical Parametric Oscillators (OPO), Spontaneous Parametric Down-Conversion (SPDC)	15
4	Third order nonlinear processes; third harmonic generation, self phase modulation, cross phase modulation and four wave mixing; impact of nonlinear effects in lightwave communication systems; supercontinuum generation; Phase conjugation and applications,	4
5	Stimulated Raman and Brillouin scattering; applications of stimulated processes.	4
6	Electro Optic, Photorefractive and Acousto optic effects and their applications	10
7	Ultrafast and intense field nonlinear optics.	2
8	Special topics: EIT materials, slow light, Metamaterials, photonic crystals	2
9		
10		
11		
12		
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

--

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

- | |
|--|
| <ol style="list-style-type: none"> 1. R.W. Boyd, Nonlinear Optics, Academic Press, Amsterdam, 2008 2. G.P. Agarwal, Nonlinear fiber optics, Academic Press, Boston, 1989 |
|--|

3. Y.R. Shen, The principles of nonlinear optics, Wiley, New York, 1984
4. Quantum Electronics, A Yariv, Wiley, New York, 1975

19. Resources required for the course (*itemized & student access requirements, if any*)

19.1	Software	
19.2	Hardware	
19.3	Teaching aides (videos, etc.)	
19.4	Laboratory	
19.5	Equipment	
19.6	Classroom infrastructure	
19.7	Site visits	

20. Design content of the course (*Percent of student time with examples, if possible*)

20.1	Design-type problems	
20.2	Open-ended problems	
20.3	Project-type activity	
20.4	Open-ended laboratory work	
20.5	Others (please specify)	

Date:

(Signature of the Head of the Department)

COURSE TEMPLATE

1.	Department /Centre proposing the course	PHYSICS
2.	Course Title (<i>< 45 characters</i>)	QUANTUM OPTICS
3.	L-T-P structure	3 - 0 - 0
4.	Credits	3
5.	Course number	PHL - 748
6.	Status (<i>category for program</i>)	Programme Elective

7.	Pre-requisites (course no./title)	
----	---	--

8.	Status vis-à-vis other courses (<i>give course number/title</i>)	
8.1	Overlap with any UG/PG course of the Dept./Centre	
8.2	Overlap with any UG/PG course of other Dept./Centre	
8.3	Supercedes any existing course	

9.	Not allowed for (indicate program names)	
----	--	--

10.	Frequency of offering	☐ Every sem ☐ 1 st sem ☒ 2 nd sem ☐ Either sem
-----	------------------------------	---

11.	Faculty who will teach the course Joyee Ghosh, Kedar Khare, K. Thyagarajan, V. Ravishankar	
12.	Will the course require any visiting faculty?	quantum

13.	Course objective (<i>about 50 words</i>): This course will provide a modern understanding of light as a quantum phenomenon, and explore how quantum applications such as quantum communications and quantum sensing are developed using quantum light. Significantly, landmark experiments in Quantum Optics will be discussed along with topics like entangled and squeezed states of light, quantum memories, quantum communication and related advanced topics. The areas of quantum computation and quantum information will be introduced. It will also give necessary background for understanding some contemporary experiments.	
-----	---	--

14.	Course contents (<i>about 100 words</i>) (<i>Include laboratory/design activities</i>): HBT effect, Quantization of the EM field, Quantum states of light, correlation functions, Detection of quantum light and techniques, coincidence-counting, phase-sensitive detection, quantum treatment of linear optics, Quantum light by non-linear optical processes, SPDC, signatures of quantum behaviour, Landmark experiments in quantum optics, Applications: Laser cooling and	
-----	---	--

	BEC, Ion trapping, CPT, EIT, slow light, Introduction to quantum communication: Quantum teleportation, entanglement swapping, quantum repeaters, quantum cryptography
--	---

