SACRED HEART COLLEGE (AUTONOMOUS)

Department of Physics

M.Sc. Physics

COURSE PLAN

Semester-4

2015 - 16

COURSE PLAN

PROGRAMME	MASTERS OF SCIENCE INN PHYSICS	SEMESTER	4
COURSE CODE AND TITLE	P4PHYT13: Atomic and Molecular Physics	CREDIT	4
Theory HOURS/WEEK	4	HOURS/SEM	72
FACULTY NAME	Prof. Alex Shinu Scaria		

Course Objective:

- To explain the concepts of atomic spectroscopy and to apply it for analyzing a given atomic spectrum
- To analyse a given rotational spectra and vibrational spectra from the concepts of molecular spectroscopy
- To illustrate the spectra of given molecules using techniques of electronic and Raman spectroscopy
- To explain the theory behind new spectroscopic techniques like NMR, ESR and Mossbauer spectroscopy

SESSION	TOPIC	LEARNING RESOURCES
	UNIT-1	
1,2	The hydrogen atom and the three quantum numbers *n*, *l* and m_l – electron spin - spectroscopic terms	Seminar
3,4,5	Spin-orbit interaction -2, derivationof spin-orbit interaction energy,	Derivation & Discussion
6	Fine structure in sodium atom, selection rules. Lande g-factor,	Derivation & Discussion
7,8,9	Normal Zeeman and Anomalous Zeeman effects	Derivation & Discussion
10	Paschen–Back effect	Derivation & Discussion
11,12	Stark effect in one electron system.	Derivation & Discussion
13,14	L S coupling, (vector diagram) - examples, derivation of interaction energy - 3	Derivation & Discussion
15,16	j j coupling, (vector diagram) - examples, derivation of interaction energy - 2	Derivation & Discussion
17	Hund's rule, Lande interval rule	Lecture + Discussion
18	Hyperfine structure andwidth of spectral lines.(qualitative ideas only).	Seminar
	Unit II Microwave and IRSpectroscopy (18 Hrs)	
19,20	Rotational spectra of diatomic molecules	Lecture + Discussion
21	Intensity of spectral lines, effect of isotopic substitution.	Lecture + Discussion
22	Non–rigid rotor –	Derivation & Discussion
23,24	Rotational spectra of polyatomic molecules - linear and symmetric top	Derivation & Discussion
25	Interpretation of rotational spectra.	Lecture + Discussion
26	Vibrating diatomic molecule as anharmonic oscillator,	Derivation & Discussion

27	Diatomic vibrating rotor	Derivation & Discussion
28	Break down of Born-Oppenheimer approximation	Lecture + Discussion
29,30	Vibrations of polyatomic molecules – overtone and combination frequencies	Lecture + Discussion
31,32,	Influence of rotation on the spectra of polyatomic molecules – linear molecules	Derivation & Discussion
33,34	Influence of rotation on the spectra of polyatomic molecules – symmetric top molecule	Derivation & Discussion
35	Analysis by IR technique	Seminar
36	Fourier transform IR spectroscopy.	Seminar
	Unit III **Raman and Electronic Spectroscopy.** **(18 Hrs)**	
37,38	Pure rotational Raman spectra – linear molecules	Derivation & Discussion
39	Pure rotational Raman spectra symmetrictop molecules	Derivation & Discussion
40	Vibrational Raman spectra	Derivation & Discussion
41,42	Raman activity of vibrations - mutual exclusion principle	Lecture + Discussion
43	Rotational fine structure	Derivation & Discussion
44	Structure determination from Raman and IR spectroscopy	Seminar
45	Non- linear Raman effects - hyper Raman effect - classical treatment	Lecture + Discussion
46	Stimulated Raman effect, CARS, PARS	Lecture + Discussion
47	Inverse Raman effect	Lecture + Discussion
48,49	Electronic spectra of diatomic molecules – progressions and sequences – intensity of spectral lines.	Lecture + Discussion
50	Franck – Condon principle	Lecture + Discussion

