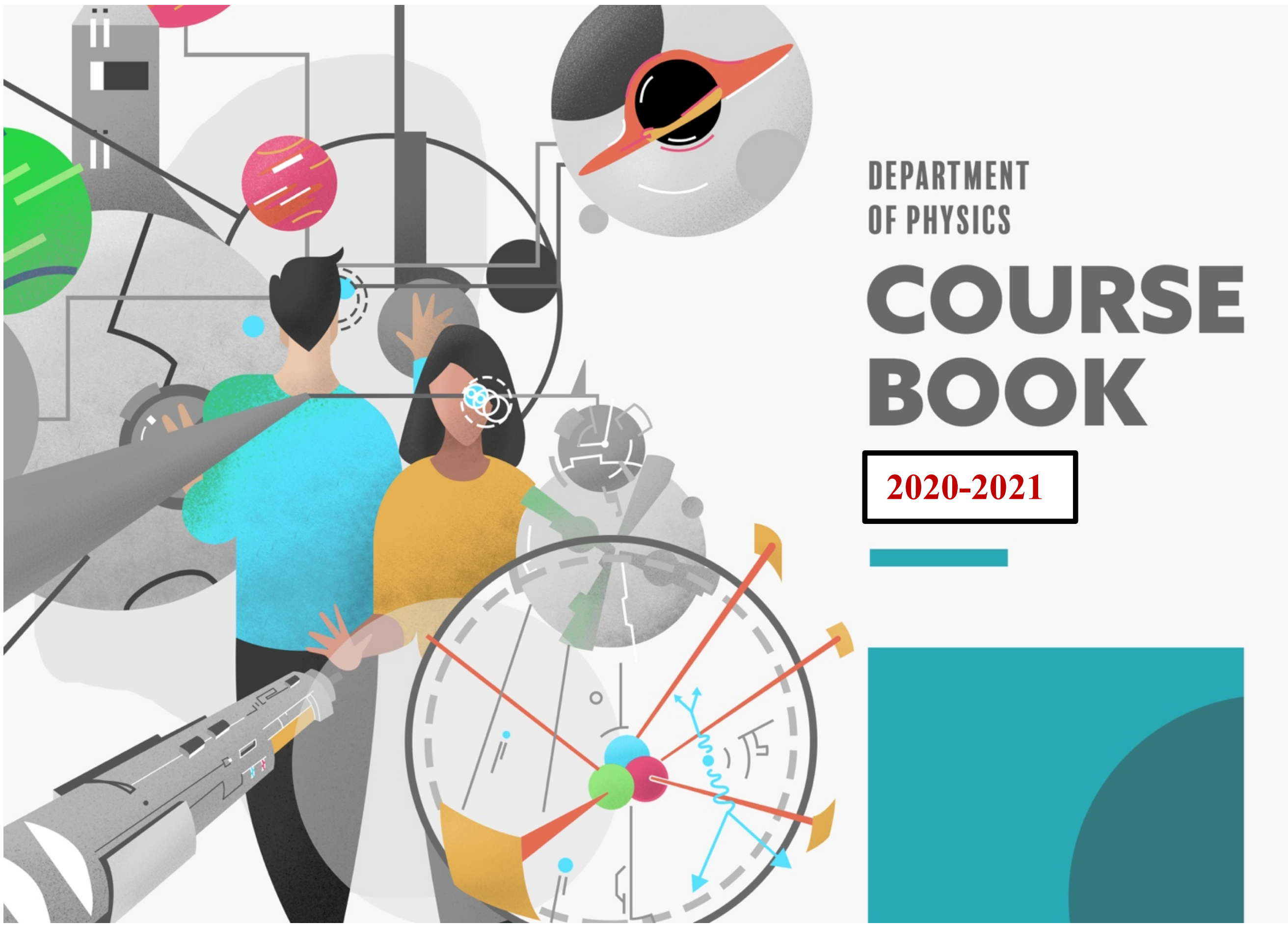

August 2020

Message from the Head of the Department:

At the outset, let me extend my heartiest congratulations to you on successfully qualifying to become a student of IITB. I understand the amount of hard work and dedication that you have put in to achieve this and I am sure that you will continue to put the same for achieving greater heights during your stay here. As these are difficult times and we are all experimenting with a new mode of education, I am sure you will try your best to adjust to the new world.

Physics department of IITB is one of the oldest departments of the institute and one of the most vibrant Physics departments in the country today. For the last couple of years, our dept. has been ranked as the number one Physics department in India according to the QS ranking. We have 46 faculty members, about 160 B.Tech. students, 80 M.Sc. students and 120 Ph.D. students. There are about 25 Post-Doctoral fellows, working in different groups. We also have support staff of about 25 people. We have all modern teaching laboratories and a well-equipped department library. A computer lab only meant for students is also available for you.

This booklet also contains the curriculum and the course contents that you have to follow. You may note that in the final year, there are a few core courses that are common for B.Tech. and M.Sc. Also, almost all elective courses are common and taught in the same class. Ph.D. students have to take some of the M.Sc. core or elective courses as indicated later.

The main areas of research in the department are (i) Condensed Matter Physics, (ii) Astrophysics/Cosmology/Gravity, (iii) High Energy Physics, (iv) Photonics and Spectroscopy (v) Statistical Physics/Bio Physics/Soft Matter Physics/Non-linear Dynamics. In almost all these areas, both theoretical as well as experimental research are going on. There is ample scope for you to interact with the faculty members to get involved in the research activities, in addition to your normal academic work. I encourage you to take up such assignments and get more exposure.

Many of our alumni (B.Tech., M.Sc. and Ph.D.) have performed very well in their career and are in leading positions in academia/industry/civil services/corporate sector in India or abroad. With the training that you get here, I am sure you will all be able to rise to such levels of excellence. Please make use of every opportunity and facility that are available in the department and in the institute to achieve this, develop your personality and come out in flying colours.

Let’s together meet the new challenges and transform them into opportunities….

With best wishes,

[K. G. SURESH]

List of Faculty Members

No.	Name	No.	Name
1	B. P. Singh	24	Parinda Vasa
2	S. S. Major	25	Dinesh Kabra
3	U. A. Yajnik	26	Pradeep Sarin
4	P. P. Singh	27	Sadhana Dash
5	Raghav Varma	28	Aftab Alam
6	S. Umasankar	29	S. Mahapatra
7	A. V. Mahajan	30	S. Shankaranarayanan
8	T. Kundu	31	Archana Pai
9	C. V. Tomy	32	Mithun K. Mitra
10	M. Senthil Kumar	33	Kumar Rao
11	K. G. Suresh	34	Vikram Rentala
12	Alok Shukla	35	Raghunath C
13	B. K. Nandi	36	Amitabha Nandi
14	P. Ramadevi	37	Sai V
15	A. Sain	38	Gopal Dixit
16	Dibyendu Das	39	Soumya Bera
17	Asmita Mukherjee	40	Sumiran Pujari
18	Punit Parmananda	41	Varun Bhalerao
19	S. Dhar	42	Sunita Srivastava
20	M. Aslam	43	Anshuman Kumar
21	B. N. Jagatap	44	Pramod Kumar
22	Pragya Das	45	Hridis Kumar Pal
23	K. Das Gupta	46	Nitin Kumar

List of faculty advisers of current batches

B.Tech. (2016)	S. Dhar
B.Tech. (2017)	M. Aslam
B.Tech. (2018)	Gopal Dixit
B.Tech. (2019)	Anshuman Kumar
M. Sc. (2019)	Raghunath C
B.Tech. (2020)	**Mithun Mitra**
M.Sc. (2020)	**Archana Pai**

Minimum Credits required

Degree	**Credits**
B. Tech. Engineering Physics	268
B. Tech. Engineering Physics (with Honors)	268+24=292 (4 years)
Minor - Engineering Physics	30
B. Tech.-M.Tech. Dual Degree*	268+126=394 (5 years)
Integrated M.Sc. (B.Tech. to M.Sc.)**	268+96=364 (5 years)
M. Sc.	145
M. Sc. (with Honors)***	145+15=160 (2 years)
M.Sc. to M.Sc.-Ph.D.****	145+30 (5 semesters)
Ph.D.	34 (for students with M.Sc.) 16 (for students with M.Tech./M.E. 44 (for students with B.Tech./B.E./B.S.)

*subject to the interest by a B.Tech. student AND the approval of the Dept. (minimum CPI required =7.5 at the end of the third year)

**Subject to the interest by a B. Tech. student AND the approval of the Dept. (minimum CPI required =7.5 at the end of the third year)
***Subject to the approval of the Senate. If approved, the students with at least 8 CPI at the end of the first semester can register and have to do 15 additional credits (1 Supervised learning project+ 2 projects/electives 3+6+6=15 credits).

**** subject to the interest by a M.Sc. student AND the approval of the Dept. (minimum CPI required =8 at the end of the first year)

Department Academic Mentorship Program (DAMP)

The Department Academic Mentorship Program works to provide assistance to students of the department, with two primary aims:

1. Providing the freshers with a smooth transition into the department in their second year
2. Enabling academically weak students to get back on track

With these broad aims, our activities can be put into the following categories:

1. Student mentorship:
    a. Freshman year has common courses for all departments, except a Department Introductory Course. From the second year onwards, there are more of department specific courses and electives, and all sophomore students are assigned a DAMP mentor to help them manoeuver their way through these.
    b. Mentors are also assigned to all third/fourth year students having a large number of backlog courses to aid them in clearing their backlogs and improving their academic standing.

Faculty Interaction: We strive to improve the level of interaction between the faculty and the students of the department, through a number of events conducted throughout the year. With regards to improving the feedback from the students, we carry out a midsem course review every semester to identify any general problems that the students might be facing and convey them to the respective course instructor. We also keep in touch with the course instructors throughout the semester and communicate their feedback about students who are falling behind to the corresponding DAMP mentors.

Support and Outreach:

. We have a DAMP blog which is run by students of the department, hosting content such as reviews of elective courses, internship experiences, AMAs with professors, and frequently asked questions (FAQs).

a. We conduct help sessions for the students, based on feedback from the class and the instructor, especially before the major exams.

b. We organize various knowledge-sharing sessions for the students, with seniors sharing their experience on minors and elective courses, internships, graduate school applications, and non-core career opportunities to name a few.

Students Association Physics Department (SAPD):

SAPD handles the informal side of the physics department. SAPD organizes events such as Freshmen Introduction, Department Trips and Kurta Days. SAPD is responsible for designing cool Department of Physics T-shirts every year.

Curricula and Course Contents

of

B.Tech.,

M.Sc. ,

And

Ph.D.

M.Sc. Physics

Year/Sem	*Course code*	*Course Description*	*Credits*
I Year I Semester	PH 401	Classical Mechanics	3-1-0-8
	PH 403	Quantum Mechanics I	3-1-0-8
	PH 407	Mathematical Physics I	3-1-0-8
	PH 405	Electronics	2-1-0-6
	PH 434	Programming Lab	1-0-3-5
	PH 443	Electronics Lab	0-0-3-3
			Total credits: 38

Year/Sem	*Course code*	*Course Description*	*Credits*
I Year II Semester	PH 410	Statistical Physics	2-1-0-6
	PH 422	Quantum Mechanics II	2-1-0-6
	PH 408	Mathematical Physics II	3-1-0-8
	PH 418	Introduction to Condensed Matter Physics	2-1-0-6
	PH 424	Electromagnetic Theory I	2-1-0-6
	PH 441	General Physics Lab	0-0-3-3
			Total credits: 35

Year/Sem	*Course code*	*Course Description*	*Credits*
II Year I Semester	PH 515	Introduction to Atomic and Molecular Physics	2-1-0-6
	PH 505	Introduction to Nuclear and Particle Physics	2-1-0-6
	PH 527	Physics Lab (Solid State and Nuclear Physics)-deferred	0-0-3-6
	PH 595	M.Sc. Project stage I	0-0-3-6
		Or Departmental Elective X	2-1-0-6
		Departmental Elective I	2-1-0-6
		Department Elective II	2-1-0-6
			Total credits: 36

II Year II Semester	PH 510	Electromagnetic Theory II	2-1-0-6
	PH 530	Light Matter Interaction	2-1-0-6
	PH 512	Physics Lab (Optics and Spectroscopy)	0-0-3-6
	PH 596	M.Sc. Project stage II	0-0-3-6
		Or Elective XX	2-1-0-6
		Departmental Elective III	2-1-0-6
		Departmental Elective IV	2-1-0-6
			Total credits: 36

Total Credits: 145

No. of Dept. electives required: 6 (including Projects)

List of prescribed courses under Electives X, I, II (odd semester)

Number	Title	Number	Title
PH 523	Quantum Mechanics III	PH 563	Group Theory Methods in Physics
PH 543	Advanced Statistical Mechanics	PH 565	Semiconductor Physics
PH 549	Physics of Biological Systems	PH 567	Nonlinear Dynamics
PH 557	Theoretical Condensed matter physics	PH 569	Applied Solid State Physics
PH 559	Introduction to nanoscience and nanotechnology	PH 575	Nanoscience: Fundamentals to Fabrication
PH 561	Ultra fast Sciences		

PH 559 may get replaced with PH 575

You have to choose electives from any 2 baskets (only) [suggested]

Basket 1	**Basket 2**	**Basket 3**
QM III	Appl. Solid State .	Phys. of Bio sys.
Group theory	Semiconductor phys.	Theort. Cond. Mat.
Adv. Stat. mech.	Ultrafast sciences	Adv. Stat. mech.
Nonlinear Dyn.	Nonlinear Dyn.	The. Con. Mat. Phys
Theort. Cond. Mat.	Theo. Cond. Mat. Phys.	Appl. Solid State

List of prescribed courses under Elective XX, III, IV <u>(even semester)</u>

PH 500	Thin film Physics and Technology	PH 562	Continuum Mechanics
PH 534	Quantum Information and Computing	PH 564	Methods in Experimental Nuclear and Particle Physics
PH 540	Elementary Particle Physics	PH 566	Advanced Simulation Techniques in Physics
PH 544	General Theory of Relativity	PH 568	Physics of Nanostructures and Nanoscale Devices
PH 546	Quantum Optics	PH 572	Special Topics in Elementary Particle Physics
PH 550	Soft Matter Physics	PH 576	Nanoscale Quantum Transport
PH 554	Computational Many Body Physics	PH 578	Nanodevices and Applications
PH 556	Astrophysics	PH 580	Magnetism and Superconductivity
PH 558	Nanomaterials, Nanostructures and Nanofabrication		

PH 558 and 568 may get replaced with PH 576 and 578

<u>You have to choose electives from any 2 baskets (only) [suggested]</u>

Basket 1
Ele. Part. Phys.
Quan. Compt.
Gen. The. Rel.
Astro Phys.
Methods Nul. Pat. Phys.
Special Topics in Ele. Part.

Basket 2
Quan. Compt.
Magn. and Supercod.
Compu. Many body phys.
Nanomaterials ..

Basket 3
Soft Matter Phys.
Quan. Compt.
Quantum Optics
Phys. of nano….
Continuum Mech.

B. Tech. (Engineering Physics)

Year/Sem	*Course code*	*Course Title*	*Credits*
I Year I Sem	CH 105	Organic + Inorganic Chemistry	3-1-0-4
	CH 107	Physical Chemistry	3-1-0-4
	CS 101 or BB 101	Computer Programming & Utilization or Biology	2-0-2-6
	MA 109	Calculus-1 (half semester course)	3-1-0-4
	MA 111	Calculus-2 (half semester course)	3-1-0-4
	ME 119 Or ME 113	Engg. Graphics & Drawing or Workshop	0-1-3-5 or 0-0-4-4
	PH 107	Quantum Physics and applications	2-1-0-6
	PH 117 or CH 117	Physics/Chemistry Lab	0-0-3-3
		NCC/NSS/NSO	P/NP
	Total credits: 35/36		
I Year II Sem	CS 101 or BB 101	Computer Programming & Utilization or Biology	2-0-2-6
	EE 112	Introduction to Electronics- **DIC**	2-1-0-6
	MA 106	Linear Algebra (half semester course)	2-0-0-4
	MA 108	Ordinary Differential Equations I (half semester course)	2-0-0-4
	ME 119 or ME 113	Engg. Graphics & Drawing or Workshop	0-1-3-5 or 0-0-4-4
	PH 108	Basics of Electricity and Magnetism	2-1-0-6
	PH 117 or CH 117	Physics or Chemistry Lab	0-0-3-3
		NCC/NSS/NSO	P/NP
	Total credits: 34/33		

Year/ Sem	*Course code*	*Course Title*	*Credits*
II Year I Sem	PH 207	Introduction to Special Theory of Relativity	2-1-0-3
	PH 215	Thermal Physics	2-1-0-3

	PH 217	Classical Mechanics	2-1-0-6
	HS 101	Economics	3-0-0-6
	PH 219	Data Analysis and Interpretation	2-1-0-6
	MA 205	Complex Analysis (half semester course)	3-1-0-4
	MA 207	Ordinary Differential Equation II (half semester course)	3-1-0-4
	EE 224	Digital Systems (earlier offered in the 4th sem)	2-1-0-6
	PH 231	Electronics Lab I(Basic circuits)-deferred	0-0-3-3
	PH 232	Gen Physics Lab -deferred	0-0-3-3
	Total credits: 38		
	PH 202	Waves, Oscillations and Optics	2-1-0-6
	PH 204	Quantum Mechanics I	3-1-0-8
	MA 214	Introduction to Numerical Analysis	3-1-0-8
	PH 230	Electronics Lab III (Digital Electronics)	1-0-3-5
	PH 233	Electronics Lab II (Op amp circuits)	0-0-3-3
	Total credits: 36		

Year/Sem	***Course code***	***Title***	***Credits***
III Year I Sem	PH 421	Photonics	2-1-0-6
	PH 423	Quantum Mechanics II	2-1-0-6
		Institute/Open Elective I	2-1-0-6
		HSS core course	2-1-0-6
	PH 435	Electronics Lab IV (Microprocessors)	1-0-3-5
		Total credits: 29/35	
III Year II Sem		Department Elective I	2-1-0-6
	EN 301	Introduction to Renewable Energy Technologies ***In place of this, any engineering elective can be taken for 2019 batch onwards***	2-1-0-6
	PH 436	Introduction to Condensed Matter Physics	2-1-0-6
	PH 438	Statistical Physics	2-1-0-6
	PH 444	Electromagnetic Theory	2-1-0-6
	PH 446	Physics Lab (Solid State and Nuclear Physics)	0-0-3-3
		Total credits: 33	

Year/Sem	***Course code***	***Title***	***Credits***
		Institute elective II	2-1-0-6
IV Year I Sem	PH 587	BTP-1 or Department Elective II	2-1-0-6
	PH 515	Introduction to Atomic and Molecular Physics	2-1-0-6
	PH 505	Introduction to Nuclear and Particle Physics	2-1-0-6
	PH 517	Methods in Analytical Techniques	2-0-2-6
	PH 447	Physics Lab (Optics and spectroscopy)-deferred	0-0-3-3
			Total credits: 33

IV Year II Sem	PH 588	BTP-II or Department Elective III	2-1-0-6
		Department Elective IV	2-1-0-6
	PH 536 to be changed to PH 574	Physics of Quantum Devices to be changed to Physics of Semiconductor Devices	2-1-0-6
	HS 200 and ES 200	Environmental Studies: Science and Eng. Environmental Studies	2-1-0-6
		Institute Elective III	2-1-0-6
			Total credits: 30

Total credits (minimum)=268

No. of Institute/Engineering/HSS electives=4 (including EN 301)

No. of Dept. electives=4 (including BTPs)

List of prescribed courses under Elective II (odd semester)

Number	Title	Number	Title
PH 523	Quantum Mechanics III	PH 563	Group Theory Methods in Physics
PH 543	Advanced Statistical Mechanics	PH 565	Semiconductor Physics
PH 549	Physics of Biological Systems	PH 567	Nonlinear Dynamics
PH 557	Theoretical Condensed matter physics	PH 569	Applied Solid State Physics
PH 559	Introduction to nanoscience and nanotechnology	PH 575	Nanoscience: Fundamentals to Fabrication
PH 561	Ultra fast Sciences		

PH 559 may get replaced with PH 575

You have to choose electives from any 2 baskets (only) [suggested]

Basket 1	Basket 2	Basket 3
QM III	Appl. Solid State	Phys. of Bio sys.
Group theory	Semiconductor phys.	Theort. Cond. Mat.
Adv. Stat. mech.	Ultrafast sciences	Adv. Stat. mech.
Nonlinear Dyn.	Nonlinear Dyn.	The. Con. Mat. Phys
Theort. Cond. Mat.	Theo. Cond. Mat. Phys.	Appl. Solid State

List of prescribed courses under Elective I, III, IV (even semester)

PH 500	Thin film Physics and Technology	PH 558	Nanomaterials, Nanostructures and Nanofabrication
PH 530	Light Matter Interaction – core for MSc.	PH 562	Continuum Mechanics
PH 534	Quantum Information and Computing	PH 564	Methods in Experimental Nuclear and Particle Physics
PH 540	Elementary Particle Physics	PH 566	Advanced Simulation Techniques in Physics
PH 544	General Theory of Relativity	PH 568	Physics of Nanostructures and Nanoscale Devices
PH 546	Quantum Optics	PH 572	Special Topics in Elementary Particle Physics
PH 550	Soft Matter Physics	PH 576	Nanoscale Quantum Transport
PH 554	Computational Many Body Physics	PH 578	Nanodevices and Applications
PH 556	Astrophysics	PH 580	Magnetism and Superconductivity

PH 558 and 568 may get replaced with PH 576 and 578

You have to choose electives from any 2 baskets (only) [suggested]

Basket 1	Basket 2	Basket 3
Ele. Part. Phys.	Quan. Compt.	Soft Matter Phys.
Quan. Compt.	Magn &Supercond	Quan. Compt.
Gen. The. Rel.	Compu. Many body phys.	Quantum Optics
Astro Phys.	Nanomaterials ..	Phys. of nano….
Methods Nul. Pat. Phys.	Light matter int.	Continuum Mech.
Special Topics in Ele. Part.		

