Foreword

There seems to be little knowledge among students in the School of Natural Sciences at the University of Zambia of physics-based study programs, and the job prospects associated with them. Students in the School frequently have trouble making the right career choices. Many of them have already fixed their minds on proceeding to fields like Engineering, Medicine, and Agricultural Sciences. The result is that at the end of their first year in Natural Sciences, most of the good students leave. Little are they aware that the School, and the Department of Physics in particular, offers some exciting study programs and future prospects to students that many faculties in the university cannot match. It is necessary to counteract this ignorance among students if the situation is to be rectified.

This handbook provides information on the various undergraduate and graduate programs available in the Department of Physics, and the job opportunities associated with these specialisations. This will provide students with the data necessary for them to be able to make informed and wise decisions about the kind of career for them, even as they seek to satisfy their academic interests.

This handbook highlights the various academic and professional opportunities on offer in the Department of Physics. Over the years the Department has diversified its offerings, so that in addition to the traditional areas of Solid State Physics, Nuclear Physics, Theoretical Physics and Electronics, students can take courses in the new fields of Energy and the Environment, Computational Physics and Applied Optics. Major changes have been made to the undergraduate curriculum in order to adapt to the newly-introduced semester system; in the process the courses have been completely overhauled. As well, new courses have been introduced, and this has resulted in the Physics degree becoming more flexible and attractive. In consequence, Physics graduates now have a wider variety of job prospects.

For those students who would like careers in academia and research, there are exciting academic programs and research activities in Solid State Physics (now being popularly referred to as Condensed Matter Physics), Nuclear Physics, Computational Physics, Electronics, Energy and Environment, and others. Graduates in these fields are employed in very diverse professions ranging from lecturing and teaching to research. Some have gone into instrumentation in industry, while others are working in the IT/ICT field. The training in the Department is such that graduates are successful in the job market. No one ends up being unemployed.

Special notice of first years is in order. They are enjoined to consider pursuing one of the departmental specialisations. They are encouraged to think hard about the exciting academic challenges and opportunities in the Department of Physics. Their path in the Department of Physics is assisted if they opt for the physical sciences stream during the streaming exercise in the second semester.

Second years should take note of the four different B.Sc. degree programs to choose from. These should be scrutinised carefully for the purpose of identifying the particular one that suits the career intentions of the student.

It is hoped that the third and final year-students are getting ready to put the skills they have acquired to successful use in the outside world.

The vision of the Department of Physics has always been to produce physics graduates who will play key roles in both the public and private sectors of the Zambian economy. It is the hope of the Department that it has lived up to this lofty aim.

Whether the student chooses Physics or not, the ball is in his or her court. The Department wishes every student success in his or her university endeavours. Good luck!

Head of Department
2009

Introduction to the Department of Physics

Physics is the most fundamental of the Natural Sciences. It is the parent science of Biology, Chemistry, Geology and Engineering, which are but specialisations in areas, which are ultimately a part of Physics. For this reason, the Physics Department occupies an important place in the School of Natural Sciences. A basic level of Physics is required by anyone who wishes to study any science subject or Mathematics. The purpose of the Physics first-year courses is to offer this foundation.

Students wishing to pursue Physics after first year will find various strong programmes being offered by the Department. Physics may be taken by itself or in combination with other sciences like Biology, Chemistry and Geology, as well as with Mathematics. In the past, the Department specialised in Solid State Physics, Nuclear Physics, Electronics, and Theoretical Physics. Recently it has diversified its offerings and in addition to the above-mentioned areas, the Department offers courses in the new fields of Energy and the Environment, Computational Physics, and Applied Optics.

The main specialisations on offer are:

Solid State Physics: This is one of the most exciting areas of Physics and is advancing very fast. Past developments in this field of Physics have changed our world profoundly. One or two may be mentioned. Semiconductors have led to miniaturization in electronics and ultimately facilitated the development of the computer. Solid State Physics is therefore at the base of the information revolution. Superconductors, which are substances which exhibit no electrical resistance in certain temperature regions, have been known to physicists since the beginning of the last century, but are now exciting great interest because the temperatures at which they possess this property have become higher. Such materials will make possible, among other things, magnets strong enough to levitate trains, and the storage of electricity until it is needed. These developments are certain to result in another revolution. Students opting for this specialisation will be able to participate directly in this revolution.

Nuclear Physics: This is good for more than making weapons of mass destruction. Not only is the study of Nuclear Physics fascinating, but the field has many peaceful applications. Cancer patients are routinely treated with radiotherapy. Dating by means of radioactive nuclides is an indispensable tool in Geology and Archaeology. Food can be preserved for long periods after irradiation. The list of such applications is endless. The Physics Department conducts research into the beneficial exploitation of Nuclear Physics. Graduates in this field are much in demand, especially by the National Institute for Scientific and Industrial Research (NISIR) locally, and the International Atomic Energy Agency (IAEA) internationally.

Computational Physics: Courses in this field of Physics are offered at the third- and the fourth-year levels. The programme is unique in the region and offers courses that teach the basics of computers, programming, and the numerical solution and modelling of practical problems. Students taking them will have the opportunity of practical experience in computing in the Computational Physics Laboratory. They will be exposed to modern software packages such as Word, Excel, CAD, those for web applications, and programming languages such as Fortran-77 and C++. In this age of computers, these courses are highly contemporary and will open the gates to a wide spectrum of job opportunities in the computer and IT/ICT fields. The organisations interested in graduates having the skills imparted by this programme include software firms, computer firms, banks, the mining sector, NISIR, schools, universities, and all those establishments involved in intensive computer use. Nowadays, computer literacy is almost always a requirement for a good job and higher studies.