51	Dissociation energy and dissociation products	Lecture + Discussion
52,53	Rotational fine structure of electronic-vibrational transition	Derivation & Discussion
54	Fortrat parabola - Pre-dissociation.	Lecture
	Unit IV **Spin Resonance Spectroscopy (18 Hrs)**	
55,56	**NMR:** Quantum mechanical descriptions	Lecture
57,58	Classical descriptions – Bloch equations	Derivation & Discussion
59	Relaxation processes – chemical shift	Seminar
60	Relaxation processes- spin–spin coupling	Lecture
61	**ESR:** Theory of ESR	Lecture
62	Thermal equilibrium and relaxation processes	Seminar
63,64	g- factor -hyperfine structure	Derivation & Discussion
65,66	**Mossbauer spectroscopy**: Mossbauer effect - recoilless emission andabsorption –	Lecture
67	Hyperfine interactions – chemical isomer shift	Seminar
68,69	Hyperfine interactions – magnetic hyperfine	Lecture
70,71	Hyperfine interactions – electronic quadrupole interactions	Lecture
72	Applications of NMR, ESR & Mossbauer spectroscopy	Seminar

INDIVIDUAL ASSIGNMENTS/SEMINAR – Details & Guidelines

	Date of completion	Topic of Assignment & Nature of assignment (Individual/Group – Written/Presentation – Graded or Non-graded etc)
1	Before 1st Internal	Individual- Graded – Best of 2 sets
2	Before 2nd Internal	Individual- Graded –Best of 2 sets

ASSIGNMENTS– Details & Guidelines – Will be notified prior to the announcement of the assignment – marks will be scaled to 5.

SEMINARS will be given to each student (20 mins duration) – 5 marks

Basic Reference:

1. Fundamentals of molecular spectroscopy, C.N. Banwell, MGH
2. Molecular structure and spectroscopy, G. Aruldhas, PHI Learning Pvt. Ltd.
3. Lasers and Non-Linear Optics, B.B Laud, Wiley Eastern

References

1. Introduction of Atomic Spectra, H.E. White, McGraw Hill

2. Spectroscopy (Vol. 2 & 3), B.P. Straughan& S. Walker, Science paperbacks 1976

3. Raman Spectroscopy, D.A. Long, McGraw Hill international, 1977

4. Introduction to Molecular Spectroscopy, G.M. Barrow, McGraw Hill 5. Molecular Spectra and Molecular Structure, Vol. 1, 2 & 3. G. Herzberg, Van Nostard, London.

6. Elements of Spectroscopy, Gupta, Kumar & Sharma, PragathiPrakshan

7. The Infra Red Spectra of Complex Molecules, L.J. Bellamy, Chapman & Hall. Vol. 1 & 2.

8. Laser Spectroscopy techniques and applications, E.R. Menzel, CRC Press, India

COURSE PLAN

PROGRAMME	MASTERS OF SCIENCE INN PHYSICS	SEMESTER	4
COURSE CODE AND TITLE	**P4PHYT14 NUCLEAR AND PARTICLE PHYSICS**	CREDIT	4
Theory HOURS/WEEK	4	HOURS/SEM	72
FACULTY NAME	Dr. Pius Augustine		

Course Objective:

- To describe the nature of nucleus and its various constituents
- To analyze the nature of nucleus by applying the quantum mechanical scattering.
- To understand the nuclear models and nuclear reactions
- To analyze and understand elementary particles and quarks.

SESSION	TOPIC	LEARNING RESOURCES
	MODULE 1 Nuclear Properties and Force between Nucleons	
1	Nuclear radius	Lect + PPT
2	Mass and abundance of nuclides	Lect + PPT
3	Nuclear binding energy	Lect + PPT
4	Nuclear binding energy	Lect + PPT
5	Nuclear angular momentum and parity	Lect + PPT
6	Nuclear angular momentum and parity	Lect + PPT
7	Nuclear electromagnetic moments	Lect + PPT
8	Nuclear electromagnetic moments	Lect + PPT
9	Nuclear excited states Duetron	Lect + PPT
10	Nuclear excited states Duetron	Lect + PPT
11	Nucleon-nucleon scattering	Lect + PPT