B.Tech.- M.Tech. Dual Degree Program

In addition to the 4 year B.Tech. credits, Dual Degree students have to do 8 additional electives of which the following 3 theory electives and PH 570 lab are compulsory. They must also do the SLP and the two projects. The extra credits for DD is 126. (8x6+6+30+42=126). Total credits =268+126= 394. The extra courses are given below:

Course Number	**Title**	**Credits**
PH 500	Thin Film Physics and Technology	2-1-0-6
PH 559	Introduction to nanoscience and nanotechnology	2-1-0-6
PH 558	Nanomaterials Nanostructures and nanofabrication	2-1-0-6
PH 570	Advanced Lab Techniques in Nanoscience	2-1-0-6
PH 303	Supervised Learning	2-1-0-6
PH 591	Dual Degree Project – I	30
PH 592	Dual Degree Project –II	42
Total Credits		**126**

B.Tech. Engineering Physics - Honours

** for the award of Honors, a student should take any 4 courses, completing 24 credits.*

Sl. No.	***Course code***	***Title***	***Credits***
1	PH 303	Supervised Learning (runs in both semesters)	2-1-0-6
2	PH 523	Quantum Mechanics III	2-1-0-6
3	PH 534	Quantum Information and Computing	2-1-0-6
4	PH 563	Group Theory Methods in physics	2-1-0-6
5	PH 565	Semiconductor Physics	2-1-0-6
6	PH 567	Non linear Dynamics	2-1-0-6
7	PH 562	Continuum Mechanics	2-1-0-6
8	PH 540	Elementary Particle Physics	2-1-0-6
9	PH 557	Theoretical Condensed matter physics	2-1-0-6
10	PH 544	General Theory of Relativity	2-1-0-6
11	PH 554	Computational Many Body Physics	2-1-0-6
12	PH 564	Methods in Exp. Nuclear and Particle Physics	2-1-0-6
13	PH 580	Magnetism and Superconductivity	2-1-0-6
14	PH 587	B.Tech. Project I	2-1-0-6
15	PH 588	B.Tech. Project II	2-1-0-6

B.Tech. Engineering Physics - Minor

* *for the award of minor, a student should take any 5 courses, completing 30 credits*.

Sl. No.	***Course code***	***Title***	***Credits***
1	PH 251	Classical Mechanics	3-1-0-8
2	PH 252	Introduction to Quantum Mechanics	2-1-0-6
3	PH 253	Thermal and Statistical Physics	2-1-0-6
4	PH 352	Introduction to Condensed Matter Physics	2-1-0-6
5	PH 353	Light Matter Interaction	2-1-0-6

Out of the required 5, Classical Mechanics, Quantum mechanics and Thermal & Statistical Phys. are compulsory. The remaining 2 can be taken from the list of department electives as well.

Integrated M. Sc. (4 year EP B.Tech. to 5 year integrated M.Sc.)

In addition to the courses/credits required by the B.Tech. EP program, a student needs to complete the following courses: (Credits: 6x6+30+30=96)

Semester	**Course**	**Credits**
VII	Extra dept. elective–I	2-1-0-6
VIII	Extra dept. elective -2	2-1-0-6
IX	Extra dept. elective –3	2-1-0-6
	Extra dept. elective -4	2-1-0-6
	Integrated M.Sc. Project I (PH 593)	30
X	Extra dept. elective –5	2-1-0-6
	Extra dept. elective -6	2-1-0-6
	Integrated M.Sc. Project II (PH 594)	30
Total Credits		**96**

Ph.D. courses (Jan 2019 onwards)

Group A	Group B
ODD SEMESTER (July)	**ODD SEMESTER (July)**
Semiconductor Physics-PH 565	Methods in Analytical Techniques – PH 517
Mathematical Physics- I – PH 407 (8 credits)	Advanced Statistical Mechanics – PH 543
Quantum Mechanics III -PH 523	Applied Solid State Physics – PH 569
Non-linear Dynamics – PH 567	Ultrafast Sciences - PH 561
Introduction to Atomic and Molecular Physics - PH 515	Group Theoretical Methods in Physics- PH 563
Introduction to Nuclear and particle Physics- PH 505	Physics of Biological Systems - PH 549
Theoretical Condensed Matter Physics- PH 557	Data analysis and Interpretation- PH 219
Introduction to Nanoscience and Nanotechnology- PH 559*	
Photonics – PH 421	
EVEN SEMESTER (January)	**EVEN SEMESTER (January)**
Introduction to Condensed Matter Physics – PH 418	
Quantum Mechanics II – PH 422	Physics of Quantum Devices – PH 536
Electromagnetic Theory II -PH510	Elementary Particle Physics – PH 540
Mathematical Physics II - PH 408 (8 credits)	Quantum Information and Computing – PH 534
Laboratory Techniques- PH 804 (8 credits)	Methods in Experimental Nuclear and Particle Physics- PH 564
Astrophysics – PH 556	Thin film Physics and Technology – PH 500
Programming Lab- PH 434 (5 credits)**	Nanomaterials, Nanostructures and Nanofabrication – PH 558
Light Matter Interaction – PH 530	Special topics in Elementary Particle Physics -PH 572
Physics of Nanostructures & Nanoscale Devices- PH 568*	Computational Many Body Physics- PH 554
Continuum Mechanics -PH 562	Soft Matter Physics – 550
Statistical Physics - PH 410	General Theory of Relativity- PH 544
Advanced Simulation Techniques in Physics- PH 566**	Quantum Optics – PH 546
	Magnetism and Superconductivity- PH 580

*you can take either Introduction to Nanoscience and Nanotechnology- PH 559 **OR** Physics of Nanostructures & Nanoscale Devices- PH 568. Both will not be allowed to credit.

** You can take either one of these.

PhD students with M.Sc. have to complete 34 credits. This includes 4 credits of a seminar course (PHS 801/802). Regarding the theory courses, you have to take at least 2 from each of the two groups. One course can be taken from outside the dept. In addition, all Ph.D. students should pass HS 791+PH 792 in their first year. Those with M.Tech./M.E need to do only 16 credits, while those with B.Tech./B.E./B.S. need to do 44 credits. The credits requirements for PMRFs are the same as those of other students.

B. Tech. Course Contents

First Year, First Semester

Course Name	**Organic and Inorganic Chemistry**
Course Code	CH 105
Total Credits	4
Type	T (Theory)
Lecture	3
Tutorial	1
Practical	N
Half Semester	Y
Description	Molecular orbitals of common functional groups, Qualitative Huckel MOs of conjugated polyenes and benzene. Aromaticity. Configuration, molecular chirality and isomerism, Conformation of alkanes and cycloalkanes, Reactivity of carbonyl group), Functional group inter-conversions involving oxidation and reduction, Periodic properties: trends in size, electron affinity, ionization potential and electronegativity, Use of Ellingham diagram and thermodynamics in the extraction of elements, Transition metal chemistry: inorganic complexes, bonding theories, magnetism, bonding aspects and structural distortion, Bioinorganic chemistry: storage and transport proteins, Catalysis: hydrogenation, hydroformylation and olefin metathesis.
Text Reference	1. P. Volhardt and N. Schore, Organic Chemistry: Structure and Function, 5th Edition, W. H Freeman & Co, 2006 2. T. W. G. Solomons, C. B. Fryhle, Organic Chemistry, 9th Edition, WileyIndia Pvt. Ltd., 2009 3. R. T. Morrison and R. N. Boyd, Organic Chemistry, 6th edition, Pearson Com., 1992 4. L. G. Wade, Organic Chemistry, Pearson Education 6th edition, 2006. 5. M. J. Sienko and R. A. Plane, Chemical Principles and Applications, McGraw Hill, 1980. 6. J. D. Lee, Concise Inorganic Chemistry, 4th Edition, ELBS, 1991. 7. D. D. Ebbing, General Chemistry, Houghton Miffin Co., 1984.

Course Name	**Physical Chemistry**
Course Code	CH 107
Total Credits	4
Type	T
Lecture	3
Tutorial	1
Practical	N

Half Semester	Y
Description	Schrodinger equation, Origin of quantization, Born interpretation of wave function, Hydrogen atom: solution to ϕ-part, Atomic orbitals, many electron atoms and spin orbitals. Chemical bonding: MO theory: LCAO molecular orbitals, Structure, bonding and energy levels of diatomic molecules. Concept of sp, $sp^2$and sp^3hybridizations; Bonding and shape of many atom molecules; Intermolecular Forces; Potential energy surfaces-Rates of reactions; Steady state approximation and its applications; Concept of pre-equilibrium; Equilibrium and related thermodynamic quantities
Text Reference	1. P. Atkins and J. de Paula, Atkins, Physical Chemistry, Oxford University Press, 8th edition, 2006. 2. I. N. Levine, Physical Chemistry, 5th edition, Tata McGraw-Hill, New Delhi, 2002. 3. D. A. McQuarrie and J.D. Simon, Physical Chemistry - a molecular approach, Viva Books Pvt. Ltd. (1998).

Course Name	**Computer Programming**
Course Code	CS 101
Total Credits	6
Type	T
Lecture	2
Tutorial	1
Practical	2
Half Semester	N
Description	This course provides an introduction to problem solving with computers using a modern language such as Java or C/C++. Topics covered will include : * Utilization : Developer fundamentals such as editor, integrated programming environment, Unix shell, modules, libraries. * Programming features : Machine representation, primitive types, arrays and records, objects, expressions, control statements, iteration, procedures, functions, and basic i/o. * Applications : Sample problems in engineering, science, text processing, and numerical methods. <u>Hours:</u> 2 lectures (55 minutes each), 2 hours of laboratory time which will include practice on computers. <u>Description:</u> This course provides an introduction to problem solving with computers using a modern language such as Java or C/C++. Topics covered will include: A. Utilization: Developer fundamentals such as editor, integrated programming environment, Unix shell, modules, libraries. B. Programming features: Machine representation, primitive types, arrays and records, objects, expressions, control statements, iteration, procedures, functions, and basic i/o.

	C. Sample problems in engineering, science, text processing, and numerical methods.
Text Reference	1.* C++ Program Design: An introduction to Programming and Object-Oriented Design, 3rd Edition, by Cohoon and Davidson, Tata McGraw Hill. 2003. Other references (Not required reading)* 2. Thinking in C++ 2nd Edition by Bruce Eckel(available online)* G. Dromey, 3. How to Solve It by Computer, Prentice-Hall, Inc., Upper Saddle River, NJ, 1982.* Polya, G., 4. How to Solve _It (2nd ed.), Doubleday and co. (1957).* 5. Let Us C. Yashwant Kanetkar. Allied Publishers, 1998.* 6. The Java Tutorial, Sun Microsystems. Addison-Wesley, 1999 7. C++ Program Design: An introduction to Programming and Object-Oriented Design, 3rd Edition, by Cohoon and Davidson. Tata McGraw Hill. 2003. 8. A First Book of C++, 2nd Ed, by Gary Bronson, Brooks/Cole, Thomson Learning

Course Name	**Calculus**
Course Code	MA 105
Total Credits	8
Type	T
Lecture	3
Tutorial	1
Practical	N
Half Semester	N
Description	Review of limits, continuity, differentiability. Mean value theorem, Taylors Theorem, Maxima and Minima. Riemann integrals, Fundamental theorem of Calculus, Improper integrals, applications to area, volume. Convergence of sequences and series, power series. Partial Derivatives, gradient and directional derivatives, chain rule, maxima and minima, Lagrange multipliers. Double and Triple integration, Jacobian and change of variables formula. Parametrization of curves and surfaces, vector Fields, line and surface integrals. Divergence and curl, Theorems of Green, Gauss, and Stokes.
Text Reference	1. Hughes-Hallett et al., Calculus - Single and Multivariable (3rd Edition), John-Wiley and Sons (2003). 2. James Stewart, Calculus (5th Edition), Thomson (2003). 3. T. M. Apostol, Calculus, Volumes 1 and 2 (2nd Edition), Wiley Eastern 1980. 4. G. B. Thomas and R. L. Finney, Calculus and Analytic Geometry (9th Edition), ISE Reprint, Addison-Wesley, 1998.

Course Name	**Engineering Graphics and Drawing**
Course Code	ME 119
Total Credits	5
Type	L
Lecture	0

Tutorial	1
Practical	3
Half Semester	N
Description	Introduction to engineering drawing and orthographic projections; Projection of points and straight line; Projection of planes and solids; Projection of simple machine elements; Development of surfaces, Intersection of surfaces; Construction of isometric views from orthographic projections.
Text Reference	1. Bhatt N. D. and Panchal V. M., Engineering Drawing, Charotar Publishers, Anand, 2007. 2. Luzadder Warren J. and Duff Jon M., Fundamentals of Engineering Drawing, Prentice Hall of India, 2001. 3. French Thomas E. and Vierck Charles J., Engineering Drawing and Graphic Technology, McGraw Hill, 1993. 4. Jolhe Dhananjay A., Engineering Drawing, Tata McGraw Hill, 2007. 5. Shah M. B. and Rana B. C., Engineering Drawing, Dorling Kindersley (India) Pvt. Ltd, Pearson Education

Course Name	**Quantum Physics and Applications**
Course Code	PH107
Total Credits	6
Type	T
Lecture	2
Tutorial	1
Practical	0
Half Semester	N
Description	Classical equipartition theorem. Kinetic Theory, Concept of degrees of freedom, specific heat, mono - atomic, diatomic gases and solids, Black body radiation, Photoelectric Effect, Compton Scattering Concept of Wave packets: Phase velocity, group velocity, de-Broglie wavelength Experiments demonstrating wave properties of electron : Electron interference (double slit experiment), Electron Diffraction (Davison - Germer experiment) Mathematical interlude: Introduction to Fourier Transforms; Few examples (Step potentials, Gaussian wave packet), leading to concept of Uncertainty relation. Heuristic derivation of Schrodinger Equation. Concept of free particle, particle in a box problem. Finite Square well. Bound vs. unbound states. Superposition principle of eigenstates. Concept of collapse of wave function. Scattering problem. Reflection and Transmission coefficients. A few examples Concept of Quantum Tunneling. Few realistic examples of tunneling, e.g. alpha decay, Scanning Tunneling microscope. Simple Harmonic Oscillator, explanation in 1D (no detailed derivation). Some brief description to 2D and 3D. Concept of degeneracy. Brief overview of Hydrogen atom problem. Introduction to Statistical Physics. Basic intro to classical and quantum particles. Pauli's exclusion principle. Microstates and macro-states. A few examples. Classical (Maxwell-Boltzmann) and Quantum statistics,[Bose Einstein (BE)and Fermi Dirac (FD)]. Derivation of

	classical statistics and give hints to derive BE and FD. Planck's distribution. Free Electron theory. Drude and Sommerfeld Models for specific heat and conductivity. Introduction to Fermi energy, Fermi velocity, Fermi temperature etc. Concept of density of states. Failure of free electron theory. Electrons in periodic potentials. Bloch Theorem. Discuss (no derivation) the solution of Kronig-Penney model. Concept of Band gap. Concept of effective mass. Electron vs. Hole.
Text Reference	1. Quantum Physics of Atoms, Molecules, Solids, Nuclei and Particles, Eisberg and Resnik. 2. Modern Physics, R. A. Serwey, C. J. Moses, C. A. Moyer 3. Introduction to Modern Physics, E. H. Kennard, T. Lauristen, F. K. Richtmyer

Course Name	**Physics Lab**
Course Code	PH 117
Total Credits	3
Type	T
Lecture	0
Tutorial	0
Practical	3
Half Semester	N
Description	1. Laser diffraction 2. Thermal conductivity 3. LCR bridge 4. Determination of e/m of electron 5. Grating Spectrometer 6. Fresnel's Bi-prism 7. Measurement of centrifugal force 8. Torque on a current loop 9. Hydrogen spectrum
Text Reference	1. Lab Manual 2. Advanced Practical Physics, Worsnop and Flint

Course Name	**Biology**
Course Code	BB 101
Total Credits	6
Type	T
Lecture	2
Tutorial	1
Practical	0
Half Semester	N

Description	Quantitative views of modern biology. Importance of illustrations and building quantitative/qualitative models. Role of estimates. Cell size and shape. Temporal scales. Relative time in Biology. Key model systems - a glimpse. Management and transformation of energy in cells. Mathematical view - binding, gene expression and osmotic pressure as examples. Metabolism. Cell communication. Genetics. Eukaryotic genomes. Genetic basis of development. Evolution and diversity. Systems biology and illustrative examples of applications of Engineering in Biology.
Text Reference	Physical Biology of the Cell, R. Phillips, J. Kondev and J. Theriot. Garland science publishers. 2008. 1st edition. Campbell Biology, J. B. Reece, L. A. Urry, M. L. Cain, S. A. Wasserman, P. V. Minorsky, R. B. Jackson. Benjamin Cummings publishers. 2010. 9th edition.