Electronics: This is an important specialisation, which lays the foundation for the understanding of many of the great technical developments of modern times. The fundamentals of how measuring instruments, computers, robots, etc., work are taught. The courses are highly applied and so prepare the student directly for the use of electronics in the real world. The courses stress the basics so well that graduates in this specialisation have often been preferred to engineers by employers. A total of four courses are offered in electronics at the third- and the fourth-year levels. Graduates in this field will find exciting employment opportunities in such areas as telecommunications, broadcasting, computer hardware manufacturing, and control of industrial processes.

Theoretical Physics: This is an option offered to those who have a stronger interest in the academic side of Physics and offers a high degree of intellectual stimulation. Students taking it may wish to pursue an academic career after graduation. However, they will still be in demand in the job market. Such organisations as the National Institute for Scientific and Industrial Research (NISIR), the Environmental Council of Zambia, the Radiation Protection Board (at the University Teaching Hospital), the Zambia Bureau of Standards, the Zambia Consolidated Copper Mines, Chilanga Cement, and TAP Building Products are interested in such graduates.

Energy and Environmental Physics: This will bring students in touch with some of the most challenging developmental problems and issues of our time. In this specialisation, students are taught the fundamentals and applications of solar energy, as well about the other renewable sources of energy: wind, biomass, and hydroelectricity. The courses provide an introduction to the very topical environmental problems of global warming and ozone depletion. The organisations interested in graduates in this discipline include the Energy Department, the Environmental Council of Zambia, the Ministry of Environment, the Department of Meteorology, and the National Institute for Scientific and Industrial Research (NISIR).

Applied Optics: This course is yet another new offering. Applications of optics have grown at a phenomenal pace in recent decades. Optical fibre technology has ushered in the age of fast communications. Lasers are now widely used in industry, computers, medicine, scientific research, and in home entertainment. Holography, one of the branches of optics, is used in producing three-dimensional images, in non-destructive testing, and in information storage. The optics course at fourth-year level teaches the fundamentals of these exciting developments.

The reorganisation of the courses offered by the Department went hand in hand with a review of the teaching and examination policy. As a result of these improvements, substantially better student performance in examinations is being recorded.

Recently, collaboration with certain South African universities has opened up opportunities for Physics graduates. In particular, graduates with good grades have a chance to do an extra year of study in Astrophysics at the University of Cape Town (South Africa) in order to qualify for an Honours degree. Thereafter, they can pursue a Masters degree in Astrophysics, and if they wish they can go on to do a Ph.D. Such a qualification gives the students international marketability, and the chance to participate in the exciting developments currently going on in the field of Cosmology.

Collaboration with the University of Cape Town in the field of climate change, and with Ben Gurion University (Israel) in the field of solar energy has enabled some physics graduates to embark on Masters degree programmes with the possibility of a Ph.D. later.

Research projects are also an essential component of the physics programme. They are sometimes mandatory in order for a student to fulfil the requirements for the award of the B.Sc. degree. The Department therefore offers a variety of exciting final year undergraduate research projects. Through the various research groups, Physics students can undertake research in solar energy materials. In addition, the Department offers research experiments in solar radiation measurements on photo-voltaic (PV) modules and the design and construction of instruments like temperature controllers, inverters and charge controllers. Also on offer is very challenging computer interface research work involving applications of electronics and computational physics. The nuclear physics laboratory offers work in energy dispersive X-ray fluorescence (XRF) experiments in elemental sample analysis. These and many more make the Physics Department quite unique in the provision of real academic activity.

Finally, it is worth stressing again that graduates of the Department of Physics have not had problems with getting into employment because of the applied nature of the degree programmes.

As can be gathered from what has been said above, the Physics Department offers very exciting opportunities for students. Students opting to join the Department are assured of both intellectual stimulation and job marketability when they graduate.

Students considering joining the Department should see the Head of Department or indeed any member of academic staff for further information.

DEPARTMENT OF PHYSICS

Main Office, Room 523 **Telephone: 290429. UNZA extension 2514.**

Academic Staff

Head of Department and Senior Lecturer	Qualifications	Extension
Mweene, H. V.	B.Sc., M.Sc.(UNZA), Ph.D.(Surrey), MSAIP	
Professor		
Jain, P. C.	B.Sc.(Hons.), M.Sc., Ph.D.(Delhi), MInstP.	
Associate Professor		
Kaloyerou, P. N.	B.Sc.(Salford), M.Sc., Ph.D. (London)	
Senior Lecturer		
Hussain, M. M.	B.Sc.(Hons.), M.Sc.(Karachi), Ph.D.(Louvain)	
Lecturer I		
Chishimba, G. M.	B.Sc.(UNZA), M.Sc.(Wis.), Dip.(NUS)	
Kalebwe, P. C.	B.Sc.(UNZA), M.Sc.(Birmingham)	
Munyeme, G.	Dip.Ed.(Zambia), M.Sc.(St. Petersburg), Ph.D.(Utrecht)	
Lecturer II		
Habanyama, A.	B.Sc., M.Sc.(UNZA), Ph.D.(Cape Town)	
Hansingo, K	B.Sc.(UNZA), M.Sc.(Cape Town), Ph.D.(Cape Town)	
Hatwaambo, S.	Dip.Ed.(Nkrumah), B.Sc.(Ed.),M.Sc., Ph.D.(UNZA)	
Mbewe, D. J.	M.Sc.(St. Petersburg)	
Mwiinga, N	B.Sc.Ed.(UNZA), M.Sc.(Ben Gurion)	
Rajan, R.	B.Sc., M.Sc.(Kerala), Ph.D.(Mahatma Gandhi Univ.)	
Lecturer III		
Mudenda, S.	B.Sc.(UNZA), M.Sc.(WesternCape)	
SDF		
Mulindwa, L.	B.Sc.(UNZA), Dip.(ICTP)	
Banda, Y.	B.Sc.(UNZA),	
Mwalaba, M	B.Sc.(UNZA),	
Mwalaba, M	B.Sc.(UNZA),	
Pumulo, N	B.Sc.(UNZA),	
Wamunyima, N	B.Sc.(UNZA),	