15. Lecture Outline *(with topics and number of lectures)*

Module no.	Topic	No. of hours
1	Mandel's photon counting formula, Intensity correlations, Hanbury Brown Twiss effect, intensity interferometry	4
2	Quantization of the electromagnetic field and Vacuum fluctuations	4
3	Quantum states of light: Fock states, Coherent states, Glauber-Sudarshan representation, test for non-classicality, bunching and anti-bunching	5
4	Quantum correlation functions, normal and time ordering, two photon coherence function and coincidence rate /counting.	4
5	Behavior of quantum fields with linear optics. Quantum treatment of beamsplitter and interferometers	4
6	Detection of quantum light, photon counting, phase-sensitive detection. Photodetection Techniques: APD, SPCM, etc.	2
7	Generation of quantum light by non-linear optical processes: Spontaneous Parametric Down-Conversion, FWM, etc.	3
8	Squeezed states & applications	4
9	Landmark experiments in Quantum Optics.	4
10	Applications: Interaction of light with atoms/ions/atomic ensembles: Laser cooling, BEC, Ion trapping, etc.	3
11	Applications: Coherence Population Trapping, Electromagnetically Induced Transparency & slow light	2
12	Applications: Introduction to quantum communication experiments : Quantum teleportation, entanglement swapping, quantum repeaters, quantum cryptography	3
COURSE TOTAL (14 times 'L')		42

16. Brief description of tutorial activities

--

17. Brief description of laboratory activities

Module no.	Experiment description	No. of hours
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		
COURSE TOTAL (14 times 'P')		

18. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

L. Mandel and E. Wolf, Coherence and Quantum Optics, Cambridge Univ. Press 1995
M. O. Scully and S. Zubairy, Quantum Optics, Cambridge university Press, 1997

P. Lambropoulos and D. Petrosyan, Fundamentals of Quantum Optics and Quantum Information, Springer 2007

H-A. Bachor and T.C. Ralph, A Guide to Experiments in Quantum Optics, Wiley-VCH 2004
Additional Relevant Journal Articles

19. Resources required for the course *(itemized & student access requirements, if any)*

19.1	Software	
19.2	Hardware	
19.3	Teaching aides (videos, etc.)	
19.4	Laboratory	
19.5	Equipment	
19.6	Classroom infrastructure	
19.7	Site visits	

20. Design content of the course *(Percent of student time with examples, if possible)*

20.1	Design-type problems	
20.2	Open-ended problems	
20.3	Project-type activity	
20.4	Open-ended laboratory work	
20.5	Others (please specify)	

Date:

(Signature of the Head of the Department)

COURSE TEMPLATE

(Please avoid changing the number of tables, rows and columns or text in dark black, but fill only the columns relevant to the template by editing the columns in grey letters or blank columns: this would help in automating the processing of template information for curricular use)

1.	Department/Centre/School proposing the course	PHYSICS DEPARTMENT	
2.	Course Title	QUANTUM INFORMATION AND COMPUTATION	
3.	L-T-P structure	3-0-0	
4.	Credits	3	Non-graded Units
			Please fill appropriate details in S. No. 21
5.	Course number	PHL-749	
6.	Course Status (Course Category for Program) (list program codes: eg., EE1, CS5, etc.)		
	Institute Core for all UG programs		(Yes / No)
	Programme Linked Core for:		List of B.Tech. / Dual Degree Programs
	Departmental Core for:		List of B.Tech. / Dual Degree Programs
	Departmental Elective for:		List of B.Tech. / Dual Degree Programs
	Minor Area / Interdisciplinary Specialization Core for:		Name of Minor Area / Specialization Program
	Minor Area / Interdisciplinary Specialization Elective for:		Name of Minor Area / Specialization Program
	Programme Core for:		List of M.Tech. / Dual Degree Programs
	Programme Elective for:		List of M.Tech. / Dual Degree Programs
	Open category Elective for all other programs (No if Institute Core)		(Yes / No)
7.	Pre-requisite(s)		
8.	Status vis-à-vis other courses		
8.1	List of courses precluded by taking this course (significant overlap)		NIL
	(a)	Significant Overlap with any UG/PG course of the Dept./Centre/ School	NIL
	(b)	Significant Overlap with any UG/PG course of other Dept./Centre/ School	NIL
8.2	Supersedes any existing course		NIL
9.	Not allowed for	NIL	