First Year, Second Semester

Course Name	**Introduction to Electronics (Dept. Introductory Course, DIC)**
Course Code	EE 112
Total Credits	6
Type	T
Lecture	2
Tutorial	1
Practical	0
Half Semester	N
Description	Operational Amplifiers, Bipolar Junction Transistors, PN Diodes, and an introduction to digital systems such as Karnaugh maps and Boolean Algebra
Text Reference	Micro-electronics, Sedra and Smith

Course Name	**Linear Algebra**
Course Code	MA 106
Total Credits	4
Type	T
Lecture	2
Tutorial	0
Practical	0
Half Semester	Y
Description	Vectors in Rn, notion of linear independence and dependence, linear span of a set of vectors, vector subspaces of Rn , basis of a vector subspace. Systems of linear equations, matrices and Gauss elimination, row space, null space, and column space, rank of a matrix. Determinants and rank of a matrix in terms of determinants. Abstract vector spaces, linear transformations, matrix of a linear trans-formation, change of basis and similarity, rank-nullity theorem. Inner pro duct spaces, Gram-Schmidt pro cess, orthonormal bases, projections and least squares approximation. Eigenvalues and eigenvectors, characteristic polynomials, eigen values of special matrices (orthogonal, unitary, hermitian, symmetric,

	skew-symmetric, normal). algebraic and geometric multiplicity, diagonalization by similarity transformations, spectral theorem for real symmetric matrices, application to quadratic forms.
Text Reference	1. H. Anton, Elementary linear algebra with applications (8th Edition), John Wiley (1995). 2. G. Strang, Linear algebra and its applications (4th Edition), Thom- son(2006). 3. S. Kumaresan, Linear algebra - A Geometric approach, Prentice Hall of India (2000). 4. E. Kreyszig, Advanced engineering mathematics (8th Edition), John Wiley (1999).

Course Name	**Ordinary Differential Equations : 1**
Course Code	MA 108
Total Credits	4
Type	T
Lecture	2
Tutorial	0
Practical	0
Half Semester	Y
Description	Exact equations, integrating factors and Bernoulli equations. Orthogonal trajectories. Lipschitz condition, Picard's theorem, examples on non-uniqueness. Linear differential equations generalities. Linear dependence and Wronskians. Dimensionality of space of solutions, Abel-Liouville formula. Linear ODEs with constant coefficients, the characteristic equations. Cauchy-Euler equations. Method of undetermined coefficients. Method of variation of parameters. Laplace transform generalities. Shifting theorems.
Text Reference	1. E. Kreyszig, Advanced engineering mathematics (8th Edition), John Wiley (1999). 2. W. E. Boyce and R. DiPrima, Elementary Differential Equations (8th Edition), John Wiley (2005). 3. T. M. Apostol, Calculus, Volume 2 (2nd Edition), Wiley Eastern, 1980.

Course Name	**Workshop**
Course Code	ME 113
Total Credits	4
Type	L (Lab)
Lecture	0
Tutorial	0
Practical	4
Half Semester	N

Description	Introduction to wood work: hand tools & various operations. Introduction to pattern making: types of patterns, allowances, colour coding. etc. Introduction to bench work & fitting: tools & operations. Introduction to metal cutting and machine tools: Safety measures, principles of operation of basic machine tools like lathe, shaping, &drilling. Important operations on these machines. Cutting tools and their usage, selection of cutting speeds, feeds, etc. Introduction to welding. Assignments: Simple assignments in wood working, fitting, electric arc welding, lathe and shaping machine work.
Text Reference	1. Elements of Workshop Technology, Vol. I by S. K. Hajra Choudhury &Others, Media Promoters and Publishers, Mumbai. 14th Edition, 2007. 2. Elements of Workshop Technology, Vol. II by S. K. Hajra Choudhury &Others, Media Promoters and Publishers, Mumbai. 12th Edition, 2007. 3. Workshop Practice by H. S. Bawa, Tata-McGraw Hill, 2004.

Course Name	**Basics of Electricity and Magnetism**
Course Code	PH108
Total Credits	6
Type	T
Lecture	2
Tutorial	1
Practical	0
Half Semester	N
Description	Review of vector calculus: Spherical polar and cylindrical coordinates; gradient, divergence and curl; Divergence and Stokes' theorems; Divergence and curl of electric field, Electric potential, properties of conductors; Poisson's and Laplace's equations, uniqueness theorems, boundary value problems, separation of variables, method of images, multipoles; Polarization and bound charges, Gauss' law in the presence of dielectrics, Electric displacement D and boundary conditions, linear dielectrics; Divergence and curl of magnetic field, Vector potential and its applications; Magnetization, bound currents, Ampere's law in magnetic materials, Magnetic field H, boundary conditions, classification of magnetic materials; Faraday's law in integral and differential forms, Motional emf, Energy in magnetic fields, Displacement current, Maxwell's equations, Electromagnetic (EM) waves in vacuum and media, Energy and momentum of EM waves, Poynting's theorem;

	Reflection and transmission of EM waves across linear media.
Text Reference	1. Introduction to Electrodynamics (3rd ed.), David J. Griffiths, Prentice Hall, 2011. 2. Classical Electromagnetism, J. Franklin, Pearson Education, 2005. 3. Electricity and Magnetism, E. M. Purcell and D. J. Morrin
Course Name	**Chemistry Lab**
Course Code	CH 117
Total Credits	3
Type	T
Lecture	0
Tutorial	0
Practical	3
Half Semester	N
Description	1. Electrochemical Cell (A) To measure the standard electrode potential of Zn2+ / Zn couple. (B) To determine the concentration of Fe2+ by potentiometric titration. 2. Chemical kinetics To determine the rate constant for the inversion of sucrose using a polarimeter. 3. Estimation of Iron To estimate the amount of ferrous and ferric ion in a solution containing both. 4. Oscillatory Chemical Reactions a) To introduce the students to a fascinating example of an oscillating chemical reaction. b) To introduce the concept of non-equilibrium thermodynamics. c) To speculate on the possible causes and applications of oscillating chemical phenomena. 5. Electrolytic Conductance (A) To determine the ionization constant of weak monobasic acid. (B) To determine the solubility of a sparingly soluble salt. 6. Colorimetric Analysis To determine the equilibrium constant of a reaction with the help of a colorimeter. 7. Complexometric Titration Determination of total hardness of water using complexometric titration with Ethylenediaminetetraacetic Acid (EDTA). 8. Thin Layer Chromatography (A) To prepare a fluorescent dye in microscale using a one pot sequential amide formation – nucleophilic aromatic substitution reactions. (B) To understand the principles and application of Thin Layer

	Chromatography. (C) Analysis of TLC using ‘ImageJ’.
Text Reference	1. Lab Manual

Second Year, First Semester

Course Name	**Introduction to Special Theory of Relativity**
Course Code	PH 207
Total Credits	3
Type	T (half semester)
Lecture	2
Tutorial	1
Practical	0
Half Semester	Y
Description	Problems with Classical Physics, Postulates of Special Theory of Relativity, Galilean and Lorentz transformations, Examples of length contraction and time dilation. Velocity Transformation, Relative velocity. Space-like and Time-like intervals. Concept of causality. Doppler effect in special relativity. Need to redefine momentum. Minkowski space. Four vectors and four scalars. Proper time interval as a four scalar. Velocity and Momentum-Energy Four Vectors. New definitions of momentum and Energy, Momentum Energy Transformation. Concept of zero rest mass particle. Transverse and longitudinal Doppler Effect. Problems involving L- frame and C-frame. Force in relativity. Newton’s second law in relativity. Equation of motion in special cases when force is along and perpendicular to the instantaneous direction of velocity and of motion in one dimension. Force four vector and transformation of force. Elementary idea of transformation of electric and magnetic fields and current density four vector.
Text Reference	1. Introduction to Special Relativity: R. Resnick, John Wiley 2002, 2nd edition. 2. An Introduction to Mechanics: D. Kleppner and R.J. Kolenkow, Tata McGraw Hill 2007, 1st edition. 3. Introduction to Modern Physics: Mani and Mehta, East-West Press Pvt. Ltd. New Delhi2000, 1st edition. 4. Elements of Modern Physics: S. H. Patil, Tata McGraw Hill, 1984.

Course Name	**Thermal Physics**
Course Code	PH 215
Total Credits	3
Type	T (half semester)
Lecture	2
Tutorial	1
Practical	0

Half Semester	Y
Description	Thermal equilibrium, zeroth law and concept of temperature. First law and its consequences, reversible, irreversible and quasi-static processes. Second law: heat engines, concept of entropy and its statistical interpretation. Thermodynamic potentials, Maxwell's relations. Joule Kelvin effect. Phase transitions, order of phase transitions, order parameter, critical exponents and the Clausius-Clapeyron equation. Applications to magnetism, superfluidity and superconductivity.
Text Reference	1. An Introduction to Thermal Physics: D.V. Schroeder, Addison Wesley 1999, 2nd Edition. 2. Heat and Thermodynamics: M.W.Zemansky and R.H.Dittman, McGraw Hill 1997, 7th edition. 3.Equilibrium Thermodynamics: C.J.Adkins, Cambridge University Press, 1983, 3rd edition.

Course Name	**Classical Mechanics**
Course Code	PH 217
Total Credits	6
Type	T
Lecture	2
Tutorial	1
Practical	0
Half Semester	N
Description	Review of Newton`s laws of motion, frames of reference, rotating frames, centrifugal and Coriolis forces. Free and constrained motion, D`Alemberts principle and Lagrange`s equation of first kind. Lagrangian formulation, Hamilton's equation of motion. Variational principles. Canonical transformation and Poisson Bracket. Hamilton Jacobi theory and action angle variables.Periodic motion, small oscillations, normal coordinates, Central force, Kepler`s Laws and Rutherford scattering.
Text Reference	1. H. Goldstein, Classical Mechanics, Addison Wesley 1980 2. N. C. Rana and P. S. Joag, Classical Mechanics, Tata McGraw Hill 1991 3. L. D. Landau and E. M. Lifshitz, Pergamon Press 1960 4. V. I. Arnold, Mathematical Methods of Classical Mechanics, Springer Verlag 1981 5. S. N. Biswas, Classical Mechanics 1998

Course Name	**Economics**
Course Code	HS 101
Total Credits	6
Type	T
Lecture	3
Tutorial	0
Practical	0

Half Semester	N
Description	Basic economic problems. resource constraints and Welfare maximizations. Nature of Economics: Positive and normative economics; Micro and macroeconomics, Basic concepts in economics. The role of the State in economic activity; market and government failures; New Economic Policy in India. Theory of utility and consumer's choice. Theories of demand, supply and market equilibrium. Theories of firm, production and costs. Market structures. Perfect and imperfect competition, oligopoly, monopoly. An overview of macroeconomics, measurement and determination of national income. Consumption, savings, and investments. Commercial and central banking. Relationship between money, output and prices. Inflation - causes, consequences and remedies. International trade, foreign exchange and balance payments, stabilization policies : Monetary, Fiscal and Exchange rate policies.
Text Reference	1. P. A. Samuelson & W. D. Nordhaus, Economics, McGraw Hill, NY, 1995. 2. A. Koutsoyiannis, Modern Microeconomics, Macmillan, 1975. 3. R. Pindyck and D. L. Rubinfeld, Microeconomics, Macmillan publishing company, NY, 1989. 4. R. J. Gordon, Macroeconomics 4th edition, Little Brown and Co., Boston, 1987. 5. William F. Shughart II, The Organization of Industry, Richard D. Irwin, Illinois, 1990.

Course Name	**Data Analysis and Interpretation**
Course Code	PH 219
Total Credits	6
Type	T
Lecture	2
Tutorial	1
Practical	0
Half Semester	N
Description	Probability: Probability distributions with continuous and discrete outcomes, Moments and moment generating function, transformation of variables, multivariate probability densities, contour plots, common distribution functions Errors: Error assignment, statistical and systematic errors, error propagation, error correlations Parameter Inference: Bayesian vs. Frequentist statistics, likelihood function and its properties, likelihood ratio for hypothesis comparison, maximum likelihood estimator Hypothesis testing: Test statistic, chi-squared test, p-values

	Course involves several programming assignments to gain familiarity with various kinds of plots and histograms, error estimation, curve fitting and parameter extraction.
Text Reference	1. Gerhard Bohm, Günter Zech, Introduction to Statistics and Data Analysis for Physicists

Course Name	**Complex Analysis**
Course Code	MA 205
Total Credits	4
Type	T
Lecture	3
Tutorial	1
Practical	N
Half Semester	Y
Description	Definition and properties of analytic functions. Cauchy-Riemann equations, harmonic functions. Power series and their properties. Elementary functions. Cauchy's theorem and its applications. Taylor series and Laurent expansions. Residues and the Cauchy residue formula. Evaluation of improper integrals. Conformal mappings. Inversion of Laplace transforms.
Text Reference	1. R. V. Churchill and J. W. Brown, Complex variables and applications (7th Edition), McGraw-Hill (2003). 2. J. M. Howie, Complex analysis, Springer-Verlag (2004). 3. M. J. Ablowitz and A. S. Fokas, Complex Variables- Introduction and Applications, Cambridge University Press, 1998 (Indian Edition) 4. E. Kreyszig, Advanced engineering mathematics (8th Edition), John Wiley (1999).

Course Name	**Ordinary Differential Equations II**
Course Code	MA 207
Total Credits	4
Type	T
Lecture	3
Tutorial	1
Practical	N
Half Semester	Y
Description	Review of power series and series solutions of ODEs. Legendre's equation and Legendre polynomials. Regular and irregular singular points, method of Frobenius. Bessel's equation and Bessel's functions. Sturm-Liouville problems. Fourier series. D'alembert solution to the wave equation. Classification of linear second order PDE in two variables. Laplace, Wave, and Heat equations using separation of variables. Vibration of a circular membrane. Heat equation in the half space.

Text Reference	1. E. Kreyszig, Advanced engineering mathematics (8th Edition), John Wiley (1999). 2. W. E. Boyce and R. DiPrima, Elementary Differential Equations (8th Edition), John Wiley (2005). 3. R. V. Churchill and J. W. Brown, Fourier series and boundary value problems (7th Edition), McGraw-Hill (2006).

Course Name	**Electronics Lab I : Basic Circuits**
Course Code	PH 231
Total Credits	3
Type	L
Lecture	0
Tutorial	0
Practical	3
Half Semester	N
Description	Lab 0 - Introduction to electronics instrumentation Lab 1 – Basic Electronics Lab 2 – Active electronic elements : DIODE Lab 3 : I/V characteristics Lab 4: Transistor I-V characteristics Lab 5: Common Emitter Amplifier Lab 6 : CE amplifier improved with feedback Lab 7: Emitter Follower as a transistor current amplifier Lab 8(A): Push-pull amplifier Lab 8(B) : Push-pull amplifier (advanced) Laboratory 9: Current mirrors
Text Reference	Lab manual

Course Name	**Electronics Lab II : Analog Circuits**
Course Code	PH 233
Total Credits	3
Type	L
Lecture	0
Tutorial	0
Practical	3
Half Semester	N
Description	Lab 1: Introduction to Opamps Lab 2: Positive feedback – Schmitt Trigger Lab 3: Negative Feedback in Opamps Lab 4: Filters: Passive, Active and Oscillating Lab 5: Instrumentation amplifier Lab 6: LockinAmplifier A

	Lab 7: Lockin amplifier Part B: application in a physics experiment Lab 8: Power transfer (DC/AC) and Reflectometry
Text Reference	Lab manual

Second Year, Second Semester

Course Name	**Digital Systems**
Course Code	EE 224
Total Credits	6
Type	T
Lecture	2
Tutorial	1
Practical	0
Half Semester	N
Description	The course contents included Boolean Algebra, Combinational Logic, Sequential Logic design, Memories and Timing Analysis.
Text Reference	1. Switching and FiniteAutomata Theory by ZviKohavi

Course Name	**Waves, Oscillations and Optics**
Course Code	PH 202
Total Credits	6
Type	T
Lecture	2
Tutorial	1
Practical	0
Half Semester	N
Description	Waves & Oscillations: Simple Harmonic motion, damped SHM, critical damping, Sustaining oscillations in a damped oscillator. Driven oscillation, resonance, damped-driven oscillator and its resonance, Q-factor, Vanderpol oscillator, non-linear feedback for sustained oscillations. SHM in 2-dim, dependence on initial conditions, Lissajous figures, condition for closed orbits, SHM in 3-dim. Oscillations of two particle systems, symmetric and asymmetric modes, general solution to the problem. Driven oscillations of two particle system. Oscillations of \`n\` particle systems, normal modes, Formulation of the general problem, eigenvalues and eigenvectors of normal modes, general solution for arbitrary initial conditions. Driven oscillations. Example of a linear triatomic molecule. Longitudinal and transverse oscillations, modding out the zero frequencies. Oscillations of a chain of \`n\` atoms. Continuum limit, vibrational modes of a string of constant density. Equation of Motion for waves, Standing waves and travelling waves in 1 dimensions. Properties of waves in two and three dimensions Harmonics, Linear superposition of harmonics, odd harmonics, construction of pulse shapes. Fourier components of a periodic pulse, Fourier

	analysis and Fourier coefficients. Fourier analysis of arbitrary functions, Fourier Coefficients, Properties of Fourier transform. Electromagnetic wave description of light, waves in vacuum,plane waves,polarization(stokes parameters), confined waves,Gaussian wave propagation,diffraction free beams, waves in isotropic media, optical response of media, Lorentz and Drude models, dispersion and absorption,wave propagation in uniaxial media, Reflection and refraction,Fresnel`s equations and their consequences. Interference,Fabry-Perot and Michelson interferometers, interference coatings,Spatial and temporal coherence,introduction to Fourier transforms,convolution theorem, Fourier transform spectroscopy, optical coherence tomography, Fraunhofer diffraction, diffraction gratings and their uses, Fabri-Perot resonator with gain, stimulated emission,lasers and holography.
Text Reference	1. Berkeley Physics Course (Vol 3) 2. Waves by Frank S. Crawford 3. Introduction to Mechanics by D. Kleppner and R. J. Kolenkow (for topics 1 and 2) 4. Introduction to Non-linear Dynamics by Steven Strogatz (for topics 3) 5. Mechanics, Landau and Lifshitz (for topics 4 to 7) 6. Mathematical Methods for Physicists, G. Arfken and Weber (for topics 11 to 13) 7. Optics, Principles and applications , K. K.Sharma, Elsevier(2006) 8. Optics, M.V.Klein and T.E. Furtak, Wiley(1986) 9. Principles of Optics, M. Born and E. Wolf, McMillan,1974. 10. Introduction to Modern Optics, G. B. Fowles, , Dover, 1975.

Course Name	**Quantum Mechanics 1**
Course Code	PH 204
Total Credits	8
Type	T
Lecture	3
Tutorial	1
Practical	0
Half Semester	N
Description	Review quantum ideas using wavefunction formalism; Linear vectorspaces and Dirac bra(ket) notation; Operators, state vector approach ofharmonic oscillator; Hydrogen atom; angular momentum, spin, addition ofangular momentum, Clebsch-Gordan coefficients.
Text Reference	1. Principles of Quantum Mechanics, R. Shankar, 2. Introduction to Quantum Mechanics by Griffiths, Modern Quantum 3. Mechanics, J. J. Sakurai 4. Quantum Mechanics by C. Cohen-Tannoudji and F. Lalo ̈e for reference material.