12	Nucleon-nucleon scattering	Lect + PPT
13	Proton-proton and neutron-neutron interactions	Lect + PPT
14	Proton-proton and neutron-neutron interactions	Lect + PPT
15	Properties of nuclear forces	Lect + PPT
16	Properties of nuclear forces	Lect + PPT
17	Exchange force model	Lect + PPT
18	Revision/Test	
	Unit II - Nuclear Decay and Nuclear Reactions	
19	Beta decay energy release	Lect + PPT
20	Beta decay energy release	Lect + PPT
21	Beta decay energy release	Lect + PPT
22	Fermi theory	Lect + PPT
23	Experimental tests	Lect + PPT
24	Angular momentum and parity selection rules	Lect + PPT
25	Comparative half lives and forbidden decays	Lect + PPT
26	Neutrino physics	Lect + PPT
27	Non conservation of parity	Lect + PPT
28	Types of reactions and conservation laws	Lect + PPT
29	Energetics of nuclear reactions	Lect + PPT
30	Isospin	Lect + PPT
31	Reaction cross sections	Lect + PPT
32	Coulomb scattering	Lect + PPT
33	Nuclear scattering	Lect + PPT
34	Scattering and reaction cross sections	Lect + PPT

35	Compound-nucleus reactions	Lect + PPT
36	Direct reactions, heavy ion reactions.	Lect + PPT
	Unit – III Nuclear Models, Fission and Fusion	
37	Shell model potential	Lect + PPT
38	Spin-orbit potential	Lect + PPT
39	Magnetic dipole moments	Lect + PPT
40	Electric quadrupole moments	Lect + PPT
41	Valence Nucleons, Collective structure	Lect + PPT
42	Nuclear vibrations, Nuclear rotations	Lect + PPT
43	Liquid drop Model	Lect + PPT
44	Semi-empirical Mass formula	Lect + PPT
45	Semiempirical mass formula	Lect + PPT
46	Characteristics of fission - energy in fission - fission and nuclear structure	Lect + PPT
47	Controlled fission reactions	Lect + PPT
48	Fission reactors	Lect + PPT
49	Fusion processes	Lect + PPT
50	Characteristics of fusion	Lect + PPT
51	Controlled fusion reactors	Lect + PPT
52	Revision	Lect + PPT
53	Revision	Lect + PPT
54	Test	Lect + PPT
	UNIT IV - Particle Physics	
55	Types of interactions between elementary particles	Lect + PPT
56	Hadrons and leptons-masses	Lect + PPT
57	Hadrons and leptons-masses	Lect + PPT

58	Spin, parity and decay structure	Lect + PPT
59	Quark model	Lect + PPT
60	Confined quarks, coloured quarks	Lect + PPT
61	Experimental evidences for quark model	Lect + PPT
62	Quark-gluon interaction	Lect + PPT
63	Gell-Mann-Nishijima formula	Lect + PPT
64	Symmetries and conservation laws	Lect + PPT
65	Symmetries and conservation laws	Lect + PPT
66	C, P and T invariance	Lect + PPT
67	Applications of symmetry arguments to particle reactions	Lect + PPT
68	Parity non-conservation in weak interactions	Lect + PPT
69	Grand unified theories	Lect + PPT
70	Revision	Lect + PPT
71	Revision	Lect + PPT
72	Exam	Lect + PPT

INDIVIDUAL ASSIGNMENTS/SEMINAR – Details & Guidelines

	Date of completion	Topic of Assignment & Nature of assignment (Individual/Group – Written/Presentation – Graded or Non-graded etc)
1	Before 1st Internal	Individual- Graded – 3 sets
2	Before 2nd Internal	Individual- Graded -3 sets

ASSIGNMENTS– Details & Guidelines – Will be notified prior to the announcement of the assignment – marks will be scaled to 5.