10.	Frequency of offering (check one box)	☐ Every semester ☐ I sem ☐ II sem ☐ Either semester
------------	---	---

11.	Faculty who will teach the course Joyee Ghosh, Sankalpa Ghosh, V. Ravishankar, K. Thyagarajan.
------------	---

12.	Will the course require any visiting faculty? No
------------	---

13.	Course objectives: To introduce the students to the basics of quantum information and computation.
------------	--

14.	Course contents: Basic classical and quantum mechanics; basic information theory; bits, qubits and ebits; non-locality and entanglement; quantum gates and circuits; teleportation, superdense coding, quantum oracles; quantum algorithms; quantum encryption; quantum error correction; quantum computers.
------------	--

15. Lecture Outline(with topics and number of lectures)

Module no.	Topic	No. of hours (not exceeding 5h per topic)
1	Basic classical mechanics Phase space; states, observables and dynamics; pure and mixed states; deterministic and stochastic evolutions; states of subsystems and locality of classical mechanics.	3
2	Basic quantum mechanics Hilbert space; states, observables and dynamics; superposition principle and uncertainty principle; pure and mixed states; nonlocality and violation of Bell's inequality; entanglement; other formulations of nonlocality; experimental verification of nonlocality; Kochen-Specker theorem.	5
3	Basic information theory	4

	Probability schemes; entropy as measure of information; conditional probabilities; mutual information and relative entropy; application to compression and error correction codes; Von-Neumann entropy for quantum states and comparison with classical information theorems.	
4	Quantum information -I c-bits, qubits and e-bits; Bloch representation of a qubit state; generalization to qudits; no cloning theorem; quantum gates and quantum circuits; measurement basis; single qubit gates; CNOT, fredkin and toffoli gates; circuits to add and subtract numbers; circuit complexity.	5
5	Applications I teleportation; superdense coding; quantum oracles: Deutsch and Deutsch-Josza algorithms; Simon and Bernstein-Vazirani algorithms; experimental implementations.	5
6	Applications II Grover's search algorithm; quantum Fourier transform; period finding algorithm; basic ideas of RSA encryption; Shor's algorithm for factorization of numbers; protocols for quantum encryption.	10
7	Quantum error correction Brief discussion of classical error correction; Hamming distance; interaction with environment; quantum error correction; Shor and other codes.	5
8	quantum computers Candidates for quantum computers; NMR, trapped ions; superconducting quanta; optical computers; a general computer architecture; current status.	5
Total Lecture hours (14 times 'L')		

16. Brief description of tutorial activities:

Module no.	Description	No. of hours
Total Tutorial hours (14 times 'T')		

17. Brief description of Practical / Practice activities

Module no.	Description	No. of hours
Total Practical / Practice hours (14 times 'P')		

18. Brief description of module-wise activities pertaining to self-learning component

(Only for 700 / 800 level courses) (Include topics that the students would do self-learning from books / resource materials: Do not Include assignments / term papers etc.)

Module no.	Description
(The volume of self-learning component in a 700-800 level course should typically be 25-30% of the volume covered in classroom contact)	

19. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

M.A. Nielsen and I.L. Chuang, Quantum computation and quantum information, Cambridge University Press (N.Y.), (2011).
E. Desurvire, Classical and quantum information theory, Cambridge University Press (N.Y.), (2009).
N.D. Mermin, Quantum computer science, Cambridge University Press (N.Y.), (2007).

20. Resources required for the course (itemized student access requirements, if any)

20.1	Software	Name of software, number of licenses, etc.
20.2	Hardware	Nature of hardware, number of access points, etc.
20.3	Teaching aids (videos, etc.)	Description, Source, etc.
20.4	Laboratory	Type of facility required, number of students etc.
20.5	Equipment	Type of equipment required, number of access points, etc.