	5. L. D. Landau and E. M. Lifshitz, Pergamon Press 1965

Course Name	**Introduction to Numerical Analysis**
Course Code	MA 214
Total Credits	8
Type	T
Lecture	3
Tutorial	1
Practical	0
Half Semester	N
Description	Interpolation by polynomials, divided differences, error of the interpolating polynomial, piecewise linear and cubic spline interpolation.Numerical integration, composite rules, error formulae.Solution of a system of linear equations, implementation of Gaussianelimination and Gaussseidel methods, partial pivoting, row echelonform, LU factorization Cholesky's method, ill-conditioning, norms.solution of a nonlinear equation, bisection and secant methods.Newton's method, rate of convergence, solution of a system of nonlinear equations, numerical solution of ordinary differential equations, Euler and Runge-Kutta methods, multi-step methods, predictor-correctormethods, order of convergence, finite difference methods, numericalsolutions of elliptic, parabolic, and hyperbolic partial differential equations.Eigenvalue problem, power method, QR method, Gershgorin's theorem.Exposure to software packages like IMSL subroutines, MATLAB.
Text Reference	1. S. D. Conte and Carl de Bo or, Elementary Numerical Analysis- An Algorithmic Approach (3rd Edition), McGraw-Hill, 1980. 2. C. E. Froberg, Introduction to Numerical Analysis (2nd Edition), Addison-Wesley, 1981. 3. E. Kreyszig, Advanced engineering mathematics (8th Edition), John Wiley (1999).

Course Name	**Electronics Lab III (Digital Electronics)**
Course code	PH 230
Total Credits	5
Type	L
Lecture	1
Tutorial	0
Practical	3
Half Semester	N
Prerequisite	

Description	Introduction to Digital electronics: Ring Oscillator Combinational to sequential circuits Sequential circuits: Memory and feedback Multi-vibrators using IC 555 Advanced Finite State machines Storage of n-bits and feedback in sequential circuits Basics of FPGA and Installation guidelines of FPGA IDE FPGA based project work
Text Reference	Lab manual

Course Name	**General Physics Lab**
Course Code	PH 232
Total Credits	3
Type	L
Lecture	0
Tutorial	0
Practical	3
Half Semester	N
Description	1. Photoelectric Effect 2. Frank-Hertz Experiment 3. Elastic Constant by Cornu's Method 4. Dielectric Constant 5. Viscosity by Stokes' Method 6. Thermal conductivity by Forbes' Method 7. Magnetic Susceptibility Gouy's Method 8. Potential Energy of a Magnet
Text Reference	Lab manual

Third Year, First Semester

Course Name	**Photonics**
Course Code	PH 421
Total Credits	6
Type	T
Lecture	2
Tutorial	1
Practical	0
Selfstudy	0
Half Semester	N
Prerequisite	Nil

Description	Non-linear optical response of the medium, origin of the optical non-linearities (second and third order susceptibilities), classical and quantum pictures, a synopsis of nonlinear optical processes. Electromagnetic wave propagation in nonlinear medium, coupled wave equations for three wave mixing, Manley-Rowe relation, second harmonic generation- weak and strong coupling regimes, phase matching considerations, birefringence phase matching, harmonic generation with focused Gaussian beams, Difference frequency generation, optical parametric generation, optical parametric oscillators and amplifies. Third order nonlinear optical processes, four wave mixing, intensity dependent refractive index, self focusing, degenerate four wave mixing and its applications, optical bi-stability and optical logic, stimulated Raman and Brillouin scatterings, Raman gain amplifiers, plasmonics and applications Photonic crystals- an introduction to their band structure, nonlinear optical processes such as SHG and optical bi-stability in photonic crystals and applications.
Text Reference	1. R. Menzel, Photonics-linear and nonlinear interactions of laser light and matter, Springer Verlag, 2001 2. R. W. Boyd, Nonlinear optics, academic press, 2003 3. Saleh and Teich, Fundamental of Photonics, John Wiely 1991 4. S. L. Chuang, Physics of Photonics Devices, Wiley 2009 5. Silfvast, Laser fundamentals, Cambridge Univ. press 2004 6. K.K.Sharma, Optics, Principles and applications, Elsevier 2006 7. M.V.Klein and T. E.Furtak , Optics, Wiley 1986 8. M. Born and E. Wolf, Principles of Optics, McMillan,1974. 9. J.D.Jackson, Electrodynamics (Chapter 7) 10. G. B. Fowles, Introduction to Modern Optics, Dover, 1975.

Course Name	**Quantum Mechanics II**
Course code	PH 423
Total Credits	6
Type	T
Lecture	2
Tutorial	1
Practical	0
Half Semester	N
Prerequisite	Nil
Description	Recap of angular momentum, Clebsch-Gordan coefficients, tensor operators, Wigner-Eckart theorem; Approximation methods - variational principle, WKB method, time-independent and time dependent perturbation theory; Scattering theory- Born approximation, partial wave analysis; relativistic quantum mechanics- Klein-Gordan equation and Dirac equation and their solutions.

Text Reference	1. Principles of Quantum Mechanics by R. Shankar, 2. Introduction to Quantum Mechanics by Griffiths, 3. Modern Quantum Mechanics by J. J. Sakurai 4. Quantum Mechanics by C. Cohen-Tannoudji and F. Lalo ̈e for reference material. 5. L. D. Landau and E. M. Lifshitz, Pergamon Press 1965 6. W. Greiner, Quantum Mechanics: An introduction

Course Name	**Institute Elective/ Open Elective 1**
Course code	
Total Credits	6
Type	T
Lecture	2
Tutorial	1
Practical	0
Half Semester	N

Course Name	**HSS Core Course**
Course code	
Total Credits	6
Type	T
Lecture	2
Tutorial	1
Practical	0
Half Semester	N
Prerequisite	
Description	
Text Reference	

Course Name	**HSS Core Course**
Course code	
Total Credits	6
Type	T
Lecture	2
Tutorial	1
Practical	0

Half Semester	N
Prerequisite	
Description	
Text Reference	

Course Name	**Electronics Lab IV (Microprocessors)**
Course code	PH 435
Total Credits	5
Type	L
Lecture	1
Tutorial	0
Practical	3
Half Semester	N
Prerequisite	Nil
Description	Introduction to Arduino: "Hello World" Analog output from Arduino and its post processing Handling Interrupts in Arduino Implementing Feedback control system using PID Project work
Text Reference	Lab manual

Third Year, Second Semester

Course Name	**Department Elective I**
Course code	
Total Credits	6
Type	T
Lecture	2
Tutorial	1
Practical	0
Half Semester	N

Course Name	**Introduction to Renewable Energy Technologies**

Course code	EN 301
Total Credits	6
Type	T
Lecture	2
Tutorial	1
Practical	0
Half Semester	N
Prerequisite	Nil
Description	Introduction to world energy scenario, Renewable energy resources, Radiation, Solar Geometry, radiation models; Solar Thermal, Optical efficiency, thermal efficiency, concentrators, testing procedures, introduction to thermal systems (flat plate collector), solar architecture, solar still, air heater, panel systems; Photovoltaic; Introduction to semiconductor physics, doping, p-n junction, Solar cell and its I-V characteristics, PV systems components, design of a solar PV systems. Biomass, Biomass resources, wood composition, pyrolysis, gasifiers, biogas, biodiesel, ethanol; Wind, Introduction, types of wind machines, Cp-l curve &betz limits, wind recourse analysis; Systems, stand alone, grid connected, hybrid, system design; Hydro systems, Hydro resources, types of hydro turbine, small hydro systems; Other systems, Geothermal, wave energy, ocean energy.
Text Reference	1. S. P. Sukhatme, Solar Energy - Principles of thermal collection and storage, second edition, Tata McGraw-Hill, New Delhi, 1996 2. J. A. Duffie and W. A. Beckman, Solar Engineering of Thermal Processes, second edition, John Wiley, New York, 1991 3. D. Y. Goswami, F. Kreith and J. F. Kreider, Principles of Solar Engineering, Taylor and Francis, Philadelphia, 2000 4. D. D. Hall and R. P. Grover, Biomass Regenerable Energy, John Wiley, New York, 1987. 5. J. Twidell and T. Weir, Renewable Energy Resources, E & F N Spon Ltd, London, 1986. 6. M. A. Green, Solar Cells, Prentice-Hall, Englewood Cliffs, 1982.

Course Name	**Introduction to Condensed Matter Physics**
Course Code	PH 436
Total Credits	6
Type	T
Lecture	2
Tutorial	0
Practical	1
Selfstudy	0

Half Semester	N
Prerequisite	Nil
Description	Crystal structures, reciprocal lattice, X-ray and electron diffraction. Lattice vibrations, Einstein and Debye models, phonons. Drude and Sommerfeld models. Bloch theorem, Empty lattice and nearly free electron model, tight-binding model, Density of states and Fermi surfaces. Semi classical model of electron dynamics. Concept of Effective mass.
Text Reference	1. N. Ashcroft and N.D. Mermin, Solid state physics 2. C. Kittel, Introduction to solid state physics, 7th ed., John Wiley 1997. 3. J. R. Christman, Fundamentals of Solid State Physics. John Wiley 1988 4. Ibach and Luth, Solid State Physics, Springer Verlag 2009

Course Name	**Statistical Physics**
Course Code	PH 438
Total Credits	6
Type	L
Lecture	2
Tutorial	1
Practical	0
Selfstudy	0
Half Semester	N
Prerequisite	Nil
Description	1)Random walk, gaussian statistics and diffusion.2) Statistical ensembles: a) phase space, ergodicity, microcanonical ensemble, Liouville`s theorem, Ideal-gas. b)canonical ensemble, partition function c)grand-canonical ensemble,equivalence of ensembles, 3) Quantum statistical Mechanics: density matrix, Boltzmann, Bose & Fermi statistics.4) Fermi gas: high and low temp limits, electrons in magnetic field, para and diamagnetism.5) Bose gas: black body radiation, phonons, B.E. condensation.
Text Reference	1. K. Huang, Statistical Mechanics, John Wiley 1987 2. R. K. Pathria, Statistical Mechanics, Butterworth Heinemann 1996 3. J. Bhattacharjee, Statistical mechanics, Allied Publishers 1996

Course Code:	PH 444
Title:	**Electromagnetic Theory**
Credits:	6
Pre-requisite:	Nil

Description:	Poisson's and Laplace's Equations, Green's Theorem, Green's Function and boundary value problems with spherical harmonics and Bessel functions, Multipole Expansion up to quadrupole moment, Maxwell's Equations (recap), Continuity Equation, Poynting Theorem, Newton's 3rd law in ED, Maxwell's stress tensor, Conservation of linear and angular momentum, Potential formulation of ED, 4D-Poisson's equation, Time dependent Green's function and Jefimenko's equations, Lienard-Wiechert Potential and EM fields, Electric Dipole radiation, Larmor's formula, Bremsstrahlung, Synchrotron, Cerenkov radiation.
Text/Reference	1. J. D. Jackson, Classical Electrodynamics, John Wiley and Sons 1998 2. Lecture notes, book by A. Zangwill (Modern Electrodynamics) 3. D. J. Griffiths (Introduction to Electrodynamics) References for specific topics: 1. Classical Electrodynamics by Julian Schwinger, L. L. De Raad Jr., K. A. Milton, and W. Tsai (Green's function, Gauge Transformations, Retarded Green's function) 2. Matrices and Tensors in Physics by A. W. Joshi (Special Relativity) 3. The Elements of Mathematical Physics by V. Balakrishnan (Green's Function)

Course Name	**Physics Lab (Solid State Physics and Nuclear Physics)**
Course Code	PH 446
Total Credits	3
Type	L
Lecture	3
Tutorial	3
Practical	0
Selfstudy	0
Half Semester	N
Prerequisite	Nil
Description	**SSP:** 1) g value using ESR spectrometer, 2) spin-lattice relaxation time using NMR spectrometer, 3) energy gap of a semiconductor using four-probe method, 4) carrier concentration using Hall measurement, 5) wave length of microwaves. **NP:** 1) Absorption coefficient of gamma-rays in Aluminium. 2) Low and high counting statistics using G. M. Counter. 3) Gamma-ray spectrometry using NaI(Tl) scintillator.

	4) Compton scattering of gamma-ray using 137Cs source. 5) Coincident study of annihilation photons using 22Na source. 6) Rutherford scattering of alpha particles in gold.
Text Reference	Lab manuals of SSP and NP.

Fourth Year, First Semester

Course Name	**Introduction to Atomic and Molecular Physics**
Course code	PH 515
Total Credits	6
Type	T
Lecture	2
Tutorial	1
Practical	0
Half Semester	N
Prerequisite	Nil
Description	***Review of one and two-electron atoms***: Relativistic effects (spin orbit, mass-velocity and Darwin terms) in hydrogen and hydrogenic atoms, Lamb shift, ground and excited states of helium, shell structure of alkalis, quantum defect, Rydberg levels. ***Basics of spectroscopy***: Absorption and emission of photons, Transition probabilities and cross-sections, Lifetime, Line broadening mechanisms, Homogenous and in-homogenous broadening. ***Many electron atoms***: Central field approximation, coupled and uncoupled representations, L-S and j-j coupling schemes, Selection rules, Zeeman and Paschen-Back effects, Hyperfine interaction (magnetic dipole and electric quadrupole interactions), Isotope shift (mass shift and volume shift). ***Molecular structure***: Born-Oppenheimer approximation, Rotational structure of diatomic molecules and extension to linear, symmetric/spherical top molecules, vibrational structure of diatomic molecules and extension to triatomic molecules, Rotational-vibrational spectrum of diatomic molecules, Electronic structure of diatomic molecules and extension to simple polyatomic molecules, Selection rules for rotational, vibrational and electronic transitions, Franck-Condon principle, Raman effect. ***Experimental techniques in atomic and molecular physics***: Absorption, Fluorescence, Raman, Two-photon, Doppler-limited and Doppler-free spectroscopy, X-ray and photoelectron spectroscopy, Cooling and trapping of atoms/ions.
Text Reference	1. Atomic Physics by C.J. Foot, Oxford Master Series in Physics, Oxford University Press (2005). 2. Atoms, Molecules and Photons: An Introduction to Atomic-, Molecular- and Quantum Physics by Wolfgang Demtröder, Springer (2010). 3. Fundamentals of Molecular Spectroscopy by C.N. Banwell and E.M. McCash, Tata-McGraw-Hill (1995). 4. Spectra of Atoms and Molecules by Peter F. Bernath, Oxford University Press (2005).

	5. Physics of atoms and molecules, Bransden and Joachain, Pearson 2003

Course Name	**Introduction to Nuclear and Particle Physics**
Course code	PH 505
Total Credits	6
Type	T
Lecture	2
Tutorial	1
Practical	0
Half Semester	N
Prerequisite	Nil
Description	Basic properties of nuclei and interactions, Nuclear binding energy, Nuclear moments, Nuclear models- independent particle model, shell model, Deuteron problem, Central and tensor forces, Radioactive decay-theory of alpha decay, Fermi theory of beta decay, gamma decay, Nuclear reactions- direct and compound reactions, Elementary particles- classification, symmetries and conserved quantum numbers, quark model
Text Reference	1. S S M Wong, Introductory Nuclear Physics, 2nd Edition, Wiley-VCH Verlag GmbH & Co. 2. B L Cohen, Concepts Of Nuclear Physics, Mc Graw Hill 3. H A Enge, Introduction to Nuclear Physics Addison-Wesley 4. J S Lilley, Nuclear Physics: Principles and Applications, John Wiley and Sons 5. K Hyde, Basic ideas and concepts in nuclear physics, CRC Press 6. W E Burcham, Nuclear and Particle Physics, Addison Wesley 7. G Kane, Modern Elementary Particle Physics, Westview Press 8. D J Griffiths, Introduction to Elementary Particles, John Wiley and Sons

Course Name	**Methods in Analytical Techniques**
Course code	PH 517
Total Credits	6
Type	T
Lecture	2
Tutorial	0
Practical	2
Half Semester	N
Prerequisite	Nil

Description	Structure and Microstructure analysis by X-ray and electron diffraction, transmission and scanning electron microscopy techniques. Study of molecular structure by resonance techniques like Nuclear magnetic resonance (NMR), Fourier transform NMR (FTNMR) and Electron spin resonance (ESR). Study of molecular structure by Infrared (IR), Fourier transform IR (FTIR) and Raman spectroscopies. Study of electronic structure by Photoelectron Spectroscopy and X-ray absorption techniques. Composition analysis by Energy dispersive X-ray (EDX), Auger Electron Spectroscopy (AES) and Secondary ion mass spectrometry (SIMS). Study of surface morphology and structure by Scanning tunneling and Atomic Force microscopies (STM, AFM). Study of magnetic thin films by Ferromagnetic resonance, vibrating sample and torque magnetometry and Magnetic force microscopy.
Text Reference	1. R.S. Drago, Physical methods, 2nd ed., Saunders College Publishing, 1992. 2. B.G.Yacobi, D.B.Holt and L.L.Kazmerski, Microanalysis of Solids, Plenum Press, 1994.