Secretarial Staff

Chindefu, V.	Secretary	Extension: 2514

Technical Staff

Wazili, D.	Adv Cert, C&G I,II,III SLT, Dip. Comp. Int.	Chief Technician
Changwe, B. C.	Adv Cert, C&G II SLT, Dip. SLT	Senior Technician
Mbewe, B.	Adv Cert, C&G I SLT, Dip. SLT	Senior Technician
Chibwe, W.	Adv Cert SLT, Dip. SLT	Senior Technician
Musa, K. C.	Adv Cert SLT, Dip. SLT, BSc-Physics	Technician I
Musonda, F. L.	Adv Cert SLT, Dip. SLT	Technician II
Mushoke, D. S.	Adv Cert SLT, Dip. SLT	Technician II
Chinyama, M.	Adv Cert SLT	Technician II
Bundala, E.	Craft Certificate	Technician II
Mwansa, G.	Adv Cert SLT	Technician II

Technical Staff (Natural Sciences Workshop)

Chanda, G. M.	Higher National Dip.(UK); Cert (UK)	Chief Technician
Njobvu , J	Adv Cert SLT, Dip. SLT	Senior Technician
Munyukwa, C.	Crafts Cert; Cert (IAEA, Vienna)	Technician I
Funda, P.	Crafts Certificate	Technician II
Yabalwashi, G.	Crafts Certificate	Carpenter II
Phiri, N.	Trade Test Certificate	Carpenter II

Overview of Programmes

The Department of Physics is currently offering the following courses to students pursuing a degree in Physics. Depending on circumstances, a given course may not be available in a given year. Students are advised to check with the Department before registering for a given course. Some of the courses have an associated laboratory course. Normally, the grading of a course has a continuous assessment (C.A.) component and a final-examination component. The laboratory course marks are incorporated into the continuous assessment. Below is the full list of courses offered by the department together with the division of marks between continuous assessment and the final examination. It is important for students to understand that where a course has a laboratory component associated with it, the student has to pass this independently of the theory, with a minimum mark of 40%.

		Assessment %	
Course Code	**Course Name**	**Exam.**	**C.A.**
P191	Introductory Physics-I	50	50
P192	Introductory Physics-IIA or	50	50
P198	Introductory Physics-IIB	50	50
P251	Classical Mechanics I	60	40
P252	Classical Mechanics II & Special Relativity	60	40
P261	Electricity & Magnetism	60	40
P212	Atomic Physics	60	40
P231	Properties of Matter & Thermal Physics	60	40
P272	Optics	60	40
P302	Computational Physics I	50	50
P332	Statistical and Thermal Physics	60	40
P341	Introduction to Electronics	50	50
P342	Digital Electronics I	50	50
P351	Quantum Mechanics I	60	40
P361	Electromagnetic Theory	60	40
P401	Computational Physics II	50	50
P411	Nuclear Experimental Techniques	60	40
P412	Nuclear Physics	60	40
P421	Solid State Physics I	60	40
P422	Solid State Physics II	60	40
P441	Analogue Electronics	50	50
P442	Digital Electronics II	50	50
P455	Quantum Mechanics II	70	30
P452	Selected Topics in Theoretical Physics	70	30
P475	Applied Optics	60	40
P485	Physics of Renewable Energy Resources and Environment	60	40
P495	Special Project	50	50
MP415	Mathematical Methods for Physics	70	30

DEGREE STRUCTURE IN PHYSICS

The following course combinations are available for the various degree options:

Physics may be offered as a single subject, or it may be combined with other subjects. Candidates opting for the Physics Single-Subject Major must have the approval of the Head of Department.

Year 1: P191/192, M 111/112, C 101/102, BIO 1011/1012 (option A) or
P 191/198, M 111/114, C 101/102 (option B)

	S.S.Major	**Phys/Maths**	**Chem/Phys(minor)**	**Phys/Geology**
Year 2:	M211/212	M211/212	M211/212	M211/212
	P251/252	M221/222	C205/265	P251/252
	P261/212	P251/252	C251/252	P261/212
	P231/272	P261/212	P261/212	GG201/202
Year 3:	M911/912	M911/912	P251/252	P231/272
	P351/302	M261/292	C341/342	P341/342
	P361/332	P351/302	C361/362	SE481
	P341/342	P231/272 or	C351/352 or	GG311/312
		P341/342	C321/322	GG335
Year 4:	MP415	M335/325	P361/302 or	P361
	P411 and/or	M411/412	P341/342	GG435
	P421		C461/462	GG442
				GG551
				GG581
	+ 4/5 from	+ 2 from	+ 4 from	+ 3 from
	P401	P361/332	C421/422	P332
	P411/412	P401/455	C441/442	P441
	P421/422	P401/485	C451/452	P442
	P441/442	**or**	C481/482	
	P455	P361/332	C491/492	
	P452	P411/412		
	P475	P441/442		
	P485	P401/485		
	P495	P401/455		