20.6	Classroom infrastructure	Type of facility required, number of students etc.
20.7	Site visits	Type of Industry/ Site, typical number of visits, number of students etc.
20.8	Others (please specify)	

21. Design content of the course (Percent of student time with examples, if possible)

21.1	Design-type problems	Eg. 25% of student time of practical / practice hours: sample Circuit Design exercises from industry
21.2	Open-ended problems	
21.3	Project-type activity	
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: (Signature of the Head of the Department/ Centre / School)

Date of Approval of Template by Senate	
---	--

The information on this template is as on the date of its approval, and is likely to evolve with time.

COURSE TEMPLATE

(Please avoid changing the number of tables, rows and columns or text in dark black, but fill only the columns relevant to the template by editing the columns in grey letters or blank columns: this would help in automating the processing of template information for curricular use)

1.	Department/Centre/School proposing the course	Physics	
2.	Course Title	Biophotonics	
3.	L-T-P structure	3-0-0	
4.	Credits	3	Non-graded Units Please fill appropriate details in S. No. 21
5.	Course number	PHL-760	
6.	Course Status (Course Category for Program) (list program codes: eg., EE1, CS5, etc.)		
	Institute Core for all UG programs		(Yes / No)
	Programme Linked Core for:		List of B.Tech. / Dual Degree Programs
	Departmental Core for:		List of B.Tech. / Dual Degree Programs
	Departmental Elective for:		List of B.Tech. / Dual Degree Programs
	Minor Area / Interdisciplinary Specialization Core for:		Name of Minor Area / Specialization Program
	Minor Area / Interdisciplinary Specialization Elective for:		Name of Minor Area / Specialization Program
	Programme Core for:		List of M.Tech. / Dual Degree Programs
	Programme Elective for:		List of M.Tech. / Dual Degree Programs
	Open category Elective for all other programs (No if Institute Core)		(Yes / No)
7.	Pre-requisite(s)	combinations of courses: eg. (XYZ123 & XYW214) / XYZ234	
8.	Status vis-à-vis other courses		
8.1	List of courses precluded by taking this course (significant overlap)		(course number)
	(a)	Significant Overlap with any UG/PG course of the Dept./Centre/ School	(course number)
	(b)	Significant Overlap with any UG/PG course of other Dept./Centre/ School	(course number)
8.2	Supersedes any existing course		(course number)
9.	Not allowed for	(indicate program names)	

10.	Frequency of offering (check one box)	☐ Every semester ☐ I sem ☐ II sem ☐ Either semester
11.	Faculty who will teach the course D. S. Mehta, Kedar Khare	
12.	Will the course require any visiting faculty?	(Yes/no)
13.	Course objectives: Bio-photonics is the emerging area of advanced photonics technologies which are important for light-tissue interaction, non-contact, non-invasive imaging, sensing and diagnostics in biology and medicine. The objective is to develop understanding and experience about the Physics of medical imaging and Biophotonics and their principles and imaging concepts. Following the completion of this course, students will have a basic understanding of the different optical signatures found in biological systems and the various methods and instruments used to measure them. This will enable the student to evaluate modern bio-photonics instrumentation and understand the most recent literature in the field of bio-photonics.	
14.	Course contents: Introduction to Biophotonics: Photobiology: Light-tissue interactions and light induced effects in Biological systems. Optical properties of tissue – absorption, scattering, diffraction, and emission. Spectroscopy: Fluorescence, Raman and diffuse reflectance spectroscopy: Physics and their applications Basic principles of optical imaging and spectroscopy systems. Principles of standard optical microscopy/fluorescence microscopy/ endoscopy and instrumentation. Confocal microscopy: Principles and instrumentation and applications. Two-photon and multi-photon microscopy. Physics of optical tweezers and its applications in biology. Bio-medical applications of lasers: Laser scissors, Photo-dynamic therapy. Optical coherence tomography (OCT): Physics, imaging concepts and applications. Photo-acoustic tomography (PAT): physics, imaging concepts and applications. Radiation physics, X-Ray imaging: Physics and working principles. Magnetic resonance imaging (MRI): Physics, working principles and imaging and applications. Ultrasound imaging: physics, principles, imaging concepts and application.	