Course Name	**Physics Lab (Optics and Spectroscopy)**
Course code	PH 447
Total Credits	3
Type	L
Lecture	0
Tutorial	0
Practical	3
Half Semester	N
Prerequisite	Nil
Description	**Optics** Spatial Filtering Spatial Coherence Mach-Zehnder Interferometer Nonlinear Optics / Z Scan CdS Nanoparticles (Theory) **Spectroscopy** Spin Orbit Coupling of Cu

	Absorption Spectrum of Iodine Rotation Spectrum of CN
Text Reference	Lab manuals

Course Name	**Institute Elective II**
Course code	
Total Credits	6
Type	T
Lecture	2
Tutorial	1
Practical	0
Half Semester	N

Course Name	**Department Elective II or BTP-1**
Course code	
Total Credits	6
Type	T
Lecture	2
Tutorial	1
Practical	0
Half Semester	N
Prerequisite	

Fourth Year, Second Semester

Course Name	**Physics of Quantum Devices**
Course code	PH 536
Total Credits	6
Type	T
Lecture	2
Tutorial	1

Practical	0
Half Semester	N
Prerequisite	Nil
Description	Introduction: Length and timescales, quantum and semi-classical regimes. Basics of Semiconductors: band structure, effective mass, carrier statistics Junctions: formation of p-n junctions, I-V characteristics, tunnel diodes, p-i-n diodes, p-i-n-i-p.....superlattice structures, semiconductor heterostructures, growth issues, band alignment, interfacial 2DEG formation, self-consistent Schrodinger Eq. and Poisson Eq. Solution. DOS in 2D, 1D and 0D Transport: Diffusion equations, Boltzmann transport equations, scattering mechanisms, calculation of mobility, carrier dynamics under illumination condition, Generation and recombination of carriers rate equations, different recombination processes MOSFETs: MIS structures, C-V characteristics, MOSFET Band diagram, operation regimes, surface charge density, surface potential, charge and field distribution, principle of operation of MOSFETs, Current-Voltage characteristics. Single Electron Transistors: SET structure, Equivalent circuit, coulomb blocked effect, coulomb diamond, Current-Voltage characteristics. Optoelectronic devices: Semiconductor under EM field, absorption, reflection, refraction, transmission, basic operation principle of Solar cell, Quantum well LEDs and Laser diodes (LDs).
Text Reference	1. Physics of semiconductor devices, Michael Shur (Prentice-Hall) 2. Quantum Heterostructures: Microelectronics and Optoelectronics, V. V. Mitin, V. A. Kochelap and M. A. Stroscio (Cambridge) 3. Physics of Low dimensional Semiconductors : An Introduction. J.H. Davies 4. Electron Transport in Mesoscopic Systems: Supriyo Dutta. 5. Quantum Heterostructures, Vladimir Mitin, ViacheslavKochelap, Michael A. Stroscio 6. Nanotechnology (AIP Press: edited by Gregory Timp) 7. Superconducting devices : Ruggerio& Rudman

Course Name	**Physics of Semiconductor Devices (in place of Phys. of Quantum Devices)**
Course code	PH 574
Total Credits	6
Type	T
Lecture	2
Tutorial	1
Practical	0
Half Semester	N
Prerequisite	Nil

Description	**Basics of Semiconductors:** Brief review of Band structure. Band diagram of few important semiconductors: Si, Ge, GaAs, GaN, constant energy surface, density of states, effective mass, different directions in the Brillouin zone and their common names. Direct and indirect gaps. **Doping**: Hydrogenic impurity model in detail (show how to construct impurity wave function using the band wave functions as the basis.) shallow and deep donors, Probability of Ionisation of a dopant (Saha ionization equation) Fermi level, Intrinsic, extrinsic and compensated semiconductors, carrier statistics, carrier density product $np = n_i^2$ [How does one experimentally measure donor level positions?] **Boltzmann transport equation,** Mobility, drift, diffusion, electrochemical potential and its difference with electrostatic potential. Discuss clearly the questions like what does a voltmeter actually measure. **Band-bending and band discontinuity at the interface:** Poisson-Boltzmann formulation: Metal-semiconductor junctions, Schottky and Ohmic contacts, p-n junction, derivation of forward and reverse bias I-V equation, tunnel diodes (NDR region and its use in oscillator circuits), Gunn effect, p-i-n structures. BJTs (with band diagrams under bias), Triac/SCR, Metal-insulator-semiconductor (MIS) structures. **Field effect devices:** JFET, MOSFET Band diagram, operation regimes, principle of operation of MOSFETs, Basic derivation of the inversion voltage (use Poisson-Boltzmann). current-voltage and capacitance-voltage characteristics of MOSFET, Source-Drain/Transfer characteristics of MOSFET, comparison with BJT's $I_C - V_{CE}$ curves. **Band engineering:** Poisson Schrodinger equation, the envelope function approximation, alloying, strain and polarization charges at interfaces, Modulation doping, Single heterojunction, Quantum wells. Explain why modulation doping gives higher mobility. HEMT devices (GaAs-AlGaAs, GaN-AlGaN) Formation of the 2DEG at the interface, compare with MOSFETs. **Optoelectronic devices:** Carrier statistics under illumination condition, Generation and Recombination of Carriers, Quasi-Fermi levels, photovoltaic Effect, working of Solar Cells, Current-Voltage characteristics. Shockley-Quessar limit. **Light emitting diodes** (LED), Internal Quantum Efficiency, External Quantum Efficiency, How to improve quantum efficiency of LEDs, Laser-diodes.
Text Reference	(i) Solid State Electronic Devices - B. G. Streetman and S. K. Banerjee, Boston : Pearson, 7th edition, 2015 (ii) Physics of Semiconductor Devices -S.M. Sze and K. K. Ng, Wiley- Interscience, 3rd edition, 2006.

	(iii) Semiconductor Physics: An Introduction -K. Seeger, Springer-Verlag, Berlin, 9th edition, 2004. (iv)Physics of semiconductor devices – M. Shur, Prentice/Hall International, 1990 (v) The Physics of Low-dimensional Semiconductors: An Introduction- J. M. Davies, Cambridge University Press, 1997

Course Name	**Environmental Studies**
Course code	HS 200
Total Credits	6
Type	T
Lecture	2
Tutorial	1
Practical	0
Half Semester	N
Prerequisite	
Description	
Text Reference	

Course Name	**Environmental Studies**
Course code	ES 200
Total Credits	6
Type	T
Lecture	2
Tutorial	1
Practical	0
Half Semester	N
Prerequisite	
Description	

Text Reference	

Course Name	**Department Elective III or BTP-II**
Course code	
Total Credits	6
Type	T
Lecture	2
Tutorial	1
Practical	0
Half Semester	N

Course Name	**Institute Elective III**
Course code	
Total Credits	6
Type	T
Lecture	2
Tutorial	1
Practical	0
Half Semester	N

Course Name	**Department Elective IV**
Course code	
Total Credits	6
Type	T
Lecture	2
Tutorial	1
Practical	0

Minor in Engineering Physics

Course Code:	**Classical Mechanics**
Title:	PH 251
Credits:	6

Pre-requisite:	Nil
Description:	Review of Newton's laws of motion. Hamilton's principle, variational method and Lagrange's equations with and without constraints. Central force, Kepler's laws. Hamilton's equations, canonical transformation, Poisson brackets. Periodic motion, small oscillations, normal coordinates. Rigid body dynamics, moment of inertia tensor, Euler equations, motion of asymmetric top. Frames of reference, rotating frames, centrifugal and Coriolis forces.
Text/References:	1. H. Goldstein, Classical Mechanics, Addison Wesley 1980 2. N. C. Rana and P. S. Joag, Classical Mechanics, Tata McGraw Hill 1991 3. S. N. Biswas, Classical Mechanics 1998

Course Name	**Introduction to Quantum Mechanics**
Course Code	PH 252
Total Credits	6
Prerequisite	Nil
Description	Basic Ideas and Origin of Quantum Mechanics, Various Experiments, which led to the birth of Quantum Mechanics, Wave Particle Duality Schrodinger Equation and Interpretation of Wave functions, Elementary Ideas of Operators, Eigenvalue problem, Various boundary value Problems, Bound States, Harmonic Oscillator problem (1-dimension), Derivation of Hermite polynomial. Creation and Annihilation Operators, Higher Dimensional Problems, Degeneracy, Hydrogen atom problem in some detail, Many Body Theory , Going beyond Hydrogen atom problem(Helium, Lithium), Many Body Hamiltonian, Born -Oppenheimer Approximation, Tight - binding Approximations, Few simple problems, Introduction to Hartree and Hartree-Fock Theory. Perturbation Theory (Time independent), Derivation of 1st order and 2nd order correction to eigen energy and eigenstate, Various Problems.
Text Reference	1. Principles of Quantum Mechanics by R. Shankar, 2. Introduction to Quantum Mechanics by Griffiths,

Course Name	**Thermal and Statistical Physics**
Course Code	PH 253
Total Credits	6
Prerequisite	Nil

Description	Review of thermodynamics: notion of equilibrium, equation of state, first and second laws of thermodynamics, thermodynamic potentials and Maxwell`s relations. Phase space, ergodicity, Liouville's theorem, microcanonical, canonical and grand canonical ensembles, Boltzmann statistics and its applications to ideal gas. Bose-Einstein and Fermi-Dirac statistics, and their applications.
Text Reference	1. K. Huang, Statistical Mechanics, 2nd ed., John Wiley, 1987. 2. H.B. Callen, Thermodynamics and an Introduction to Thermostatistics, 2nd edn, John Wiley, 1985 3. F. Reif, Fundamentals of Statistical and Thermal Physics, McGraw Hill, 1965.

Text Reference

Course Code:	**Introduction to Condensed Matter Physics**
Title:	PH 352
Credits:	6
Pre-requisite:	Nil
Description:	Crystal structures, reciprocal lattice, X-ray and electron diffraction. Lattice vibrations, Einstein and Debye models, phonons. Drude and Sommerfeld models. Block theorem, Empty lattice and nearly free electron model, tight-binding model, Density of states and Fermi surfaces. Semi classical model of electron dynamics. Concept of Effective mass.
Text/References:	1. N. Ashcroft and N.D. Mermin, Solid State Physics, Holt Finehart & Winston 1976 2. C. Kittel, Introduction to solid state physics, 7th ed., John Wiley 1997. 3. J.R. Christman, Fundamentals of Solid State Physics. John Wiley 1988

Course Code:	**Light matter Interactions**
Title:	PH 353
Credits:	6
Pre-requisite:	
Description:	Maxwell's equations and propagation of light, Fourier analysis, Lorentz model of optical response, optical response of various natural and artificial materials, metamaterials, photonic crystals, polarization of light, scattering phenomena, lasers, nonlinear light-matter interaction, ultrafast phenomena, strong light-matter interaction, plasmonics, and few applications of light-matter interactions like photovoltaics and optical switching.
Text/References:	1. Optics by Eugene Hecht 2. Introduction to Nonlinear Optics by Robert Boyd 3. Femtosecond Laser Pulses: Principles and Experiments by Claude Rullière

M.Sc.

First Year, First Semester

Course Code:	PH 401
Title:	**Classical Mechanics**
Credits:	8
Pre-requisite:	Nil
Description:	1. A short revision of elementary Newtonian mechanics - Forces, Torques, Rotational motion, Sliding friction, Rolling friction as a constraint, Oscillations of single degrees of freedom, Energy conservation, Energy non-conservation and inelasticity. 2. Lagrangian formalism (i) Generalised Kinetic energy, Potential energy, Symmetries leading to Lagrangian of a free particle in non-relativistic and relativistic mechanics. (ii) Hamilton's principle, Variational method, and Euler-Lagrange equations. (iii) Symmetries and conservation laws — generalised momenta, energy function, and Gauge freedom of Lagrangian. (iv) Lagrangian systems with constraint — Lagrange multipliers, and generalised forces of constraint and virtual work. (v) Particles to fields — derivation of 1-dimensional wave equation, and electromagnetic Lagrangian to Lorentz force law and Maxwell's equations. 3. Coupled Oscillators and small oscillations Lagrangian formulation of linearly coupled systems — normal modes and normal frequencies. Examples. 4. Hamiltonian formulation (i)Derivation of the Hamilton's equations of motion. Hamiltonian of certain systems, specially of a particle in an electromagnetic field. (ii) Phase space flows in second-order autonomous systems. Special case of Classical Hamiltonian systems — comparison to incompressible fluids. Examples of Hamiltonian phase space flows — elliptic and hyperbolic fixed points. (iii) Gauge freedom of the Lagrangian and corresponding changes in the Hamiltonian. 5. Central forces

	(i)Differential and integral equations of orbit. (ii)Conditions for bounded orbits or/and closed orbits. Precession of the axis of ellipse. 6. Canonical Transformations (i)Motivation, condition for canonical transformation, and types of generating functions. (ii) Symplectic criterion for Canonical Transformations. (iii) Infinitesimal Canonical transformations, Generators. (iv) Poisson bracket invariance, and Jacobi's identity. (v) Phase space volume conservation, and Liouville's Theorem. Hamilton's Jacobi equation. Discuss the quantum to classical limit. 7. Rigid bodies (i)Frames of reference — accelerating and rotating frames and pseudo-forces. (ii)Rigid body motion with one point fixed. The orthogonal rotation matrix — its components, determinant, and eigenvalues. Euler's theorem. Finite rotation formula. Infinitesimal rotation matrix, and concept of angular velocity. (iii) Velocity of different points of a rigid body. Motion split into that of the Centre of mass, and about the Centre of mass — angular momentum, and kinetic energy formulas. The inertia tensor. Its components related to the symmetries of the rigid body. Parallel axis theorem. (iv) The body frame, Euler angles and Euler equations. (v) The symmetric top — force and torque free motion, and motion under constant gravity.
Text/References:	6. H. Goldstein, Classical Mechanics, Addison Wesley 1980 7. N. C. Rana and P. S. Joag, Classical Mechanics, Tata McGraw Hill 1991 8. L. D. Landau and E. M. Lifshitz, Pergamon Press 1960 9. V. I. Arnold, Mathematical Methods of Classical Mechanics, Springer Verlag 1981 10. S. N. Biswas, Classical Mechanics 1998 11. Percival & Richards, Introduction to Dynamics, Cambridge

Course Code:	PH 403
Title:	**Quantum Mechanics I**
Credits:	8
Pre-requisite:	Nil
Description:	1. Experimental Motivation, Future of Quantum Mechanics. Axioms of QM. 2. Mathematical Preliminaries: Linear Algebra (esp. trace, partial trace, tensor products. . .), Hilbert Space, Orthogonal Polynomials, Rotations &Unitaries.

	3. Quantum States & Density Matrices. 4. Schr¨odinger's equation, Schr¨odinger's equation for Unitaries, Schr¨odinger, Heisenberg & Interaction Pictures. 5. Simple Problems in One Dimension, Preview of Selection Rules. 6. Harmonic Oscillators, Uncertainty Principle, Ladder Operators. 7. Spin-1/2: Qubit states, Bloch Sphere Representation, Transitions, Rabi Oscillations. . . 8. Coupled Quantum Systems. . . 9. Central Force Problems, Rigid Rotor. . . 10. Hydrogen Atom, Angular Momentum Operators, Addition of Angular Momentum.
Text/References:	1. Principles of Quantum Mechanics, R.Shankar, 2. Introduction to Quantum Mechanics, D. J. Griffiths, 3. Modern Quantum Mechanics, J.J.Sakurai 4. Quantum Mechanics, C. Cohen-Tannoudji and F. Lalo¨e for reference material. 5. L. D. Landau and E. M. Lifshitz, Pergamon Press 1965

Course Code:	PH 405
Title:	**Electronics**
Credits:	6
Pre-requisite:	Nil
Description:	Semiconductor basics, diodes, transistors, transistor models, biasing, amplifiers(CE, CC, Swamped), Darlington pairs, difference amplifiers, operational amplifiers, feedback, instrumentation amplifier, filters, JFETs and MOSFETs, Digital electronics : Logic gates, Boolean algebra, Karnaugh maps, flip flops, shift registers, adders, counters, ADC and DAC.
Text/References:	1. J. Millman and C. Halkias, Integrated Electronics: Analog and Digital Systems, McGraw Hill 1972 2. A. P. Malvino, Electronic Principles, Tata McGraw Hill 1979 3. J. Millman and H. Taub, Pulse and Digital Circuits, McGraw Hill 1956

Course Code:	**PH 407**
Title:	**Mathematical Physics I**
Credits:	8
Pre-requisite:	Nil
Description:	1. Linear Vector space - Scalar product, Metric spaces, Linear operator, Matrix algebra, Eigenvalues and Eigenvector, , Infinite dimensional vector spaces, Introduction to tensors.

	2. Theory of analytical functions : Complex analysis - Complex numbers, Cauchy-Riemann condition, Analytic function, Taylor and Laurent series, Classification of singularities, Series, Calculus of residue, Various contour integration, Conformal mapping , Riemann surface, Branch cut integrals, Analytic continuation, Integral approximation.
Text/References:	1. M. R. Spiegel, Vector Analysis, Schaum's Outline Series, Tata McGraw Hill 1979 2. V. Balakrishnan, Mathematical Physics, Ane Books 2017 3. J. W. Brown and R. V. Churchill, Complex Variables and Applications, McGraw Hill International 1996 4. G. B. Arfken and H. J. Weber, Mathematical Methods for Physicists, Academic Press 1995 5. H. A. Hinchey, Introduction to Applicable Mathematics, Part 1, Wiley Eastern, 1980 6. Dennery & Krzywicki, Mathematics for Physicists, Dover, 7. Dender & Orszag, Advanced Math. Methods for scientists & Engineers

Course Code:	**General Physics Lab**
Title:	PH 441
Credits:	3
Pre-requisite:	Nil
Description:	1. e/m Ratio 2. Photoelectric Effect 3. Frank-Hertz Experiment 4. Elastic Constant by Cornu's Method 5. Dielectric Constant 6. Linear Expansion of Brass – Fizeau's Method 7. Thermal conductivity by Forbes' Method 8. Magnetic Susceptibility Gouy's Method 9. Potential Energy of a Magnet
Text/References:	Lab manual

Course Code:	**Electronics Laboratory**
Title:	PH 441
Credits:	3
Pre-requisite:	Nil
Description:	Laboratory techniques-I Laboratory techniques-II I-V characteristics of electronic components

	Single stage CE amplifier with feedback Introduction to Opamps ---Comparator and Buffer Inverting and Non-inverting amplifier using Opamp Passive and active filters Positive Feedback in Opamp circuits---- Schmitt Trigger Introduction to Digital Electronics ---Comparator and Buffer Sequential circuits using registers
Text/References:	Lab manual

First year, Second Semester

Course Code:	PH 410
Title:	**Statistical Physics**
Credits:	6
Pre-requisite:	Nil
Description:	1. Revision of Thermodynamics: Zeroth law, First law, Second law, Carnot cycle, Claussius theorem, reversible work and heat transfer. Entropy. Extensivity — Euler and Gibbs-Duhem relations. Ideal gas. Response functions. Stability conditions, second law, and positivity of response functions. Thermodynamic potentials. Maxwell's relations. 2. Elementary aspects of probability theory: Empirical versus theoretical probabilities, equal a priori probabilities. Probability distributions functions, and cumulative distribution functions. Characteristic function and moments. Cumulant generating function and cumulants. Transformation of variables and corresponding distributions. Central limit theorem statement and explaining its significance. Problem set should clarify the procedure of attaining the central limit result, starting from various initial distributions, using asymptotic analysis of integrals. 3. Statistical Ensembles: Microscopic dynamics and Liouville's theorem. Different hypotheses of Boltzmann leading up to the formula of Entropy in terms of number of configurations in an isolated system. Microcanonical ensemble. Example of ideal gas. Entropy of mixing. Canonical Ensemble, and partition sum. Asymptotic analysis and relation to thermodynamic free energy. Fluctuation of energy and fluctuation-response relationship. Ideal gas in canonical ensemble. Gibbs ensemble for fluids. Volume fluctuations. Ideal gas. Gibbs ensemble for a magnetic system. Non-interacting spins. Grand canonical ensemble. Number fluctuations. Ideal gas. Connection of ensembles through inverse transforms. Problem set may clarify ideal gases in various situations including constant

	gravity, freely jointed polymer chains, magnetic systems, classical oscillators, and hard rods in 1-dimension. 4. Quantum Statistical systems, and quantum gases: Density matrix and its time evolution. Density matrix in energy basis. Density matrix for a single oscillator, a single spin, and a single particle in a box in position basis. Exchange symmetry in many particle system. Fermions and Bosons. Off-diagonal density matrix in position basis, Canonical partition function and Pressure as a series. Grand canonical ensemble. Bose and Fermi distributions. Fermions — pressure, chemical potential, occupancy of levels, energy and specific heat. Bosons — Bose-Einstein condensation. Chemical potential, pressure, energy, specific heat. Vibrations in solids, and blackbody radiation. 5. [If time permits] Fluids of interacting particles: Cluster expansion, Virial coefficients, and Pressure as a series in density. Derivation of Vander Waals equation of state for real gases.
Text/References:	1. Mehran Kardar, Statistical Physics of Particles 2. K. Huang, Statistical Mechanics, John Wiley 1987 3. R. K. Pathria, Statistical Mechanics, Butterworth Heinemann 1996 4. J. Bhattacharjee, Statistical mechanics, Allied Publishers 1996

Course Code:	PH 422
Title:	**Quantum Mechanics II**
Credits:	6
Pre-requisite:	Nil
Description:	Recapitulation of angular momentum, tensor operators and Wigner-Eckart theorem. Variational principle method and WKB approximation methods and their applications. Formalism of time independent perturbation theory - both non-degenerate and degenerate cases. Techniques and application of time dependent perturbation theory. Scattering theory concepts with particular discussion on Born approximation, partial wave analysis. Brief exposure to relativistic quantum mechanics and solution of Dirac equation.
Text/References:	1. Principles of Quantum Mechanics, R. Shankar 2. Introduction to Quantum Mechanics, D. J. Griffiths, 3. Modern Quantum Mechanics, J.J.Sakurai 4. Quantum Mechanics, C. Cohen-Tannoudji 5. Quantum Mechanics with Basic Field Theory, Bipin R Desai