First Year Programmes:

For all course combinations, the curriculum for the first year is as follows:

First Semester:

BIO1011	Cell Biology & Genetics
C101	Introduction to Chemistry I
M111	Mathematical Methods I
P191	Introductory Physics I

Second Semester:

Option A		**or** **Option B**	
BIO1012	Systems Biology	C102	Introduction to Chemistry II
C102	Introduction to Chemistry II	M114	Mathematical Methods IIB
M112	Mathematical Methods IIA	P198	Introductory Physics IIB
P192	Introductory Physics IIA		

Post-first year programmes:

PHYSICS (SINGLE - SUBJECT MAJOR)

Second Year:

Semester I		Semester II	
M211	Mathematical Methods III	M212	Mathematical Methods IV
P251	Classical Mechanics I	P252	Class. Mech. II & Special Relativity
P261	Electricity & Magnetism	P212	Atomic Physics
P231	Prop. of Matter & Thermal Physics	P272	Optics

Third Year:

Semester I		Semester II	
M911	Mathematical Methods V	M912	Mathematical Methods VI
P351	Quantum Mechanics I	P302	Computational Physics I
P361	Electromagnetic Theory	P332	Statistical and Thermal Physics
P341	Introduction to Electronics	P342	Digital Electronics I

Fourth Year:

	Semester I		Semester II	
	M411	Theory of Functions. of Complex Vars. I	M412	Th. of Functions of Complex Variables II
or	MP415	Math. Methods for Physics	(not required	if MP415 is offered)
	P411	Nuclear Exptl. Techniques	**plus 3 from:**	(if M411/M412 are offered)
	and/or			
	P421	Solid State Physics I	**plus 4 from:**	(if MP415 is offered)
			P412	Nuclear Physics
Any 1 or 2 courses from:	P401	Computational Physics II	P422	Solid State Physics II
	P411	Nuclear Exptl. Techniques	P442	Digital Electronics II
	P421	Solid State Physics I	P485	Phy. of Ren. Energy Res. & Environment
	P441	Analogue Electronics	P475	Applied Optics

P455	Quantum Mechanics II	P452	Sel.Topics on Theor. Physics
		P495	Special Project

PHYSICS/MATHEMATICS (TWO-SUBJECT MAJOR)

Second Year:

	Semester I		Semester II	
	M211	Mathematical Methods III	M212	Mathematical Methods IV
	M221	Linear Algebra I	M222	Linear Algebra II
	P251	Classical Mechanics I	P252	Class. Mech. II & Sp. Relativity
	P261	Electricity & Magnetism	P212	Atomic Physics

Third Year:

	Semester I		Semester II	
	M911	Mathematical Methods V	M912	Mathematical Methods VI
	M261	Intro to Statistics	M292	Intro to Probability
	P351	Quantum Mechanics I	P302	Computational Physics I
Either	P231	Prop. of Matter & Thermal Physics	P272	Optics
Or	P341	Introduction to Electronics	P342	Digital Electronics I

Fourth Year:

	Semester I		Semester II	
	M411	Theory of Functions of Complex Vars. I	M412	Th. of Functions of Comp. Vars.II
	M335	Topology	M325	Intro to Group & Ring Theory
	+ 2 from:			
	P361	Electromagnetic Theory	P332	Statistical and Thermal Physics
	P401	Computational Physics II	P455	Quantum Mechanics II
	P401	Computational Physics II	P485	Phy.of Ren.Energy Res.& Environment
	Or			
	P361	Electromagnetic Theory	P332	Statistical and Thermal Physics
	P411	Nuclear Experimental Techniques	P412	Nuclear Physics
	P401	Computational Physics II	P455	Quantum Mechanics II
	P401	Computational Physics II	P485	Phy.of Renewable Energy Res.& Environment
	P441	Analogue Electronics	P442	Digital Electronics II

CHEMISTRY(major) - PHYSICS(minor)

Second Year:

	Semester I		Semester II	
	C205	Analytical & Inorganic Chemistry	C265	Basic Physical Chemistry
	P261	Electricity & Magnetism	P212	Atomic Physics
	M211	Mathematical Methods III	M212	Mathematical Methods IV
	C251	Organic Chemistry I	C252	Organic Chemistry II

Third Year:

	Semester I		Semester II	
	C361	Chem.Kinetics & Nuclear Chemistry	C362	Colloids & Electrochemistry
	C341	Inorganic Chemistry II	C342	Inorganic Chemistry III
	P251	Classical Mechanics I	P252	Class. Mech.II & Sp. Relativity
Either	C321	Analytical Chemistry II	C322	Analytical Chemistry III
Or	C351	Organic Chemistry III	C352	Organic Chemistry IV

Fourth Year:

	Semester I		Semester II	
	C461	Quant. Mech. & Mol. Spectro.	C462	Stat. Mech. & Thermodynamics
Either	P341	Introduction to Electronics	P342	Digital Electronics I
Or:	P361	Electromagnetic Theory	P302	Computational Physics I
Any 2 chemistry	C421	Appl. Analytical Chem.(Inorganic)	C422	Appl. Analyt. Chem. (Organic)
courses from:	C481	Inorganic Industrial Chem. I	C482	Inorganic Industrial Chem. II
	C491	Organic Industrial Chem. I	C492	Organic Industrial Chem. II
	C441	Adv. Inorganic Chemistry I	C442	Adv. Inorganic Chemistry II
	C451	Adv. Organic Chemistry I	C452	Adv. Organic Chemistry II