15. Lecture Outline(with topics and number of lectures)

Module no.	Topic	No. of hours
1	Introduction to Biophotonics: Light-tissue and light-biological cell interaction/Light induced effects in Biological systems.	3
2	Spectroscopy: Fluorescence, Raman and diffuse reflectance spectroscopy: Physics and their applications.	4
3	Optical microscopy/fluorescence microscopy/endoscopy and confocal microscopy, two-photon and multi-photon microscopy	4
4	Optical coherence tomography (OCT): physics, imaging concepts and applications.	6
5	Photo-acoustic tomography (PAT): physics, imaging concepts and applications.	6
6	Optical tweezers: physics and applications in biology and Biomedical applications of lasers.	4
7	Radiation physics, X-Ray imaging:Physics and working principles.	3
8	Magnetic resonance imaging (MRI): Physics, working principles and imaging and applications.	3
9	Ultrasound imaging: physics, principles, imaging concepts and applications	3
10	Optical Biosensors: fiber optics, evanescent wave, surface plasmon resonance and Nano-Biophotonics	3
11	Nanoscopy: Advanced biomedical imaging	3
Total Lecture hours (14 times 'L')		42

16. Brief description of tutorial activities:

Module no.	Description	No. of hours
Total Tutorial hours (14 times 'T')		

17. Brief description of Practical / Practice activities

Module no.	Description	No. of hours
Total Practical / Practice hours (14 times 'P')		

18. Brief description of module-wise activities pertaining to self-learning component (Only for 700 / 800 level courses) (Include topics that the students would do self-learning from books / resource materials: Do not Include assignments / term papers etc.)

Module no.	Description

(The volume of self-learning component in a 700-800 level course should typically be 25-30% of the volume covered in classroom contact)

19. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

- i. Biomedical Photonics Handbook, Tuan Vo-Dinh, CRC Press, 2003.
- ii. Introduction to Biophonics, P.N. Prasad, John-Wiley 2003.
- iii. Optical Imaging and Microscopy, Peter Torok, Fu-jen Kao (Eds.), Springer 2003
- iv. Handbook of Optical Coherence Tomography, Bouma and Fujimoto, 2002.
- v. Optical Coherence Tomography: Technology and Applications, Wolfgang Drexler and J.G. Fujimoto, Springer 2008
- vi. Optical Trapping and Manipulations by laser, Arthur Ashkin, 2006, World Scientific
- vii. Coherent Light Microscopy : Imaging and Quantitative Phase Analysis, Pietro Ferraro, Adam Wax, Zeev Zalevsky, Springer 2011.
- viii. Principles of optics, Born and Wolf.
- ix. Biomedical Optics: Principles and Imaging, Lihong Wang and H. Wu, Wiley 2007

20. Resources required for the course (itemized student access requirements, if any)

20.1	Software	Name of software, number of licenses, etc.
20.2	Hardware	Nature of hardware, number of access points, etc.
20.3	Teaching aids (videos, etc.)	Description, Source , etc.
20.4	Laboratory	Type of facility required, number of students etc.
20.5	Equipment	Type of equipment required, number of access points, etc.
20.6	Classroom infrastructure	Type of facility required, number of students etc.
20.7	Site visits	Type of Industry/ Site, typical number of visits, number of students etc.
20.8	Others (please specify)	

21. Design content of the course (Percent of student time with examples, if possible)

21.1	Design-type problems	Eg. 25% of student time of practical / practice hours: sample Circuit Design exercises from industry
21.2	Open-ended problems	
21.3	Project-type activity	
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: (Signature of the Head of the Department/ Centre / School)

Date of Approval of Template by Senate	
---	--

The information on this template is as on the date of its approval, and is likely to evolve with time.