Course Code:	PH 408
Title:	**Mathematical Physics II**
Credits:	8
Pre-requisite:	Nil
Description:	Partial differential equations and the method of separation of variables. Ordinary differential equations, second order homogeneous and inhomogeneous equations. Wronskian, general solutions, particular integral using the method of variation of parameters. Sturm separation and comparison theorems. Adjoint of a differential equation. Ordinary and singular points. Series solution. Gauss hypergeometric and confluent hyprgeometric equations. Sturm Liouville problem. Legendre, Hermite and the associated polynomials, their differential equations, generating functions. Bessel functions, spherical Bessel equations. Fourier series, Fourier and Laplace transforms with applications. Bromwich integral approach to inverse Laplace transform. Green's function approach to inhomogeneous differential equations.
Text/References:	1. G.F. Simmons, Differential Equations with Applications and Historical notes, 2nd edn, Mc Graw Hill, 1991. 2. H. A. Hinchey, Introduction to Applicable Mathematics Part I, Wiley Eastern, 1980. 3. G.B. Arfken, H.J.Weber, Mathematical Methods for Physicists, 4th ed., Academic Press Prism Books, 1995. 4. P. Morse and H. Feshbach, Methods of Theoretical Physics, Vol.1, McGraw Hill, 1953. 5. V. Balakrishnan, Mathematical Physics, Ane Books 2017

Course Code:	PH 424
Title:	**Electromagnetic Theory I**
Credits:	6
Pre-requisite:	Nil
Description:	1. Electrostatics Introduction: Coulomb's law, Scalar potential, Electrostatic potential energy, Total energy, electric stress tensor Multipole expansion, Conducting matter, Dielectric Matter 2. Boundary Value Problems Solution of Laplace's equation: Potential theory, Uniqueness, Separation of Variables in different coordinate Systems Solution of Poisson's equation using Green's function. Method of Images 3. Magnetostatics Introduction: Steady currents, Biot – Savart law, Ampere law, Magnetic vector potential, Magnetic multipoles Magnetic Force & Energy Magnetic matter

	4. Electrodynamics Dynamic and Quasi – static fields General EMFields Waves in vacuum and dispersive media 5. Special Theory of Relativity Introduction: Galilean relativity, Einstein's relativity Lorentz transformation Four – vectors, Relativistic Kinematics Electromagnetic quantities and Covariant Electrodynamics.
Text/References:	(1) Modern Electrodynamics, A. Zangwill (2) Classical Electrodynamics, J. D. Jackson (3) Introduction to Electrodynamics, D. J. Griffiths (4) Classical Electrodynamics, J. Schwinger

Course Code:	PH 434
Title:	**Programming Lab**
Credits:	5
Pre-requisite:	Nil
Description:	Exposure to DOS and Unix environment. Elementary numerical programming using either FORTRAN-77 or C Language.
Text/References:	B. Davis and T.R. Hoffmann, Fortran-77-A Structured Disciplined style, McGraw Hill, Singapore, 1988.

Course Code:	PH 418
Title:	**Introduction to Condensed Matter Physics**
Credits:	6
Pre-requisite:	Nil
Description:	Crystal structures, reciprocal lattice, X-ray and electron diffraction. Lattice vibrations, Einstein and Debye models, phonons. Drude and Sommerfeld models. Block theorem, Empty lattice and nearly free electron model, tight-binding model, Density of states and Fermi surfaces. Semi classical model of electron dynamics. Concept of Effective mass.
Text/References:	1. N. Ashcroft and N.D. Mermin, Solid state physics 2. C. Kittel, Introduction to solid state physics, 7th ed., John Wiley 1997. 3. J.R. Christman, Fundamentals of Solid State Physics. John Wiley 1988 4. Ibach and Luth, Solid State Physics, Springer Verlag 2009

Second Year, First Semester

Course Code:	PH 515
Title:	**Introduction to Atomic and Molecular Physics**

Credits:	6
Pre-requisite:	Nil
Description:	***Review of one and two-electron atoms***: Relativistic effects (spin orbit, mass-velocity and Darwin terms) in hydrogen and hydrogenic atoms, Lamb shift, ground and excited states of helium, shell structure of alkalis, quantum defect, Rydberg levels. ***Basics of spectroscopy***: Absorption and emission of photons, Transition probabilities and cross-sections, Lifetime, Line broadening mechanisms, Homogenous and in-homogenous broadening. ***Many electron atoms***: Central field approximation, coupled and uncoupled representations, L-S and j-j coupling schemes, Selection rules, Zeeman and Paschen-Back effects, Hyperfine interaction (magnetic dipole and electric quadrupole interactions), Isotope shift (mass shift and volume shift). ***Molecular structure***: Born-Oppenheimer approximation, Rotational structure of diatomic molecules and extension to linear, symmetric/spherical top molecules, vibrational structure of diatomic molecules and extension to triatomic molecules, Rotational-vibrational spectrum of diatomic molecules, Electronic structure of diatomic molecules and extension to simple polyatomic molecules, Selection rules for rotational, vibrational and electronic transitions, Franck-Condon principle, Raman effect. ***Experimental techniques in atomic and molecular physics***: Absorption, Fluorescence, Raman, Two-photon, Doppler-limited and Doppler-free spectroscopy, X-ray and photoelectron spectroscopy, Cooling and trapping of atoms/ions.
Text/References:	1. Atomic Physics by C.J. Foot, Oxford Master Series in Physics, Oxford University Press (2005). 2. Atoms, Molecules and Photons: An Introduction to Atomic-, Molecular- and Quantum Physics by Wolfgang Demtröder, Springer (2010). 3. Fundamentals of Molecular Spectroscopy by C.N. Banwell and E.M. McCash, Tata-McGraw-Hill (1995). 4. Spectra of Atoms and Molecules by Peter F. Bernath, Oxford University Press (2005). 5. Physics of atoms and molecules, Bransden and Joachain, Pearson 2003

Course Code:	**PH 505**
Title:	**Introduction to Nuclear & Particle Physics**
Credits:	6
Pre-requisite:	Nil
Description:	Basic properties of nuclei and interactions, Nuclear binding energy, Nuclear moments, Nuclear models- independent particle model, shell model, Deuteron problem, Central and tensor forces, Radioactive decay-theory of alpha decay, Fermi theory of beta decay, gamma decay, Nuclear reactions- direct and compound reactions, Elementary particles- classification, symmetries and conserved quantum numbers, quark model
Text/References:	1. S S M Wong, Introductory Nuclear Physics, 2nd Edition, Wiley-VCH Verlag GmbH & Co. 2. B L Cohen, Concepts Of Nuclear Physics, Mc Graw Hill 3. H A Enge, Introduction to Nuclear Physics Addison-Wesley

	4. J S Lilley, Nuclear Physics: Principles and Applications, John Wiley and Sons 5. K Hyde, Basic ideas and concepts in nuclear physics, CRC Press 6. W E Burcham, Nuclear and Particle Physics, Addison Wesley 7. G Kane, Modern Elementary Particle Physics, Westview Press 8. D J Griffiths, Introduction to Elementary Particles, John Wiley and Sons

Course Code:	PH595
Title:	**Project or a Dept. Elective X**
Credits:	6

Course Code:	
Title:	**Dept. Elective I**
Credits:	6

Course Code:	PH 527
Title:	**Solid State Physics and Nuclear Physics Lab**
Credits:	6
Pre-requisite:	Nil
Description:	**SSP:** 1. g value using ESR spectrometer, 2. spin-lattice relaxation using NMR spectrometer, 3. Energy gap of a semiconductor using four-probe method, 4. Carrier concentration using Hall measurement, 5. wave length of microwaves. **NP:** 1)Absorption coefficient of gamma-rays in Aluminium. 2) Low and high counting statistics using G. M. Counter. 3) Gamma-ray spectrometry using NaI(Tl) scintillator. 4) Compton scattering of gamma-ray using 137Cs source. 5) Coincident study of annihilation photons using 22Na source. 6) Rutherford scattering of alpha particles in gold.
Text/References:	Lab manuals

Second Year, Second Semester

Course Code:	PH 510
Title:	**Electromagnetic Theory II**
Credits:	6
Pre-requisite:	Nil

Description:	Potentials and fields of moving charges (Lienard-Wiechert), radiation basics, radiative transfer, Planck's law, dipole radiation, Thomson scattering, Cyclotron, Synchrotron, Bremmstrahlung, Cherenkov, Compton and inverse Compton, Einstein coefficients, Transmission lines, Waveguides, Antennas and Arrays, detection of radiation - detector physics.
Text/References:	1. Electrodynamics, D. J. Griffiths 2. E. K. Jordan and K. G. Balmain, Electromagnetic Waves and Radiating Systems, Prentice Hall 1971 3. S. S. Puri, Classical Electrodynamics, Tata McGraw Hill 1997 4. J. D. Jackson, Classical Electrodynamics, John Wiley and Sons 1998

Course Code:	PH 530
Title:	**Light Matter Interaction**
Credits:	6
Pre-requisite:	Nil
Description:	Interaction of two level atom with incoherent light, Einstein coefficients, multi quantum transitions, interaction of two level atom with resonant coherent light, analogy between two level and spin ½ systems, optical Bloch equations of two level systems-polarization, susceptibility and spontaneous emission, dressed states, Rabbi flopping, free precession and photon echoes. Interaction of light with three level system-irradiation of single and two transitions, coherence transfer, three level echoes, quantum beats, Raman excitation, coherent population trapping, electromagnetically induced transparency, over damped systems adiabatic limit, optical pumping, light shift and damping, ground state dynamics.
Text/References:	1. Light-Matter Interaction, Vol.1: Fundamentals, by J. Weiner and P.T. Ho, Willy (2008). This books contains all topics of interest except strong/intense field interactions. 2. Elements of quantum optics, P. Meyster and M. Sargent, Springer Verlag 2001 3. Quantum Optics, M. O. Scully and S. Zubairy, Cambridge university Press 1997 4. Atom-photon interaction: basic principles and applications, Claude Cohen Tonnoudji, J. D. Roc and G. Grynberg, John Wiley and Sons 1998 5. Lectures on Light: Nonlinear and Quantum Optics, by S.C. Rand, Oxford Univ. Press (2010). It treats topics of interest, one needs to subtract the quantum optics part (e.g. Coherent states etc). 6. Atomic Physics, by C.J. Foot, Oxford University Press (2005) Chapters 7,8,9 provide the basic issues in light-matter interaction. 7. Atoms, Solids and Plasmas in super intense laser fields, Ed. D. Batani, C.J. Joachain, S. Martelluci and A.N. Chester, Kluwer/Plenum (2001)

	8. Multiphoton ionization of atoms, Ed. S.L. Chin and P. Labropoulos, Elsevier (1984).

Course Code:	PH 596
Title:	**Project II or Department Elective XX**
Credits:	6

Course Code:	
Title:	**Department Elective III**
Credits:	6
Pre-requisite:	
Description:	
Text/References:	

Course Code:	
Title:	**Department Elective IV**
Credits:	6
Pre-requisite:	
Description:	
Text/References:	

Course Code:	**PH 512**
Title:	**Optics and Spectroscopy Lab**
Credits:	6
Pre-requisite:	Nil
Description:	**<u>Optics</u>** Spatial Filtering Spatial Coherence Mach-Zehnder Interferometer Nonlinear Optics / Z Scan CdsNanoparticals (Theory) **<u>Spectroscopy</u>**

	Spin Orbit Coupling of Cu Absorption Spectrum of Iodine Rotation Spectrum of CN
Text/References:	Lab manuals

Elective Courses(Odd semester)

Course Code:	PH 523
Title:	**Quantum Mechanics III**
Credits:	6
Pre-requisite:	Nil
Description:	Relativistic wave equation : (a) Klein-Gordon equation, solution for K-G equation (free spin zero particles), Lagrangian and energy-momentum tensor of K-G field, symmetries and Noether's theorem, conserved charge and current, Interaction of a relativistic spin-zero particle with electromagnetic field, (b) Rotation group and angular momentum, Dirac equation for spin-1/2 particle, covariant form, continuity relation, hole theory, free particle spinors, antiparticles, Lagrangian density and energy-momentum tensor, normalization of spinors and completeness relation, zero mass fermions, (c) Field theory and second quantization: quantization of free scalar field, ground state of the Hamiltonian, normal ordering, Fock space, complex scalar field, propagator of real and complex scalar field, microscopic causality, Quantization of free Dirac field, Fourier decomposition, propagator of Dirac field.
Text/References:	1. Relativistic Quantum Mechanics, Bjorken and Drell 2. Quarks and Leptons : an Introductory course in modern particle physics, Halzen and Martin 3. A first book on quantum field theory, Lahiri and Pal; 4. An introduction to quantum field theory, Peskin and Schroeder.

Course Code:	PH 543
Title:	**Advanced Statistical Mechanics**
Credits:	6
Pre-requisite:	Nil
Description:	1. Introduction and Overview 2. Probability Theory, A-priori probabilities, Distributions, generating functions (moment and cumulant series expansions) Inter-conversion of probability distributions Central Limit Theorem 3. Folklore of Phase transitions: exponents and universality Yang-Lee theorem and singularities in phase transition Lattice gas: fluid-magnet analogy 4. Transfer matrices, Ising and Dimer models Duality and exact Tc of 2-d Ising model, Overview of exactly solvable models

	5. Master Equation, Two processes in details — Random Walk, and Birth Process [method of Lagrange characteristics]. More examples. Waiting times, and continuous time random walk. Theory of W-matrices, Equilibrium versus Non-equilibrium steady states — detailed balance and other balances. Ergodicity, Kinetic Monte-Carlo, and simulation of kinetics of models. Metropolis Monte Carlo — simulations of spin systems, and other equilibrium models. 6. Fokker-Planck and Langevin equations Solutions by various methods, connection between the two approaches. Absorbing boundaries and first passage problem, reflecting boundaries, Kramer's problem, Auto-correlations using Langevin equation — [Wiener, Ornstein-Uhlenbeck, Rouse Polymer (sub-diffusion), Polymer in shear flow (super-diffusion)] 7. Approximate approaches to critical phenomena Mean field theory for magnets: calculation of Exponents Overview of Van der Waal's theory Ginzburg-Landau theory and fluctuations, Gaussian approximation, Calculation of Correlation function, and specific heat. 8. Scaling hypothesis, Renormalisation group (RG) Preliminary examples 9. Vector order parameters — equilibrium versus non-equilibrium XY model, Vicsek model
Text/References:	1. Statistical Physics of Particles (volume I), M. Kardar 2. Statistical Physics of Fields (volume II), M. Kardar 3. Handbook of Stochastic Methods, C.W. Gardiner 4. Stochastic Processes in Physics and Chemistry, N.G. Van Kampen 5. Fokker-Plank Equation, H. Risken 6. Equilibrium Statistical Physics, M. Plischke and B. Bergersen 7. Principles of Condensed matter physics, P.M. Chaikin and T.C. Lubensky 8. Statistical Mechanics, K. Huang 9. Scaling and renormalisation in statistical physics, John Cardy 10. Exactly solved models in Statistical Physics, R. J. Baxter

Course Code:	PH 547
Title:	**Advanced Magnetic Materials and their applications**
Credits:	6
Pre-requisite:	Nil
Description:	1. Basics of magnetism: Para and diamagnetism, Metals and insulators, spin and orbital contributions, paramagnetism of 3^{rd} and $4f$ ions 2. Various forms of interaction: direct exchange, super-exchange, double exchange, RKKY but also dipolar 3. Magnetic ordering: ferro, antiferro, Ferrimagnetism: mean field theory, excitations from the ground state, spin waves / magnons, Bloch law 4. Different form of magnetic energy: dipole/ demagnetizing/ magnetostatic, magneto-crystalline anisotropy, shape anisotropy, domains and domain wall, super paramagnetism

	5. Magnetoresistance: AMR, GMR, CMR, TMR in multilayers/thin films, spin dependent scattering/conductions, basics of magnetic recording, spin valves... spin polarised transport/ spintronics
Text/References:	1. Magnetism in condensed matter by Stephen Blundell, Oxford University Press 2001 2. Michael Ziese, Martin J. Thornton (Ed), Spin Electronics, Springer 2001 3. Magnetism and Magnetic Materials, J. M. D. Coey, Cambridge University Press, 2010 4. Physics of Ferromagnetism, S. Chikazumi, Oxford University Press 2009 5. Introduction to Spintronics, S. Bandyopadhya and M. Cahy, CRC press 2015 6. Spin dependent transport in magnetic nanostructures, edited by S.Maekawa and T. Shinjo 620.168.3:669.018.5 spi 7. Magnetism materials and applications edited by E. du Tremolet deLacheisserie, D. Gignoux, M. Schlenker 538.22 Mag, volume I is also useful 8. Magnetic hetereostructures, advances and perspectives in spin structuresand transport edited by H. Zabel, A.D. Bader 538.22 Mag 9. 40th IFF Springschool 200 Spintronics: From GMR to Quantum Information-Lecture Notes

Course Code:	PH 549
Title:	**Physics of Biological Systems**
Credits:	6
Pre-requisite:	Nil
Description:	Numbers and scales in Biology, temporal scales, kinetic processes, model systems. Diffusion in biological systems, Brownian motion, Reynold`s number, intra and intercellular transport. Pattern formation in biology, Turing model, Reaction diffusion systems, mechano-chemical coupling, patterns in development. Cell, cytoskeleton and motors, invitro and invivo measurements, models for filaments and motors, example systems, cell division and active matter. Chromatin structure and function, DNA and genes, nucleosomes and epigenetic regulation, higher order structures. Gene expression, Role of noise, transcription and translation. Optional: • Viral infections, lysis, lysogeny, horizontal gene transfer, immune responses. Protein folding and mis-folding, aggregation and amyloids.
Text/References:	1. R. Phillips, J. Kondev, J. Theriot & H. Garcia, Physical Biology of the Cell, Garland Science 2. K. Roberts, D. Bray, J. Lewis, M. Raff, A. Johnson, B. Alberts, Molecular Biology of theCell, Garland Science, 3. P. Nelson, Biological Physics, 4. W.H. Freeman, J. Howard, Mechanics of Motor Proteins and the Cytoskeleton, Sinauer Associates,

	5. D. Bray, Cell Movements: From Molecules to Motility, Garland Science, 6. D. Boal, Mechanics of the Cell, Cambridge University Press, 7. H.C. Berg, Random Walks in Biology, Princeton University Press, 1983

Course Code:	PH 561
Title:	**Ultrafast Sciences**
Credits:	6
Pre-requisite:	Nil
Description:	Ultrafast science: Introduction, Spatio-temporal properties of ultrashort pulses Generation of ultra-short pulses, Material dispersion and compensation Nonlinear optics, Ultrashort pulse characterization Pulse propagation through various media, Pulse-shaping and coherent control Applications in atomic and molecular physics, Applications in condensed matter physics and materials science, Applications in bio-photonics and femto-chemistry High power lasers, Extreme nonlinear effects: Experiments and theory Intense field effects and attosecond science (Theory and experiments)
Text/References:	1. Nonlinear Optics by R. Boyd (Elsevier/Academic Press) 2. Ultrafast Optics by A. M. Weiner (Wiley) 3. Ultrashort Laser Pulse Phenomena by J-C Diels and W. Rudolph (Elsevier/Academic Press) 4. Frequency resolved optical gating: The measurement of ultrashort laser pulses by R.Trebino (Springer) 5. Ultrafast Biophotonics by P. Vasa and D. Mathur (Springer) 6. Lectures on Ultrafast Intense Laser Science by K. Yamanuchi (Springer)

Course Code:	PH 563
Title:	**Group Theoretical Methods in Physics**
Credits:	6
Pre-requisite:	Nil
Description:	**<u>Discrete groups and applications</u>** : cyclic groups, permutation groups, point groups, irreducible representations, great orthogonality theorem, character tables. Applications like selection rules, normal modes of molecules possessing symmetry and energy splitting due to symmetry breaking which will highlight the power of group theory tools. **<u>Continuous groups</u>**.: space translations, time translations, rotations and their symmetry properties. A formal introduction of Lie algebras and Lie Groups with particular emphasis on Lie groups SU(2) and SU(3). The applications in

	quantum mechanical angular momentum and particle physics quark models . Young Tableau approach of understanding tensor product and irreducible representations of SU(N). Lorentz group, dynamical symmetry for appreciating the elegant way of obtaining energy spectrum of hydrogen atom.
Text/References:	1. Group theory and its application to Physical Problems, M. Hammermesh, 1965 Wiley-VCH Verlag GmbH & Co. 2. Lie groups and lie algebras for physicists - Das and Okubo 3. Lie algebras in particle physics - H. Georgi

Course Code:	PH 565
Title:	**Semiconductor Physics**
Credits:	6
Pre-requisite:	Nil
Description:	An introduction to semiconductors, their crystal structure and their band structure. Intrinsic and extrinsic semiconductors, charge carriers and their effective masses. Methods of electronic structure calculations for semiconductors: plane wave methods, pseudo-potential approaches, semi-empirical pseudo-potential method, k.p method, Luttinger Hamiltonian, and the tight-binding approach. Electron-phonon coupling. Optical properties of semiconductors: absorption edges, effective mass approximation, excitons, polaritons. Electron transport properties: high-fieldeffects and magneto-transport.
Text/References:	1. P.Y. Yu and M. Cardona, Fundamentals of Semiconductors, Springer, 1992. 2. K. Seeger, Semiconductor Physics, 9th Edition, Springer 2004. 3. C. Hamaguchi, Basic Semiconductor Physics, Springer 2001. 4. H. Haug and S.W. Koch, Quantum Theory of the optical and electronic Properties of Semiconductors, 4th Edition World Scientific 2004.