SEMINARS will be given to each student (20 mins duration) – 5 marks

Text Book:

1.Introductory Nuclear Physics, K. S. Krane Wiley, (Chapter 18)

2. Nuclear Physics, D. C. Tayal, Himalaya Publishing House (Chapter 16)

Reference Books:

1. Introduction to Elementary Particle, D.J. Griffiths, Harper and Row, NY,(1987)
2. Nuclear Physics, R.R. Roy and B.P. Nigam, New Age International, New Delhi, (1983).
3. The particle Hunters - Yuval Ne'eman&Yoramkirsh CUP, (1996)
4. Concepts of Nuclear Physics, B.L. Cohen, TMH, New Delhi, (1971).
5. Theory of Nuclear Structure, M.K. Pal, East-West, Chennai, (1982).
6. Atomic Nucleus, R.D. Evans, McGraw-Hill, New York.
7. Nuclear Physics, I. Kaplan, 2ndEdn, Narosa, New Delhi, (1989).
8. Introduction to Nuclear Physics, H.A. Enge, Addison Wesley, London, (1975).
9. Introductory Nuclear Physics, Y.R. Waghmare,Oxford-IBH, New Delhi, (1981).
10. Atomic and Nuclear Physics, Ghoshal,Vol. 2, S. Chand & Company
11. Fundamentals of Elementary Particle Physics, J.M. Longo, MGH, New York, (1971).
12. Nuclear and Particle Physics, W.E. Burcham and M. Jobes, Addison- Wesley, Tokyo, (1995).
13. Subatomic Physics, Frauenfelder and Henley, Prentice-Hall.
14. Particles and Nuclei: An Introduction to Physical Concepts, B. Povh, K. Rith, C. Scholz and Zetche, Springer (2002)
15. Elementary Particles and Symmetries, L.H. Ryder, Gordon andBreach, Science Publishers, NY, 1986

COURSE PLAN

PROGRAMME	MASTER OF SCIENCE (PHYSICS)	SEMESTER	4
COURSE CODE AND TITLE	P4PHYT15: OPTOELECTRONICS	CREDIT	4
HOURS/WEEK	4	HOURS/SEM	72
FACULTY NAME	DR. MATHEW GEORGE		

Course Objective:

- To outline the concepts of semiconductors, LEDs and fiber optics.
- To outline laser principles and output control.
- To outline the concepts of photodetectors and photovoltaics.
- To outline the concepts of modulators and nonlinear optics.

Teaching: Four lectures per week, by Dr. Mathew George. (72 hours)

Course objective: This course aims to provide a deeper understanding and mastery of the broad topic of optoelectronics and its relevance in daily life.
Course outcome: This course will create knowledge on optoelectronics and its various applications in life.

Session	Topic	Method
1	Intro, semiconductor energy bands, statistics, extrinsic semiconductors	Lecture, discussion
2	compensation doping, degenerate and non-degenerate semiconductors,	Lecture, discussion
3	energy band diagrams in applied field - direct and indirect bandgap semiconductors	Lecture, discussion
4	pn junction principles, open circuit	Lecture, discussion
5	forward and reverse bias	Lecture, discussion
6	LEDs, principles	Lecture, discussion
7	LEDs, materials	Lecture, discussion
8	high intensity LEDs	Lecture, discussion
9	single and double heterostructure	Lecture, discussion

10	LED, characteristics, fiber communication, surface and edge emitting LEDs	Lecture, discussion
11	Waveguide condition, symmetric planar dielectric slab waveguide	Lecture, discussion
12	single and multimode waveguides, TE and TM modes	Lecture, discussion
13	modal and waveguide dispersion, dispersion diagram	Lecture, discussion
14	intermodal and intramodal dispersion	Lecture, discussion
15	ispersion in SMFs, material dispersion	Lecture, discussion
16	waveguide dispersion, chromatic dispersion	Lecture, discussion
17	profile and polarization dispersion	Lecture, discussion
18	dispersion flattened fibers, bit rate and dispersion	Lecture, discussion
19	optical and electrical bandwidths, GRIN fibers	Lecture, discussion
20	attenuation in fibers, absorpion and scattering	Lecture, discussion
21	laser oscillation conditions, diode laser principles	Lecture, discussion
22	laser diode-hetero and double heterostructure	Lecture, discussion
23	stripe geometry, buried heterostructure	Lecture, discussion
24	gain and index guiding	Lecture, discussion
25	laser diode characteristics, equation	Lecture, discussion
26	single frequency SS lasers	Lecture, discussion
27	DFB lasers	Lecture, discussion
28	QW lasers	Lecture, discussion
29	VECSELs	Lecture, discussion
30	laser amplifiers	Lecture, discussion
31	high power pulse, generation	Lecture, discussion
32	Q factor	Lecture, discussion
33	Q switching, giant pulses	Lecture, discussion