PHYSICS/GEOLOGY (TWO-SUBJECT MAJOR)

Second Year:

Semester I		Semester II	
M211	Mathematical Methods III	M212	Mathematical Methods IV
P251	Classical Mechanics I	P252	Class. Mech. II & Sp. Relativity
P261	Electricity & Magnetism	P212	Atomic Physics
GG201	Introduction to Geology	GG202	Physical Geology

Third Year:

Semester I		Semester II	
P231	Prop. of Matter & Thermal Physics	P272	Optics
P341	Introduction to Electronics	P342	Digital Electronics I
SE481	Introduction to Land Surveying	GG312	Mineralogy & Petrology
GG311	Crystallography & Mineralogy	GG335	Structural Geology I

Fourth Year:

Semester I		Semester II	
P361	Electromagnetic Theory	GG442	Econ.Geol.of Metalf. Ore Deposits
GG551	Explor. Mining Geol.& Management	GG435	Str. Geol.II & Plate Tectonics
GG581	Applied Geophysics	P332	Statistical Physics
P441	Analogue Electronics	P442	Digital Electronics II

Key to Course Codes:

Starting with 1	First Year	Ending with 1	First Semester
Starting with 2	Second Year	Ending with 2	Second Semester
Starting with 3	Third Year	Ending with 4	Second Semester
Starting with 4	Fourth Year	Ending with 8	Second Semester
Starting with 9	$3^{rd}/4^{th}$ Year	Ending with 5	Either Semester

COURSE DETAILS

P191: INTRODUCTORY PHYSICS I

Rationale:

Physics is one of the four compulsory courses at the entry point in the School of Natural Sciences. The student is expected to learn Physics at a level higher than that he/she encountered in the High School, learning the basic concepts.

Objectives:

At the end of this course the student should have acquired sufficient knowledge of the basic concepts of Physics to allow her/him to continue studies at higher levels in any branch of science.

Course Content:

Vectors and their use; uniformly accelerated motion; units; Newton's laws; work and energy; linear momentum; motion in a circle; rotational work, energy and momentum; static equilibrium; mechanical properties of matter; gases and the kinetic theory; thermal properties of matter; thermodynamics; vibration and waves.

Time allocation: Lectures: 3 hrs/week. Tutorial: 1 hr/week. Lab: 3 hrs/week
Assessment: Continuous Assessment: 50%, Final Examination: 50%.

Recommended Textbook:

F. J. Bueche, D. A. Jerde, Principles of Physics 6th ed., McGraw-Hill, 1995. ISBN: 13.978-00700

P192: INTRODUCTORY PHYSICS II (Option A: Life Sciences)

Rationale:

This course is a continuation from the first semester. However, it is meant specifically for students intending to pursue higher studies in Life Sciences.

Objectives;

At the end of this course, the student is expected to have learned basic skills in Physics that would be required to pursue higher studies in any branch of science, especially the Life Sciences.

Course Content:

Sound; electric forces and fields; electric potential; direct-current circuits; magnetism; electromagnetic induction; alternating currents and electronics; e.m. waves; properties of light; optical devices; interference and diffraction; three revolutionary concepts; energy levels and spectra; the atomic nucleus; physics of the very large and very small; energy and environment.

Time allocation: Lectures: 3 hrs/week. Tutorial: 1 hr/week. Lab: 3 hrs/week.

Assessment: Continuous Assessment: 50%. Final Examination: 50%.

Recommended Textbook:

F. J. Bueche, D. A. Jerde, Principles of Physics 6th ed., McGraw-Hill, 1995. ISBN: 13.978-00700

P198: INTRODUCTORY PHYSICS II (Option B: Physical Sciences)

Rationale:

This course is meant for students pursuing higher studies in Physical Sciences, including various branches of Engineering. There are more contact hours, allowing for the teaching of more material in greater detail.

Objectives:

At the end of this course, the student is expected to have learned basic skills in Physics that would be required to pursue higher studies especially in Physical Sciences, including Engineering.

Course Content:

Fluid mechanics, molecular properties of matter, sound; electric forces and fields; electric potential; direct-current circuits; magnetism; electromagnetic induction; alternating currents and electronics; e.m. waves; properties of light; optical devices; interference and diffraction; three revolutionary concepts; energy levels and spectra; the atomic nucleus; physics of the very large and very small; energy and environment.

Time allocation: Lectures: 5 hrs/week. Tutorial: 2 hrs/week. Lab: 3 hrs/week.

Assessment: Continuous Assessment: 50%. Final Examination: 50%.

Recommended Textbook:

F. J. Bueche, D. A. Jerde, Principles of Physics 6^{th} ed., McGraw-Hill, 1995. ISBN: 13.978-00700

P251: CLASSICAL MECHANICS I

Rationale:

Classical mechanics is one of the foundation stones of all physics. A thorough understanding of it is essential to the successful assimilation of modern physics. Both quantum mechanics and relativity, which underlie higher-level physics, have to be studied in a context that emphasizes that in an appropriate limit, they reduce to classical mechanics. P251: Classical Mechanics I gives a comprehensive introduction to all the major areas of classical mechanics.