Course Code:	PH 567
Title:	**Nonlinear Dynamics**
Credits:	6
Pre-requisite:	Nil
Description:	Physics of nonlinear systems, dynamical equations and constants of motion, phase space, fixed points, stability analysis, bifurcations and their classifications, Poincar`e section and iterative maps. One dimensional non--invertible maps, simple and strange attractors, period doubling and universality, intermittency, invariant measure, Lyapunov exponents. Higher dimensional systems, Henon map, Lorenz equations. Fractal geometry and examples of simple and fat fractals, concept of dimensions. Hamiltonian systems, integrability, Liouville`s theorem, action and angle variables, introduction to perturbation techniques, KAM theorem, area preserving maps, chaos and stochasticity.

Text/References:	1. I. Percival and D. Richards, Introduction to Dynamics, Cambridge University Press, 1982. 2. Steven H. Strogatz, Nonlinear Dynamics and Chaos, Addison Weseley,1994. 3. Edward Ott, Chaos in Dynamical Systems, Cambridge University Press,1993. 4. E. A. Jackson, Perspectives of Nonlinear Dynamics, Vol. 1&2, Cambridge University Press, 1989.

Course Code:	PH 557
Title:	**Theoretical Condensed Matter Physics**
Credits:	6
Pre-requisite:	Nil
Description:	Elementary theory of groups and their representation, application solid state physics. Electronic state in solids. Hartree and Hartree-Fock approximation. Free electron, exchange, pseudopotential theory. Cohesive energy of simple metals. Energy bands and their symmetries. Magnetism: Heisenberg exchange and magnetic ordering, magnetic resonance and relaxation. Superconductivity: Microscopic theory, Josephson effect, flux quantization.
Text/References:	1. W. Harrison, Solid State Theory Tata McGraw Hill. 2. N. Ashcroft and N.D. Mermin, Solid State Physics, Holt, Rinehart and Winston, 1972. 3. J. Ziman, Principles in the Theory of Solids, Cambridge.

Course Code:	PH 559
Title:	**Introduction to Nanoscience and Nanotechnology**
Credits:	6
Pre-requisite:	Nil
Description:	Structure and bonding in nanoparticles: Electronic structures in bulk and nanoclusters. Magic clusters; Magic number, Geometric structures, electronic structures. Theoretical modelling of nanoparticles: Fullerenes, Carbon nanotubes and graphene. Free electrons in Bulk and Nanoparticles. Size and dimensionality effects: Electronic energy bands in semiconductors; electron energy states in quantum confined systems. quantum wires, quantum dots; excitons in semiconductor particles and its size dependence. Absorption and luminescence in nanoparticles. Electron transport and size scaling in nanoparticles. Size dependence of properties: Introduction to Mie theory with applications to nanoparticles; surface plasmons in noble metal nanoparticles, Magnetic nanoparticles, Superparamagnets. Mechanical properties and size scaling. Nanoparticles in Colloids.
Text/References:	Poole C P and Owens F J, Introduction to Nanotechnology, Wiley-Interscience 2003. Cao G, Nanostructures and Nanomaterials: Synthesis, properties and applications, Imperial College Press 2004. Reich S, Thomsen C and Maultzsch

	J, Carbon Nanotubes 302226 Basic concepts and physical properties, Wiley-VCH 2004. Bohren C F and Huffman D R, Absorption and scattering of light by small particles, Wiley Interscience Paperback series, 1998. Gaponenko S V, Optical properties of semiconductor Nanocrystals, Cambridge University Press,1998.

Course Name	**Applied Solid State Physics**
Course Code:	PH 569
Credits:	6
Pre-requisite:	Nil
Description:	Boltzmann transport equation, scattering and relaxation time. Optical properties of solids, excitations, concept of plasmons, polarons and polaritons. Dielectric function, dielectric and ferroelectric materials. Band structure of semiconductors, density of states and conductivity effective masses, carrier diffusion processes, excess carrier life time, recombination and trap centres, photo conductivity, electronic properties of surfaces. Dia, para and ferro magnetism, magnetic domains, magnetic materials and application. Magnetic resonance techniques, spin-spin and spin-lattice relaxation. Superconductivity, Meissner effect, tunneling in superconductors, Josephson junctions, squids, superconducting magnets.
Text/References:	1. N. Ashcroft and N.D. Mermin, Solid state physics 2. C. Kittel, Introduction to solid state physics, 7th ed., John Wiley 1997. 3. J. R. Christman, Fundamentals of Solid State Physics. John Wiley 1988 4. Ibach and Luth, Solid State Physics, Springer Verlag 2009

Course Name	**Nanoscience: Fundamentals to Fabrication**
Course Code:	PH 575
Credits:	6
Pre-requisite:	Nil
Description:	**Physical Properties of Nanomaterials:** Effect of size on thermal, electrical, mechanical, optical and magnetic properties of nanoscale materials, diffusion properties, dielectric properties, Surface area to aspect ratio, Quantum confinement size effects, bang gap effect at nanoscale. **Synthesis of Nanomaterials** The principles of nucleation and growth, thermodynamics, kinetics, and mechanisms of Nucleation and Growth of nanocrystals, crystallography, surfaces and Interfaces, Applications to growth from solutions, melts and vapors. **NanoFabrication** Introduction to micro/nano fabrication, photolithography, x-ray lithography, e-beam lithography, nanoimprint lithography, stamping techniques for micro/nano

	fabrication, methods and applications of lithographic techniques, AFM based nanolithography (DPN) and nanomanipulation, self-assembly, template based growth of nanorod arrays, 3D nanofabrication using focused ion beam (FIB), MEMS and NEMS, nano and micro-structured semiconductor materials for microelectronics.
Text/References:	Frank J. Owens and Charles P.Poole, The Physics and Chemistry of Nano Solids, Wiley-Interscience, 2008. Guozhong Cao, Nanostructures and Nanomaterials: Synthesis, Properties and Applications, World Scientific 2011 Dieter Vollath, Nanomaterials: An Introduction to Synthesis, Properties and Applications, John Wiley and Sons 2013 C. N. R. Rao, Achim Mller, A. K. Cheetham, The Chemistry of Nanomaterials: Synthesis, Properties and Applications, John Wiley and Sons 2007 A S Edelstein and R C Cammarata, Nanomaterials Synthesis, Properties and Applications, IOP Publishing Ltd 1996. Stephen A. Campbell: Fabrication Engineering at the Micro- and Nanoscale, 4th Edition. Oxford University Press 2012 P. V. Zant, Microchip Fabrication, McGraw-Hill Education; 5 edition 2004 ISBN: 978-0071432412 Ning Xi and King Lai, Nano Optoelectronic Sensors and Devices: Nanophotonics from Design to Manufacturing, Elsevier Inc. 2011, eBook ISBN: 9781437734720. Sam Zhang, Nanostructured thin films and coatings: Mechanical Properties, CRC Press 2010. H. Baltes et al, Enanabling technology for MEMS and Nanodevices, Wiley-VCH, 2008

Elective Courses (Even semester)

Course Code	PH 500
Title:	**Thin film Physics and Technology**
Credits:	6
Pre-requisite:	Nil

Description:	Vacuum technology, gas transport and pumping systems, pressure measurements, physical and chemical vapour deposition processes, sputtering and plasma CVD, deposition by electron beams, arc plasma and pulsed laser, Molecular beam epitaxy and metal organic CVD, Chemical solution based deposition processes, electrochemical deposition, Langmuir Blodgett and self assembly processes, Physics of thin film deposition, adsorption, surface deposition, nucleation, growth and structure development, surface structure, role of surfaces, epitaxial growth, lattice mismatch, strain, growth modes, self organization, self aligned structures, heterostructures, multilayer superlattice structures, patterning techniques for IC, MEMS and other device fabrications, application of thin films.
Text/References:	K. L. Chopra, Thin films phenomena, Mc Graw Hill 1968 M. Ohring, Materials science of thin films, Academic press 1992 D. L. Smith, Thin films deposition: Principles and practices, Mc. Graw Hill 1995 J. E. Mahan, Physical vapour deposition, John Wiley 2000 K. W. Kolasinski, Surface science, John Wiley 2002 J. H. Fendler, Nanoparticles and nanostructured films, Springer 2000

Course Code:	PH 546
Title:	**Quantum Optics**
Credits:	6
Pre-requisite:	Nil
Description:	Quntum theory of light: field quantization, lamb shift, quantum beats Quantum theory of coherence: photon detection and quantum coherence functions, first order coherence and Young's double source experiment, second order coherence, physics behind Hanburry-Brown and Twiss experiment, interference of two photons, photon antibunching, Poissonian and sub-Poissonian light, photon counting and photon statistics. Classical and non classical light: Coherent, Fock and squeezed states of light, coherent state as an eigen state of annihilation operator and as a displaced harmonic oscillator state, properties of coherent state, physics of squeezed states, squeezed state and uncertainty relation, squeezed coherent state, quadrature variance, multimode squeezing, squeezing via nonlinear optical processes, applications of squeezed states for quantum noise reduction beyond standard short noise limit. EPR paradox, hidden variable, Bell's theorem and quantum cryptography, Quantum nondemolition (QND) measurement: conditions for QND, QND measurement of photon number by optical Kerr effect and by dispersive atom-field coupling, QND measurement in optical parametric processes

	Quantum optical tests of complimentarity: a micro maser with path detector, quantum eraser and quantum optical Ramsey fringes
Text/References:	1. Quantum Optics, M.O. Scully and M.S. Zubairy, Cambridge University Press (2001). 2. Elements of quantum optics, P. Meyster and M. Sargent, Springer Verlag 2001 3. Quantum Optics, D. F. Walls and G. J. Miburn, Springer Verlag 4. Quantum Optics: An Introduction, Mark Fox, Oxford Master Series in Physics (2006). 5. Introductory Quantum Optics, C.C. Gerry and P.L. Knight, Cambridge University Press (2005).

Course Code:	PH 534
Title:	**Quantum information and computing**
Credits:	6
Pre-requisite:	Nil
Description:	Open Systems Theory (ref:N&C,Breuer) Basics : States and measurements in quantum mechanics: Basic quantum mechanics, unitary operators, qubits and single qubit gates, density matrices, evolution equation for density matrices, example: two-level systems, composite systems and tensor products. CPTP Maps : CPTP maps, Kraus representation, Stinesping dilation, Choi &Jamiałkowski isomorphism,... Information & Computation (ref: N&C, Wilde, Wolf, Hayashi) Entropy, Entanglement & Measures : Entropy, matrix inequalities and monotones, distance measures and their meaning, relative entropy, mutual information. Schmidt rank, concurrence, distance measures, entropic measures. Important Techniques & Algorithms: Dense coding, entanglement distillation and purification, teleportation, Deutsch-Josza, Bernstein-Vazirani, Simon, Grover, quantum Fourier transform, Shor, DQC-1... Paradigms & Implementations of Computing (ref:N&C) : circuit based QC, adiabatic QC, measurement based QC, topological QC... Experiments : ion traps, linear optics, superconducting qubits... Geometry & Metrology (Extra / Wishlist) (ref:N&C,Bengtsson) Geometry & Correlation Measures :.
Text/References:	

Course Code:	PH 572
Title:	**Special Topics in Elementary Particle Physics**
Credits:	6
Pre-requisite:	Nil

Description:	Renormalisation in QED. Ward-Takahashi Identities. Functional methods, effective action, expansion in fields and derivatives. Renormalisation Group. Wilson interpretation of RG. Non-abelian gauge theories. Fadde'ev-Popov method of quantization. BRST symmetry and renormalisation. Chiral fermions and anomalies. Optional material : Poincare group and classification of space-time fields by mass and spin or helicity. Systematic renormalisation of phi4 theory.
Text/References:	1. P. Ramond, Field Theory: A Modern Primer 2nd Ed. 2. W. Greiner and J. Reinhardt, Field quantization. 3. W. Greiner and J. Reinhardt, Quantum Electrodynamics. 4. M. Peskin and D. V. Schroder, Quantum Field Theory 5. S. Weinberg, Quantum Theory of Fields vol.s I and II 6. V. Parameswaran Nair, Quantum Field Theory : A modern perspective, Springer 2005

Course Code:	PH 548
Title:	**Superconductivity and Low Temperature Physics**
Credits:	6
Pre-requisite:	Nil
Description:	**Superconductivity** 1. Historical overview 2. Basic properties of the normal state 3. Phenomenon of superconductivity 4. Thermodynamics of the superconductivity X 5. Ginzburg Landau phenomenological theory 6. Main feature of BCS theory 7. Tunneling and applications of superconductivity 8. Experimental 9. Highlight of high tc **Low temperature physics** 1. Cooling techniques of liquefaction of gases 2. Helium bath crystals 3. Dilution refrigeration 4. Adiabatic demagnetization 5. Nuclear spin demagnetization
Text/References:	1. C. Poole, H. A. Farach and R. J. Creswick, Superconductivity, Academic Press 1995 10. R. P. Huebener, Magnetic Flux Structures, Springer 1979 11. C. Kiitel, Introduction to Solid State Physics, 7^{th}ed, John Wiley 1995 12. Superconductivity, Superfluids and condensates, Oxford University Press 2004

Course Code:	PH 550
Title:	**Soft Matter Physics**

Credits:	6
Pre-requisite:	Nil
Description:	Basic phenomenology, Liquid crystals, polymers, membranes, surfactants, colloids, gels. Phase transitions, Landau theory, order parameter (conserved and non-conserved), nucleation and spinodal decomposition. Nematic liquid crystals, Mean field theory for isotropic-nematic transition, Landau-deGennes theory, Effect of spatial gradients, Onsager's theory for isotropicnematic transition. Polymers, random walk, gaussian chain, excluded volume, Flory theory, Deforming polymer chains, Temperature effects, Field theories and RG approach, solutions, melts, dynamics – Rouse and Zimm. Membranes and interfaces – Free energy and shape transitions. Flow and deformation of soft matter, mechanical properties and molecular models, colloids – rheology and dimensional analysis, viscoelasticity and response functions. Optional: • Elastic soft matter, Fundamentals, Kuhn theory of rubber elasticity, polymer gels. Physics of jamming, Supercooled liquids, and search for a transition, Jamming phase diagram for glasses, foams, and granular matter
Text/References:	1. M. Doi, Soft Matter Physics, Oxford University Press, 2. P.M. Chaikin& T.C. Lubensky, Principles of Condensed Matter Physics, CambridgeUniversity Press, 3. M. Rubinstein & R.H. Colby, Polymer Physics, Oxford University Press, P.G. de Gennes& J. Prost, 4. The Physics of Liquid Crystals, Oxford University Press, 5. M. Doi& S.F. Edwards, The Theory of Polymer Dynamics, Oxford University Press, 6. P.G. de Gennes, Scaling Concepts in Polymer Physics, Cornell University Press, 7. W.B. Russel, D.A. Saville, W.R. Schowalter, Colloidal Dispersions, Cambridge University Press, 1989

Course Code:	PH 556
Title:	**Astrophysics**
Credits:	6
Pre-requisite:	Nil
Description:	Introduction to stellarium, telescopes and multi-wavelength/multi-messenger astronomy, sizes and distances in astrophysics, astrometry, photometry The rest of the course may follow either a mix of the following topics orexplore a given topic in depth: Stellar physics: Stellar physics observables (spectra, flux), H-R diagrams and interpretation, stellar structure equations, nuclear physics and nuclear reactions in stars, lifecycle of stars, birth of stars – giant molecular clouds and Jeans criteria, main sequence stars, post-main sequence stars, white dwarfs and Chandrashekhar limit, neutron stars, black holes

	Galactic physics: Distance ladder in astronomy, observables in galaxies(surface brightness), galaxy classification and Hubble sequence, Faber-Jackson and Tully-Fisher relations, Dynamical mass, Dark matter in galaxies, potential theory and circular speeds, rotation curves, inferred properties of dark matter halos Cosmology: Hubble expansion, Introduction to general relativity and curved space-time, geodesics, FRW metric and Friedmann equations, solutions to Friedmann equations in different epochs, cosmological history of our universe, dark matter and dark energy, global cosmological observables and the expansion rate
Text/References:	General Astrophysics: --------------------------------------- An introduction to astronomy and astrophysics - Pankaj Jain An Introduction to Modern Astrophysics - Carroll and Ostlie Astrophysical concepts - Harwitt Additional References: Stellar physics: ----------------------- An introduction to stellar astrophysics - Francis LeBlanc Black holes, White dwarfs and neutron stars- Shapiro Galactic Physics: ------------------------ Galactic Astronomy - Binney and Tremaine Galactic Dynamics - Binney and Tremaine Cosmology: ---------------- Modern cosmology - Scott Dodelson The early universe- Kolb and Turner

Course Code:	PH 562
Title:	**Continuum Mechanics**
Credits:	6
Pre-requisite:	Nil
Description:	1) Tensors: co/contra variant tensors, contraction, Levi-civita symbols. 2) Fluid mechanics: Continuity and Euler equations, Navier-Stokes equation for viscous fluids, stokes solution in various geometries, drag, vorticity, stream lines. If times permits, surface (capillary) waves. 3) Elasticity: Stress, Strain, constitutive equation, shear, extension, torsion, bending, examples in various geometries and boundary conditions. 4) Free energy of continuum media: polymer, membrane, liquid-crystals and fluctuations (if time permits).