34	Q switching methods	Lecture, discussion
35	Modelocking	Lecture, discussion
36	dispersion flattened fibers, bit rate and dispersion	Lecture, discussion
37	PN junction photodiode, principles	Lecture, discussion
38	Ramo's theorem and external photocurrent	Lecture, discussion
39	photodiode materials	Lecture, discussion
40	absorption coefficient	Lecture, discussion
41	quantum efficiency, responsivity	Lecture, discussion
42	PIN photodiodes	Lecture, discussion
43	avalanche photodiode	Lecture, discussion
44	phototransitors	Lecture, discussion
45	photoconductive detectors, gain	Lecture, discussion
46	noise in photodetectors	Lecture, discussion
47	noise in avalanche photodiodes	Lecture, discussion
48	solar energy spectrum	Lecture, discussion
49	photovolatic device principles	Lecture, discussion
50	IV characteristics	Lecture, discussion
51	series resistance, equivalent circuit	Lecture, discussion
52	temperature effects	Lecture, discussion
53	solar cell materials	Lecture, discussion
54	device efficiencies	Lecture, discussion
55	optical polarization	Lecture, discussion
56	birefringence	Lecture, discussion
57	retardation plates	Lecture, discussion
58	EO modulators, Pockel's effect	Lecture, discussion

59	longitudinal EO modulators	Lecture, discussion
60	transverse EO modulators	Lecture, discussion
61	Kerr effect	Lecture, discussion
62	Magneto-optic effect	Lecture, discussion
63	acousto-optic effect	Lecture, discussion
64	Raman Nath and Bragg type modulators	Lecture, discussion
65	Wave propagation in anisotropic crystals, polarization	Lecture, discussion
66	second order NLO proceses-SHG,	Lecture, discussion
67	SFG, OPO	Lecture, discussion
68	Third order NLO processes, THG	Lecture, discussion
69	Intensity dependent refractive index, self focusing	Lecture, discussion
70	NLO materials, phase matching, angle tuning	Lecture, discussion
71	saturable absorption	Lecture, discussion
72	optical bistability, two photon absorption	Lecture, discussion

Assignments/seminars: In addition to lectures students will have to submit assignments given, to strengthen their mastery in the subject. There will also be one seminar, to be given by the students.

References: Optoelectronics and Photonics: Principles and Practices, S.O. Kasap, Pearson.
Optoelectronics, Wilson and Hawkes
Other books specified by the syllabus

COURSE PLAN

PROGRAMME	MASTERS OF SCIENCE INN PHYSICS	SEMESTER	4
COURSE CODE AND TITLE	P4PHYT16 : INSTRUMENTATION AND COMMUNICATIONELECTRONICS	CREDIT	4
Theory HOURS/WEEK	4	HOURS/SEM	54
FACULTY NAME	Dr. Siby Mathew		

Course Objective:

- To identify mechanism to handle transducers, their basic ideas and applications
- To discuss issues of Process and Management of digital instruments including construction , structure, and applications
- To differentiate communication in space, terrestrial etc. including SSB. Impart leadership in Radio, CRO and TV

SESSION	TOPIC	LEARNING RESOURCES
1	Classification of transducers - electrical transducer	PPT talk and interaction
2	resistivetransducer -	PPT + Demonstration using examples
3	strain gauges-	Lecture + question answer session.
4	thermistor inductive transducer - differential output transducers	Lecture + question answer session.
5	- pressure transducers - pressure cell	Lecture + question answer session.
6	photoelectric transducers - photo voltaic cell – semiconductor photo diode	Lecture + question answer session.
7	ionization transducers	Lecture + question answer session.
8	ionization transducers	Lecture + question answer session.