Objectives:

After attending this course, the student should be able:
1. to solve problems in mechanics involving Newton's laws of motion
2. to solve standard problems in dynamics and the kinematics of a particle and a system of particles using vector methods.

Course Content:

1. Vectors and calculus-based treatment of problems in kinematics and dynamics of a particle. 2. Newton's laws in vector form. 3. Friction, work energy and potential. 4. Conservative forces, collisions. 5. Rigid body dynamics. Gravitation.

Associated Laboratory : P251

Time allocation: 3 one hour lectures/week, 1 one hour tutorial/week, 1 three hour lab/week

Assessment: Continuous Assessment. 40%, (labs 15%, Tests 20% and Assignments 5%)
Final examination. 60%

Pre-requisites: M111, M112/M114, P191, P192 Co-requisite: M211

Prescribed Texts:

1. C. D. Collinson, Introductory Mechanics, Edward Arnold, London, 1980. ISBN:0 7131 2786 4

Recommended Texts:

1. K. R. Symon, Mechanics, Addison-Wesley, 1971. ISBN:13:9780070350489
2. G. Sposito, An Introduction to Classical Mechanics, J. Wiley and Sons, 1976. ISBN:13:9780201029185
3. R. Grant and C. L. George, Analytical Mechanics, Brooks/Cole, USA, 1999. ISBN:0-03-022 317-2

P252: CLASSICAL MECHANICS II AND SPECIAL RELATIVITY

Rationale:

The initial stage in the development of classical mechanics is often referred to as Newtonian mechanics. More abstract and general methods include Lagrangian mechanics and Hamiltonian mechanics. Some sources exclude relativistic mechanics from the category of classical mechanics. However, a number of modern sources do include it, which in their view represents classical mechanics in its most developed and most accurate form. Among other aspects of mechanics, this course gives an introduction to the use of the Lagrangian and the Hamiltonian. It also introduces relativistic mechanics.

Objectives:

To provide students with the knowledge to be able:
1. to solve problems in oscillations (damped and undamped)
2. to solve standard problems in dynamics and the kinematics of a particle and a system of particles, through the use the Langrangian and the Hamiltonian.
3. to solve problems in relativistic mechanics.

Course Content:

1.Oscillations: damped and forced oscillations; resonance and coupled oscillations. 2. Waves: solutions of the wave equation; waves in media. 3. Introduction to analytical mechanics, and 4.Elements of the special theory of relativity.

Associated Laboratory : P252

Time allocation: 3 one hour lectures/week, 1 one hour tutorial/week, 1 three hour lab/week

Assessment: Continuous assessment: 40%, (labs 15%, Tests 20% and Assignments 5%)

Final Examination 60%

Pre-requisites: M111, M112/M114, P191, P192, P251..Co-requisite : M212

Prescribed Texts:

1. C. D. Collinson, Introductory Mechanics, Edward Arnold, 1980. ISBN: 0 7131 2786 4
2. A. P. French, Special Relativity, Van Nostrand Reingold, 1980. ISBN: 10:0393697935

Recommended Texts:

1. K. R. Symon, Mechanics, Addison-Wesley, 1971. ISBN: 10:0070350485
2. G. Sposito, An Introduction to Classical Mechanics, J. Wiley and Sons, 1976. 10:0201029189
3. R. Grant and C. L. George, Analytical Mechanics, Brooks/Cole, USA, 1999. ISBN: 0-03-022 317-2

P261: ELECTRICITY AND MAGNETISM

Rationale:

Electricity and magnetism forms the basis of important disciplines such as electrical and electronic engineering. The electromagnetic force is one of the fundamental forces of nature and is responsible for such phenomena as chemical bonding and electrostatics. Electromagnetic waves are the means by which telecommunications is accomplished. Sciences such as optics are studied on the basis of electromagnetism.

Objectives:

At the end of attending the course, the student should acquire:
1. an understanding of basic electromagnetic concepts that are required to solve problems in electrostatics, magnetism, and direct- and alternating-current circuits;
2. an understanding of the basis on which several electrical and electronic instruments such as oscilloscopes and potentiometers are based;
3. the basic skills needed in the measurement of quantities in physics experiments and the analysis of the data so obtained.

Course Content:

1. Electrostatics: Electric charge and Coulomb's law of electronic forces. The electric field, E and the electric potential, V. Capacitance and dielectrics.

2. Current and circuits. Electric current.
Resistance, Resistivity; series and parallel resistors. Ohm's law. Voltage and current divider rules.

3. The Magnetic field: law of Biot and Savart. Ampere's law. Induced electromotive force, emf (Faraday's law).

4. Transients in electric circuits: Alternating current circuits: rms values. RL, RC and RCL circuits.

5. The transformer. Transformer equation. Step-up and step-down transformers.

Associated Laboratory : P261

Time allocation: 3 one hour lectures/week, 1 one hour tutorial/week, 1 three hour lab/week
Assessment: Continuous assessment: 40%, Final Examination 60%

Pre-requisites: M111, M112/M114, P191, P192/P198. Co-requisite: M211

Prescribed Texts:

1. A. Kip, Electricity and Magnetism, McGraw-Hill, 1969. ASIN: BOOO7E60GW

Recommended Texts:

1. D. Halliday and R. Resnick, Physics Parts I & II, John Wiley and Sons, 1978. ISBN: 471097128
2. W. J. Duffin, Electricity and Magnetism, McGraw-Hill, 1980. ISBN: 13-978-0077072094