COURSE TEMPLATE

(Please avoid changing the number of tables, rows and columns or text in dark black, but fill only the columns relevant to the template by editing the columns in grey letters or blank columns: this would help in automating the processing of template information for curricular use)

1.	Department/Centre/School proposing the course	Physics	
2.	Course Title	Introduction to Liquid Crystals	
3.	L-T-P structure	3-0-0	
4.	Credits	3	Non-graded Units Please fill appropriate details
5.	Course number	PHL-761	
6.	Course Status (Course Category for Program)		
	Institute Core for all UG programs	No	
	Programme Linked Core for:		
	Departmental Core for:		
	Departmental Elective for:	M.Sc.	
	Minor Area / Interdisciplinary Specialization Core for:		
	Minor Area / Interdisciplinary Specialization Elective for:		
	Programme Core for:		
	Programme Elective for:		
	Open category Elective for all other programs (No if	No	

7.	Pre-requisite(s)	None
-----------	-------------------------	------

8.	Status vis-à-vis other courses		
8.1	List of courses precluded by taking this course (significant overlap)		None
	(a)	Significant Overlap with any UG/PG course of the Dept./Centre/ School	None
	(b)	Significant Overlap with any UG/PG course of other Dept./Centre/ School	None
8.2	Supersedes any existing course		None

9.	Not allowed for	None
-----------	------------------------	------

10.	Frequency of offering (check one box)	☐ Every semester × ☒ I sem ☐ II sem ☐ Either semester
------------	---	--

11.	Faculty who will teach the course Aloka Sinha
------------	--

12.	Will the course require any visiting faculty?	no
------------	--	----

13.	Course objectives: To introduce the basics of liquid crystals, to provide theoretical insight along with characterization techniques. This course will also include new liquid crystalline materials and novel applications of these phases.
------------	--

14.	Course contents: Nematic, Cholesteric, Smectic and Ferro-electric liquid crystals, Landau-de Gennes and Frank-Oseen free energy, Nematic-isotropic phase transition, Landau theory and Maier-Saupe theory, Kerr effect, Pockel effect, Polarizing Microscopy, Differential Scanning calorimetry, Dielectric Spectroscopy, Bent core liquid crystals, Twist bent liquid crystals, display applications
------------	---

15. Lecture Outline(with topics and number of lectures)

Module no.	Topic	No. of hours (not exceeding 5h per topic)
1	Introduction to liquid crystals	1
2	Nematic, Cholesteric, Smectic and Ferro-electric liquid crystals	4
3	Phenomenological description (Landau-de Gennes and Frank-Oseen free energy)	5
4	Nematic-isotropic phase transition	5
5	Landau theory and Maier-Saupe theory	5
6	Dielectric spectroscopy of liquid crystals	4
7	Linear and Nonlinear electro-optic effects	5
8	Characterization Techniques	4
9	New liquid crystals	5
10	Applications	4
Total Lecture hours (14 times 'L')		42

16. Brief description of tutorial activities: None

Module no.	Description	No. of hours
Total Tutorial hours (14 times 'T')		

17. Brief description of Practical / Practice activities: None

Module no.	Description	No. of hours
Total Practical / Practice hours (14 times 'P')		

18. Brief description of module-wise activities pertaining to self-learning component (Only for 700 / 800 level courses) (Include topics that the students would do self-learning from books / resource materials: Do not Include assignments / term papers etc.)

Module no.	Description
	Not applicable
(The volume of self-learning component in a 700-800 level course should typically be 25-30% of the volume covered in classroom contact)	

19. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

1. Peter J. Collings and Michael Hird, Introduction to Liquid Crystals, Taylor and Francis Publishers, 1997
2. Sven T. Lagerwall, Ferroelectric and Antiferroelectric Liquid Crystals, Wiley, 2007

20. Resources required for the course (itemized student access requirements, if any)

20.1	Software	None
20.2	Hardware	None
20.3	Teaching aids (videos, etc.)	None
20.4	Laboratory	None
20.5	Equipment	None
20.6	Classroom infrastructure	None
20.7	Site visits	None
20.8	Others (please specify)	None

21. Design content of the course (Percent of student time with examples, if possible)

21.1	Design-type problems	None
21.2	Open-ended problems	10%
21.3	Project-type activity	10%
21.4	Open-ended laboratory work	None
21.5	Others (please specify)	None

Date: (Signature of the Head of the Department/ Centre / School)

Date of Approval of Template by Senate

The information on this template is as on the date of its approval, and is likely to evolve with time.