9	digital transducers - electro chemical transducers	Lecture + question answer session.
10	**Recorders:** Strip chart recorders - XY recorders - digital XY plotters	Lecture + question answer session.
11	magnetic recorders -digital data recording	Lecture + question answer session.
12	Storage oscilloscope – Digital storage oscilloscope.	Lecture + question answer session.
13	thermo electric transducers	Lecture + question answer session.
14	piezo-electric and magnetostrictive transducers -	Lecture + question answer session.
15	-mechanical transducers	discussion
16	Time evolution operator and its properties-	Lecture + question answer session.
17	Hall effect transducers	Lecture + question answer session.
18	problems	Lecture + question answer session.
19	Transistor Voltmeter - amplified DC meter	Teacher student interactive session
20	chopper type DC amplifier voltmeter	Lecture + question answer session.
21	- milli voltmeter using operational amplifier	Lecture + question answer session.
22	differential voltmeter - A.C voltmeters using rectifiers	Lecture + question answer session.
23	true RMS responding voltmeter – Ohm meter	Lecture + question answer session.
24	electronic multimeter – commercial multimeter	Lecture + question answer session.
25	CRO (Basic ideas)	Lecture + question answer session.
26	– output power meters - stroboscope	Lecture + question answer session.

27	phase meter – vector impedance meter	Lecture + question answer session.
28	CIA -1	Exam
29	**Digital Instrumentation:** - digital voltmeter –RAMP - voltage to time conversion	Lecture + question answer session.
30	-voltage to frequency conversion	Lecture + question answer session.
31	frequency to voltage conversion	Lecture + question answer session.
32	digital millimeter	Lecture + question answer session.
33	digital frequency meter -time and Frequency measurement	Lecture + question answer session.
34	Digital counters and timers	Lecture + question answer session.
35	digital phase meter	Lecture + question answer session.
36	tachometer- pH meter.	Lecture + question answer session.
37	Bandwidth requirements – SSB technique	Lecture + question answer session.
38	radio wave propagation	Lecture + question answer session.
39	Ionosphere – Ionosphere variations	Lecture + question answer session.
40	Space waves – Extra-terrestrial communication	Lecture + question answer session.
41	Transmission lines – Basic principles	Lecture + question answer session.
42	Characteristic impedance – Losses	Lecture + question answer session.
43	Standing waves – Quarter and half wavelength lines	Lecture + question answer session.
44	Television fundamentals	Lecture + question answer session.

45	Monochrome transmission	Lecture + question answer session.
46	Scanning	Lecture + question answer
47	Composite TV video wave form	Lecture + question answer session.
48	Composite TV video wave form	
49	Monochrome reception	Discussion
50	Deflection circuits	Discussion
51	Colour Television	Discussion
52	Basic ideas of high definition TV	Discussion
53	problems	Lecture + question answer session.
53	LCD & LED TV	Lecture + question answer session.
54	Revision	Lecture + question answer session.

Text
Books:

1. Electronic Instrumentation, H.S. Kalsi, TMH (1995)
2. Transducers and instrumentation, D.V.S. Murty, PHI (1995)
3. Monochrome and Colour Television R.R. Gulati, New Age India
4. Electronic communication systems, George Kennedy, TMH

Reference Books:

1. Modern electronic Instrumentation and Measurement Techniques, A.D. Helfric& W.D. Cooper,PHI, (1997)

2. Instrumentation-Devices and Systems 2nd Edn. C.S. Rangan, G.R. Sarma, V.S.V. Mani, TMH, (1998)

3. Electronic Measurements and Instrumentation, M.B. Olive & J.M. Cage, MGH, (1975)

INDIVIDUAL ASSIGNMENTS/SEMINAR – Details & Guidelines

	Date of completion	Topic of Assignment & Nature of assignment (Individual/Group – Written/Presentation – Graded or Non-graded etc)
1	Before 1st Internal	Individual- Graded – best of 2 sets
2	Before 2nd Internal	Individual- Graded –best of 2 sets

ASSIGNMENTS– Details & Guidelines – Will be notified prior to the announcement of the assignment – marks will be scaled to 5.

SEMINARS will be given to each student (20 mins duration) – 5 marks

Assignments and Viva

	Nature of assignment and viva	**Weightage/marks**
1	Viva + assignments	10
2	Viva + assignments	10
3	Viva + assignments	10
4	Viva + assignments	10
5	Presentation + viva	10

Additional Work:

Reading session in the library: *Library reading and YouTube lectures.*