P212: ATOMIC PHYSICS

Rationale:

Many problems of interest in modern physics involve interactions between microscopic particles such as atoms and molecules. For example the modification of magnetic effects produced by currents in the presence of matter can be attributed to the circulating currents which produce atomic magnetic dipole moments within matter. The sources of this effect are the circulating currents which produce atomic magnetic dipole moments within matter. All magnetic effects of matter may be understood on the basis of current loops or their magnetic dipoles. Another case involving microscopic interactions is the production of visible light from gases. Atomic and nuclear physics provides a transition from classical to quantum mechanics and relativity. For students who may not be able to continue with higher level physics, this is the only course in which they will encounter the basic theory of electromagnetic waves such as x-rays and gamma rays. For many of them, the practical use of electromagnetic rays is a large component of their studies. X-rays and gamma rays are thus of interest to medical students because of their use in medical diagnostics. Agriculture, mining and veterinary students encounter radio-physics in various departments of their specializations.

Objectives:

At the end of attending the course, the student should acquire:
1. an understanding of the basic concepts of magnetism in matter;
2. an understanding of the basic concepts upon which modern physics is based;
3. an introduction to atomic and nuclear physics and their applications.

Course Content:

1.0 Magnetism in matter. Modification of magnetic fields produced by currents.
Magnetization, *M*. Free and bound currents. magnetic field intensity, *H*
Magnetic susceptibility χ_m and magnetic permeability μ_m. Paramagnetic, diamagnetic, and ferromagnetic materials and how they differ.

2.0 Atomic view of solids and radiation

Thomson and Rutherford atomic models; their failures and successes; black-body radiation; Stefan's, Wien's displacement and the Rayleigh-Jean law; Planck's radiation law and the quantum equation. The photoelectric effect . Optical spectra; emission and absorption lines; the spectrometer. Hydrogen emission spectrum. The Bohr model; atomic orbits; energy levels. The Pauli exclusion principle.

3.0 X-rays

Nature of X-rays. X-ray wave-lengths; X-ray production; the X-ray tube; X-ray spectrum: emission spectra and the continuous spectrum. X-ray diffraction. Energy levels. Moseley's law. Properties of X-rays. Absorption of X-rays: photo-effect; the Compton effect; pair production. the de Broglie hypothesis; the uncertainty principle;

4.0 Radioactivity

The phenomena of radioactivity. Radiations released in radioactive decay and their properties; Natural and artificial radio-activity. Radiation detectors. Law of radioactive decay; "decay constant", "half-life" and "mean life". Alpha, beta and gamma decays. Radioactive decay series. Nuclear reactions: "incident particles", "target nuclei" "outgoing particle" and "recoil-nucleus". Kinematics of nuclear reactions. "Q-value" in a nuclear reaction. Fusion and fission.

Associated Laboratory: P212

Time allocation: 3 one hour lectures/week, 1 one hour tutorial/week, 1 three hour lab/week

Assessment: Continuous assessment: 40%,   Final Examination 60%

Pre-requisites: M111, M112/M114, P191, P192/P198. Co-requisite: M212

Prescribed Texts:

1. M. R. Wehr, J. A. Richards and T. W. Adair, Physics of the Atom, Addison-Wesley, 1994. ISBN 10:0201088789
2. A. F. Kip, Fundamentals of Electricity and Magnetism, McGraw-Hill, Kogakusha Ltd. ASIN: B0007E60GW

Recommended Texts:

1. S. T. Thornton, Modern Physics for Scientists and Engineers, 2nd ed., Thomson Learning, 2002. ISBN 0-03-006049-4
2. A. J. Dekker, Electrical Engineering Materials, Prentice Hall of India, 2005. ISBN 0:9880333918333

P231: PROPERTIES OF MATTER AND THERMAL PHYSICS

Rationale:

The course P231 is one of the second-year core courses. It consists of two parts - namely, properties of matter and thermal physics. The combination of these two topics in one course has the advantage of a course that equips the student with the knowledge of the basic principles in these topics. The course thus prepares the student for further studies in Statistical Physics and Solid State Physics.   It is hoped that in future P231 will be further subdivided into two courses devoted to properties of matter and to thermal physics.

Objectives:

At the end of attending the course, the student should acquire:
1. an understanding of the basic concepts of mechanical properties of matter and thermal physics,
2. an understanding of the laws of thermodynamics and of properties of gases.

Course Content:

Properties of Matter: Viscosity of liquids and gases; Definitions; Bernoulli's equation; Surface tension; Definitions; Capillarity; Excess pressure; Curved surfaces; Elasticity; Modulus of elasticity; Torsional rigidity; Bending of beams and plasticity; Fracture

Thermal Physics: Thermal expansion and thermal conductivity; Specific heat and latent heat; Kinetic theory of gases; Bulk properties of real gases; Entropy and the second law.

Associated laboratory.

Time Allocation: Lectures 3 hrs/week; Tutorial 1hr/week; Lab 3 hrs/week

Assessment:

Continuous assessment, 40%; Final examinations, 60%

Prerequisites: P191, P192/P198, M111, M112/M114

Co-requisite: M211

Prescribed Texts:

1. M. W Zemansky and R. H. Dittman, Heat and Thermodynamics, McGraw Hill, 1981. ISBN: 13:978-0071223041
2. F.H. Newman and V. H. L Searle, The General Properties of Matter, Edward Arnold, 1965. ISBN: 13:978-071312119365

P272: OPTICS

Rationale:

Optics is a branch of physics dealing with the properties and nature of light. Its basic applications are used in all branches of science, technology and engineering. New developments in optics have increased the importance of optics and its applications.