COURSE TEMPLATE

(Please avoid changing the number of tables, rows and columns or text in dark black, but fill only the columns relevant to the template by editing the columns in grey letters or blank columns: this would help in automating the processing of template information for curricular use)

1.	Department/Centre/School proposing the course	Physics	
2.	Course Title	Statistical Optics and Optical Coherence Theory	
3.	L-T-P structure	3-0-0	
4.	Credits	3	Non-graded Units
			Please fill appropriate details in S. No. 21
5.	Course number	PHL-762	
6.	Course Status (Course Category for Program) (list program codes: eg., EE1, CS5, etc.)		
	Institute Core for all UG programs		(Yes / No)
	Programme Linked Core for:		List of B.Tech. / Dual Degree Programs
	Departmental Core for:		List of B.Tech. / Dual Degree Programs
	Departmental Elective for:		List of B.Tech. / Dual Degree Programs
	Minor Area / Interdisciplinary Specialization Core for:		Name of Minor Area / Specialization Program
	Minor Area / Interdisciplinary Specialization Elective for:		Name of Minor Area / Specialization Program
	Programme Core for:		List of M.Tech. / Dual Degree Programs
	Programme Elective for:		List of M.Tech. / Dual Degree Programs
	Open category Elective for all other programs (No if Institute Core)		(Yes / No)
7.	Pre-requisite(s)	combinations of courses: eg. (XYZ123 & XYW214) / XYZ234	
8.	Status vis-à-vis other courses		
8.1	List of courses precluded by taking this course (significant overlap)		(course number)
	(a)	Significant Overlap with any UG/PG course of the Dept./Centre/ School	(course number)
	(b)	Significant Overlap with any UG/PG course of other Dept./Centre/ School	(course number)
8.2	Supersedes any existing course		(course number)
9.	Not allowed for	(indicate program names)	

10.	Frequency of offering (check one box)	☐ Every semester ☐ I sem ☐ II sem ☐ Either semester
11.	Faculty who will teach the course: D. S. Mehta, Kedar Khare, and Joyee Ghosh	
12.	Will the course require any visiting faculty?	(Yes/no)
13.	Course objectives: To learn the statistical nature of optical fields, random processes and noise phenomenon in optics. The second-order and higher-order coherence theory of optical fields is important to achieve a deeper understanding of optical instruments/systems such as interferometers and imaging systems and inverse problems. Following the completion of this course students will have a basic and deeper understanding of statistical optical fields, partial coherence in imaging systems, coherence properties of light sources in space-time and space-frequency domain, speckle phenomenon, and propagation in random medium and their applications in various fields.	
14.	Course contents: Review of probability and random variables. Probability and Statistics in Optics. Stochastic processes to represent optical fields. Ergodicity and stationarity, Auto-correlation, cross-correlation, and Wiener-Khinchin theorem Gaussian and Poisson random processes. First-order properties of optical fields: Radiation from sources of any state of coherence. Monochromatic, polychromatic and broad light sources. Polarized, partially polarized and unpolarized thermal light and pseudo-thermal light. Second-order coherence theory in space-time domain: Temporal coherence and complex degree of self coherence. Spatial coherence and complex degree of mutual coherence, Cross-spectral density, propagation of mutual coherence, The Van Cittert-Zernike theorem and its application to stellar interferometry. Higher-order coherence theory: Hanbury-Brown and Twiss experiment, intensity-intensity correlation and Ghost imaging. Second order coherence theory in space-frequency domain: Concept of cross-spectral density, spectral degree of coherence, Wiener-Khintchin theorem, electromagnetic coherence, degree of polarization and applications. Applications of second-order coherence theory: Optical coherence tomography, stellar interferometry, Laser speckle and speckle metrology, Fourier transform spectroscopy, Partial coherence in imaging systems, Propagation through random inhomogeneous media.	