Text/References:	1. N.C. Rana and P.S. Jog: Classical Mechanics, Tata McGraw Hill, 1991. 2. 2. L.D. Landau and E.M. Lifshitz: Theory of Elasticity, Fluid Mechanics. 3. L.D. Landau and E.M. Lifshitz: Fluid Mechanics (both 2,3 from Pergamon Press) 4. P.M. Chaikin& T.C. Lubensky, Principles of Condensed Matter Physics: (Cambridge University Press),Paperback-1999. 5. David Rubin, Erhard Krempl, and W. Michael Lai, Introduction to Continuum Mechanics, Butterworth-Heinemann, 2009

Course Code:	PH 540
Title:	**Elementary Particle Physics**
Credits:	6
Pre-requisite:	Nil
Description:	Phenomenology of strong and weak interactions. Conserved quantum numbers. Leptons, nucleons and mesons. Partial conservation of axial current. Non-abelian gauge theories. Spontaneous breaking of global and local symmetries. The Higgs mechanism. Weinberg Salam Theory. Quantum Chromodynamics. Accelerator experiments and detectors. Low energy and non-accelerator experiments. Questions beyond the Standard model. Unification proposals.
Text/References:	1. F. Halzen and A.D. Martin, Quarks and Leptons, John Wiley, 1984 2. G. Kane, Modern Elementary Particle Physics, Addison Wesley, 1987 3. K. Huang, Quarks, Leptons and Gauge Fields, World Scientific,

Course Code:	PH 544
Title:	**General Theory of Relativity**
Credits:	6
Pre-requisite:	This course is a basic introduction to the general theory of relativity and its applications to isolated macroscopic objects and cosmology. Prerequisite: Classical Mechanics, Special Theory of Relativity
Description:	1. Covariance of Physical Laws [1lecture]2. Special Relativity [2 lectures]3. The Equivalence Principle [2lectures]4. Space and Space-time Curvature [4 lectures]5. Tensors in Curved Space-time [4 lectures]6. The Geodesic equation [2 lectures]7. geodesic Deviation Equation [2 lectures]8. Curvature and Einstein Field equations [4 lectures]9. Geometry Outside of a Spherical Star [3lectures]10. Tests of General Relativity [3 lectures]11. Gravitational Radiation [3 lectures]12. Black Holes[2 lectures]13. Cosmology [4 lectures] .
Text/References:	1. Gravity- An introduction to Einstein's general relativity – James B. Hartle (Addison-Wesley, 2003) 2. Gravitation and Cosmology - S. Weinberg (Wiley, 1972)

	3. Space-time and Geometry: An Introduction to General Relativity - Sean Carroll (Pearson, 2003). 4. Also see the Arxiv: gr-qc/97120194. 5. Introduction to General Relativity - J. V. Narlikar (Cambridge) 6. Classical Theory of Fields - L. D. Landau and E. M. Lifshitz (Butterworth-Heinemann)

Course Code:	PH 554
Title:	**Computational Many Body Physics**
Credits:	6
Pre-requisite:	Nil
Description:	Basic introduction of PHython, Scipy, Numpy, Mpi4Py, Exact Diagonalization, Tight Binding Models, Graphene, Chern Insulators, Quantum Hall effects, Lanczos and Krylov subspace methods. Kernel polynomial methods for thermodynamics quantities, Mean-field solutions, Interfacing Hamiltonian, Fock space representation, Density functional theory, Entanglement based methods. Density matrix renormalization group, Time evolving matrix product states, Introduction to Monte Carlo methods. Phase transition and Ising model Optional : Introduction to Quantum Monte Carlo and Dynamical mean field theory.
Text/References:	1. Numerical Phython : A Practical Techniques Approach for Industry, Robert Johansson, Apress 2. Computational Physics J.M.Thijsen, Cambridge University Press (2007) 3. Review on DMRG by Ulrich Schollwock. http://arxiv.org/abs/1008.3477 (2010) 4. The kernel polynomial method, WeiBe et.al., Rev.Mod. Phys.78.275 (2006) 5. Lecture Note by Anders W. Sandvik http://arxiv.org/abs/1101.3281v1 (2011)

Course Code:	PH 558
Title:	**Nanomaterials, Nanostructures and Nanofabrication**
Credits:	6
Pre-requisite:	Nil
Description:	Bulk nanostructured materials, nano particles in Zerolite, ferroelectric nanomaterials, metal nanoclusters, semiconducting nanocrystals and nanoparticles, nanowires, carbon clusters, carbon nanotubes, polymer and polymer based composites, conducting polymers, dendrimers, molecular and biomaterials, biological nanostructures, introduction to micro/nano fabrication, photolithography, x-ray lithography, e-beam lithography, nanoimprint lithography (method, nanomaterials synthesis and applications), stamping techniques for micro/nano fabrication, methods and applications of lithographic techniques, AFM based nanolithography (DPN) and nanomanipulation, self-assembly, template based growth of nanorod arrays, 3D nanofabrication using

	focused ion beam (FIB), MEMS and NEMS, nano and micro-structured semiconductor materials for microelectronics.
Text/References:	1. Poole C P and Owens F J, Introduction to nanotechnology, Wiley 2003 2. Ying J, Nanostructured materials, Academic Press 2001 3. Cao G, Nanostructured materials-synthesis, properties and applications, Imperial College London 2004 4. Menz W, Mohr J, Paul O, Microsystem Technology, Weinheim, Wiley VCH 2001

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Course Code:	PH 564
Title:	**Methods in Experimental Nuclear and Particle Physics**
Credits:	6
Pre-requisite:	Nil
Description:	Passage of radiation through matter : Interaction of heavy charged particles, neutrons, gamma rays and relativistic particles. Radiation Detection : Detection mechanism, characteristics of detectors. Detectors in Nuclear Physics : gas detectors, scintillation counters, solid state detectors. Detectors in Particle Physics : Drift Chambers, spark chambers, bubble chambers, time projection chambers. Accelerators : Van de Graff, LINAC, Cyclotrons, Synchrotron, Colliders. Pulse Processing : Timing and Energy measurements, data acquisition and analysis. CAMAC and NIM Standards.
Text/References:	1. W. R. Leo, Techniques for Nuclear and Particle Physics Experiments, Springer Verlag, 1994. 2. M. S. Livingston and J.P. Blewett, Particle Accelerators, McGraw-Hill, New York, 1990. 3. Glenn F. Knoll, Radiation Detection and Measurements, John Wiley and Sons, 1989.

Course Code	PH 566
Title:	**Advanced Simulation Techniques in Physics**
Credits:	8
Pre-requisite:	Nil
Description:	Basic Numerical Methods and Classical Simulations : Review of differentiation, integration (quadrature), and finding roots. Integration of ordinary differential equations. Monte Carlo simulations, applications to classical spin systems. Classical Molecular Dynamics. Quantum Simulations : Time-independent Schrodinger equation in one dimension (radial or linear equations). Scattering from a spherical potential; Born Approximation; Bound State solutions. Single particle time-dependent Schrodinger equations. Hartree-Fock Theory : restricted and unrestricted theory applied to atoms. Schrodinger equation in a basis: Matrix operations, variational properties; applications of basis functions for atomic, molecular, solid-state and nuclear calculations. Mini-projects on different fields of physics, e.g., Thermal simulations of matter using Car-

	Parrinello molecular dynamics; Many-Interacting-Particle Problems on Hubbard and Anderson model for electrons using Lanczos method (exact diagonalisation) for the lowest states; Quantum Monte Carlo methods; Computational methods for Lattice field theories; Microscopic mean-field theories (Hartree-Fock, Bogoliubov and relativistic mean-field); methods in nuclear many-body problems.
Text/References:	S. J. Chapman, Introduction to Fortran 90 and 95, Mc Graw Hill, Int. Ed.1998. S. E. Koonin and D. C. Meredith, Computational Physics, Addison-Wesley,1990. Tao Pang, An Introduction to Computationl Physics, Cambridge Univ Press,1997. R. H. Landau and M. J. P. Mejia, Computational Physics, John Wiley, 1997. J. M. Thijssen, Computational Physics, Cambridge Univ Press, 1999. K. H. Hoffmann and M. Schreiber, Computational Physics, Springer, 1996.

Course Code	PH 568
Title:	**Physics of Nanostructures and Nanoscale Devices**
Credits:	6
Pre-requisite:	Nil
Description:	Electrons in semiconductor hetero-structures: band offsets, effective mass; semiconductor hetero-junctions, 2-DEG systems, quantum wires and quantum dots; Transmission in nanostructures: tunneling in planar barrier, resonant tunnel diodes, Landauer formula, transport in quantum waveguide structures; single electron tunneling and Coulomb blockade. Electron transport in devices: Schottky diodes, p-n junction diodes, short diodes; bipolar and field-effect transistors, MOSFETS, effect of size reduction, short channels; scaling down to nanosizes, FINFETS; issues with nanoscale devices.
Text/References:	Sapoval S and Herman C, Physics of Semiconductors, Springer International Edition, 2006.Ferry D K and Goodnick S M, Transport in Nanostructures, Cambridge University Press, 1997.Datta S, Electronic Transport in Mesoscopic Systems, Cambridge University Press, 1995.Davies J H, Physics of low Dimensional Semiconductors, Cambridge University Press, 1998.Colinge J P and Colinge C, Physics of Semiconductor Devices, Springer International, 2007.Neamen D A, Semiconductor Physics and Devices, TataMcGraw-Hill, 3rd Edition, 2003.Singh Jasprit, Semiconductor Devices, Basic Principles, John Wiley & Sons Inc, 2001.Sze S M, Semiconductor Devices, Wiley-India, 2008.Hess K, Advanced Theory of Semiconductor Devices, IEEE Press, Prentice-Hall of India, 2000

Course Code	PH 576
Title:	**Nanoscale Quantum Transport**
Credits:	6
Pre-requisite:	Nil

Description:	**Preliminary concepts:** Fundamental length scales (De Broglie wavelength, Mean Free Path, Coherence Length, Thermal Diffusion Length) and classification of transport regimes, Resistance (in d-dimension) in the bulk and mesoscopic limits. Energy levels, wave functions, and DOS in quantum wells (both square and triangular), quantum wires, and quantum dots. (Optional: Coupling between quantum wells and superlattices); Revision of Bloch wavefunction and effective mass tensor. Band-structures of GaAs and Si, concept of valleys, longitudinal and transverse effective masses, the band-gap lattice parameter diagram, the concept of heterojunctions and different band alignments. Envelope function and effective mass approximation for heterostructures. **Quantum nano/heterostructures in the real world:** Quantization in (doped) heterojunction systems, the GaAs-AlGaAs heterojunction and the 2D electron gas (with comparison to fictitious quantum well discussed earlier). The double barrier structure and resonant tunneling diode. From 2DEG to quantum wires, quantum point contacts, quantum wires, and quantum dots in the real world (qualitative description of gated 2DEG based devices). **Semi-classical transport and scattering mechanisms:** Brief review of semi-classical transport (Boltzmann Transport Equation). Coulomb, Surface roughness, and Lattice scattering, Carrier mobilities in 2DEGs. **Ballistic Transport: Landauer and Landauer-Buettiker formalisms:** Current in resonant tunneling diodes (coherent and sequential tunneling), Landauer formula, introduction to the multi-channel case, generalized multi-channel case and Landauer-Buettiker formalism, specific examples (2-probe, 3-probe, and 4-probe cases). **Ballistic transport in quantum wires:** Conductance quantization in QPCs, Adiabatic transport model, Bias spectroscopy of QPCs. **Low dimensional Quantum heterostructures in magnetic field:** Quantum Hall effects, QPC in magnetic field, 0.7 feature in QPCs. **Quantum dots, Coulomb blockade, and Single Electron Transistors:** Solving for the (Fock-Darwin) eigenstates, Coulomb Blockade and fundamentals of single electron tunneling, Orthodox theory of single electron tunneling (Transfer Hamiltonian Formalism), Stability diagrams of double quantum dots (quantum dot molecules).
Text/References:	(i) Transport in Nanostructures - David K. Ferry, Stephen Goodnick, Jonathan Bird, Cambridge University Press 2009) (ii) Quantum Heterostructures: Microelectronics and Optoelectronics - Vladimir V. Mitin, Viatcheslav A. Kochelap, Michael A. Stroscio, Cambridge University Press 1999 (iii) Electronic Transport in Mesoscopic Systems - Supriyo Dutta, Cambridge University Press 1995 (iv) Quantum Transport - Introduction to Nanoscience, Y. V. Nazarov, Y. M. Blanter, Cambridge University Press 2009 (v) The Physics of Low-dimensional Semiconductors: An Introduction - John M. Davies, Cambridge University Press, 1997

Course Code	PH 578
Title:	**Nanodevices and Applications**
Credits:	6
Pre-requisite:	Nil
Description:	1) Nano sensors, nano-pressure, nanopiezeo sensors, plasmonic nanosensors, nano for gas sensors & Nano actuators, with particular emphasis on biomaterial based devices, Field effect transistor based biosensors (bio-FETs) 2) Novel batteries: Li, Na, and other materials based batteries 3) Memory devices: DVD Roms, magnetic, solid state, memristors, and other modern proposals 4) Nano and Microfluidic devices: To learn the basic behaviour of liquid in micro or nanosystems. Emphasize on interaction of fundamental mechanism and desing of microfluidic devices. Application is Lab on a chip state of art, analyse it. Theory of micro and nanofluidics, equation of change, flow at microscale, diffusion and microscale mixing, circuit analysis, Stokes flow electrostatics and electrodynamics, electrical double layer, zeta potential, species and charge transport, electro-osmosis and electrophoresis, AC field in microsystem, hyrdodymanics, surfactant/suspension and separation, technological production of components, mixure, pumps, and fabrication of lab-on-chip 5) Quantum Computing Hardware: Quantum Information Processing - Q-bits: Charge bits and Spin bits - Quantum Computing devices, quantum communication devices. Josephson Junction based quantum computing: charge, flux, and phase qubits. Building large Quantum Computers, Fabrication, testing architectural challenges, Quantum dot cellular automata (QCA) – computing with QCA
Text/References:	**Books on Nanosensors:** (i) Introduction to Biosensors From Electric Circuits to immunosensors, Yoon, Jeong-Yeol (Springer 2016). (ii) (ii) Biosensors: A Practical Approach, A. E. G. Cass IRL Press at Oxford University Press, 1990. (iii) Molecular Sensors and Nanodevices; Principles; Designs and Applications in Biomedical Engineering; JXJ Zhang, K Hoshino, Elsevier; 2014. (iv) Nanofabrication Towards Biomedical Applications, Challa Kumar, Wiley-VCH, 2016

(v) MEMS and Nanotechnology-Based Sensors and Devices for Communications, A R Jha- Medical and Aerospace Applications 1st Edition CRC Press 2019,

(vi) Nanotechnology and Biosensors, Dimitrios P Nikolelis, Georgia Paraskevi Nikoleli (Elsevier 2018)

Books on Batteries:

(i) Introduction To Nanotechnology, Poole and Owens – John Wiley and Sons 2003

Nanomaterials for Electrochemical Energy Storage Devices; Poulomi Roy, S. K. Srivastava- Wiley-Scrivener 2019

(ii) Modern Battery Engineering: A Comprehensive Introduction by Kai Peter Birke, World Scientific; Illustrated edition (2019)

(iii) Modern Batteries, 2nd Edition, by C. Vincent and Bruno Scrosati- Paperback ISBN: 9780340662786 eBook ISBN: 9780080536699 Imprint: Butterworth-Heinemann 1997

Books on Memory Devices:

(i) Nanomaterials-Based Charge Trapping Memory Devices By Ammar Nayfeh, Nazek El-Atab (Elsevier 2020)

(ii) Phase Change Memory Device Physics, Reliability and Applications - Editors: Pigozzo, Andrea (Ed.), Springer 2018

(iii) Advances in Non-volatile Memory and Storage Technology, 1st Edition, Editor: Yoshio Nishi. Hardcover ISBN: 9780857098030, eBook ISBN: 9780857098092, Imprint: Woodhead Publishing 2014

(iv) Advances in Memristors, Memristive Devices and Systems, Vaidyanathan, Sundarapandian, Volos, Christos (Eds.), Springer 2017

Books on MicroFluidics:

(i) Micro- and Nanoscale Fluid Mechanics for Engineers: Transport in Microfluidic Devices By Brian J. Kirby. 2009, http://kirbyresearch.com/textbook

(ii) Probstein, R.F. Physicochemical Hydrodynamics, 2nd Ed., Wiley, 1994

(iii) Tabeling, P. Introduction to Microfluidics, Oxford, 2005.

(iv) Bruss, H. Theoretical Microfluidics, Oxford, 2008.

(v) Nguyen, N-T and Wereley, S "Fundamentals and Applications of Microfluidics", 2nd Edition, Artech House, ISBN: 1580539726

(vi) Berthier J. and Silberzan, P. Microfluidics for Biotechnology. Artech HousePublishers. ISBN: 1-58053-961-0. (2010)

	Books on Quantum Computing: (i) Quantum Computation and Quantum Information 10th Anniversary Edition Hardcover – 9 December 2010 by Michael A. Nielsen and Isaac L. Chuang. (ii) Quantum Computer Systems: Research for Noisy Intermediate-Scale Quantum Computers, Synthesis Lectures on Computer Architecture (2020) by Yongshan Ding and Fred Chong, published by Morgan Claypool, DOI: 10.2200/S01014ED1V01Y202005CAC051

Course Code	PH 580
Title:	**Magnetism and Superconductivity**
Credits:	6
Pre-requisite:	Nil
Description:	Magnetism: Classification of magnetic materials; localized and itinerant magnetism; various types of exchange interactions- direct, super, RKKY and DM; magneto-crystalline anisotropy energy; shape anisotropy; domains, domain walls and magnetization process; magnetism in thin films and fine particles; basics of spin dependent scattering/spin-polarized transport; magneto-transport effects such as CMR, AMR, GMR, TMR; basics of magnetic recording, Hall effect, essentials of spintronics and spintronic devices; basic ideas of de Haas- van Alphen effect and quantum Hall effect. Superconductivity: Overview; types of superconductors; electrodynamics and thermodynamics of superconductors; Elements of Ginzburg-Landau theory and BCS theory; Fluxoid quantisation; Giaever tunnelling; Josephson tunnelling; principle of quantum interference; applications of superconductivity; SQUID, recent discoveries on high temperature superconductors.
Text/References:	1. Magnetism in Condensed Matter - Stephen Blundell, Oxford Master Series 2001 2. Magnetism and Magnetic Materials – J M D Coey, Cambridge University Press 2012 3. Physics of Ferromagnetism - S. Chikazumi, Oxford University Press 1997 4. Introduction to Spintronics - S. Bandyopadhya and M. Cahay, CRC press 2020 5. Introduction to Solid State Physics - C Kiitel, , 7^{th} ed, John Wiley 2005 6. Superconductivity, Superfluids and Condensates - J F Annet, Oxford Master Series 2004 7. Superconductivity - C Poole, H Farach and R Creswick, R Prozorov , Elsevier 2014