15. Lecture Outline(with topics and number of lectures)

Module no.	Topic	No. of hours (not exceeding 5h per topic)
1	Review of probability and random variables.	2
2	Probability and Statistics in Optics.	3
3	Ergodicity and stationarity, auto-correlation, cross-correlation, and Wiener-Khinchin theorem.	3
4	Gaussian and Poisson random processes	3
5	First-order properties of optical fields: Radiation from sources of any state of coherence.	4
6	Second-order coherence theory in space-time domain: Temporal coherence, Spatial coherence the Van Cittert-Zernike theorem and it's application to stellar interferometry.	5
7	Higher-order coherence theory: Hanbury-Brown and Twiss experiment, intensity-intensity correlation and Ghost imaging.	4
8	Second order coherence theory in space-frequency domain.	3
9	Applications of second-order coherence theory: Microscopy, Optical coherence tomography and stellar interferometry	3
10	Speckle phenomenon in optics: first-order and higher-order statistical properties of speckle.	3
11	Optical methods for suppressing speckle.	3
12	Speckle metrology and imaging applications: Speckle interferometry, speckle photography, laser speckle imaging of biological samples.	4
13	Noise in Lasers and Detectors	2
Total Lecture hours (14 times 'L')		42

16. Brief description of tutorial activities:

Module no.	Description	No. of hours
Total Tutorial hours (14 times 'T')		

17. Brief description of Practical / Practice activities

Module no.	Description	No. of hours

Total Practical / Practice hours (14 times 'P')		

18. Brief description of module-wise activities pertaining to self-learning component (Only for 700 / 800 level courses) (Include topics that the students would do self-learning from books / resource materials: Do not Include assignments / term papers etc.)

Module no.	Description
(The volume of self-learning component in a 700-800 level course should typically be 25-30% of the volume covered in classroom contact)	

19. Suggested texts and reference materials

STYLE: Author name and initials, Title, Edition, Publisher, Year.

i.	J. Goodman, Statistical Optics, 2000, Wiley-Interscience Publication.
ii.	A. Papoulis and S. Pillai, Probability, Random Variables and Stochastic Processes, 2001, McGraw-Hill Companies.
iii.	E. Wolf, Principles of Optics Cambridge University Press.
iv.	L. Mandel and E. Wolf, Optical Coherence and Quantum Optics, 2008, Cambridge University Press.
v.	E. Wolf, Introduction to Coherence and Polarization of Light, 2007, Cambridge University Press.
vi.	Optical Coherence Tomography: Technology and Applications by Wolfgang Drexler and J.G. Fujimoto, Springer 2008.

20. Resources required for the course (itemized student access requirements, if any)

20.1	Software	Name of software, number of licenses, etc.
20.2	Hardware	Nature of hardware, number of access points, etc.
20.3	Teaching aids (videos, etc.)	Description, Source, etc.
20.4	Laboratory	Type of facility required, number of students etc.
20.5	Equipment	Type of equipment required, number of access points, etc.
20.6	Classroom infrastructure	Type of facility required, number of students etc.
20.7	Site visits	Type of Industry/ Site, typical number of visits, number of students etc.
20.8	Others (please specify)	

21. Design content of the course (Percent of student time with examples, if possible)

21.1	Design-type problems	Eg. 25% of student time of practical / practice hours: sample Circuit Design exercises from industry
21.2	Open-ended problems	
21.3	Project-type activity	
21.4	Open-ended laboratory work	
21.5	Others (please specify)	

Date: (Signature of the Head of the Department/ Centre / School)

Date of Approval of Template by Senate	
---	--