Objectives:

At the end of attending the course, the student should acquire:

1. an understanding of the basic concepts of geometrical and physical optics,
2. an introduction to basic optical instruments and their working principles.

Course Content:

Geometrical Optics: 1. Lenses and aberrations, 2. Prisms and prism instruments; dispersion, Physical Optics: 3. Interference, 4. Diffraction, 5. Polarisation, and 6. Electro and magneto optics; quantum optics and lasers.

Associated Laboratory: P272

Time allocation: 3 one hour lectures/week, 1 one hour tutorial/week, 1 three hour lab/week

Assessment: Continuous assessment: 40%, Final Examination 60%

Pre-requisites: M111, M112/M114, P191, P192

Co-requisite: M212

Prescribed Texts:

1. A. Jenkins and H. Elliot, Fundamentals of Optics, McGraw-Hill, 1981. ISBN: 10:0070323305
2. F. G. Smith and J. H. Thompson, Optics, John Wiley, 1988. ISBN: 13:978-0471915348

Recommended Text:

1. R. S. Longhurst, Geometrical and Physical Optics, Longman, 1986. ISBN: 13:978-0582440999

P351: QUANTUM MECHANICS I

Rationale

Quantum mechanics is the most fundamental theory of physics and has the widest range of applicability. It is the cornerstone of any physics degree programme. Therefore a good introduction to the subject is essential for physics students. A thorough grasp of it is necessary for almost all postgraduate work. P351 aims to introduce the basics of quantum mechanics to the student in a way that lays a foundation for further study of the subject and for its use in other areas of physics.

Objectives

At the end of this course, the student should have learned:

1. The failings of classical physics and the need for quantum concepts
2. How quantum mechanics resolves problems that confounded classical mechanics
3. The basic principles of quantum mechanics
4. How to apply quantum mechanics in simple situations
5. The student should be ready for more advanced concepts in quantum mechanics.

Course Content:

Origins of quantum theory: Wave-particle duality; black-body radiation; Compton effect; photoelectric effect; atomic spectra and Bohr model; the correspondence principle; the de Broglie hypothesis and electron diffraction.

Wave packets and the uncertainty relations: The wave function; superposition; wave packets and group velocity; the Heisenberg uncertainty principle and examples.

The one-dimensional Schrödinger equation and applications: Time dependent and time-independent Schrödinger equation; eigenvalues and eigenfunction; one-dimensional examples; normalization; quantum mechanical tunnelling; the harmonic oscillator.

Basic postulates and formalism of quantum mechanics: The wave function; dynamical variables and operators; Hermitian operators; expansion in eigenfunctions; commuting observables; compatibility.

Angular momentum in quantum mechanics: Angular momentum operators; eigenvalues and eigenfunctions; experimental demonstration of angular momentum quantization; general solution of the eigenvalue problem; matrix representation; spin and Pauli exclusion principle.

Three-dimensional Schrödinger equation: The wave equation; separation in Cartesian coordinates; separation in spherical polar coordinates; the radial equation; application to the hydrogen atom; degeneracy.

Time Allocation:

Lectures: 3 hrs/week, Tutorial: 1 hr/week

Lab: Associated laboratory of 3 hrs/week

Assessment:

Continuous assessment: 40%, Final Examination: 60%

Pre-requisites: P251, P252, P261, P212, M211, M212
Prescribed Texts

1. B. H. Bransden and C. J. Joachain, Introduction to Quantum Mechanics, ELBS, 1989, ISBN: 0-582-44498-5

2. S. Gasiorowicz, Quantum Physics, J. Wiley & Sons, 1971, ISBN: 0 471 29281-8

Recommended Texts:

1. A. I. M. Rae, Quantum Mechanics, Institute of Physics Publisher, 1993, ISBN: 13:9780750302173

P302: COMPUTATIONAL PHYSICS I

Rationale:

In recent years the availability of powerful micro-computers has changed the approach to the method of study in physics. In many countries the use of micro-computers is encouraged even at high school levels. In its own right, the use of computers led to an applied branch of physics known as Computational Physics. This branch of physics is one of the core subjects taken by every student of Physics in many universities. It has become essential in preparing students intending to study fields of Physics like Energy and Environment that require modelling and simulation skills. On the other hand the study of Computational Physics helps a student of Physics in terms increasing job opportunities.

Objectives:

To:
1. provide the student with knowledge of the higher level programming languages which are currently used in Physics e.g. C++ and C#.
2. introduce the use of a computer as a tool for solving Physics problems by the use of numerical methods and simulation techniques.

Course Content:

1. Introduction to computer architecture and peripherals. Introduction to software tools: Word processing and graphics usage. Basics of structured programming and computation: All fundamental aspects of the currently used programming languages in Physics, computational arithmetic, precision and propagation of errors (computational and numerical).

2. Solutions of non-linear equations: Newton-Raphson method with applications to physical problems, e.g., van der Waals equation and phase transitions. Solution of non-linear equations in relation to fractals, chaos and basins of attraction.

3. Least Squares Fit: Linear fitting of experimental data, mean and variance in relation to best fit and experimental errors.

4. Numerical Integration: Trapezoidal, Simpson and Romberg methods with applications to physical problems, e.g., van der Waals equation and work done. Introduction to the Monte Carlo method of integration.

5. Linear Equations: Gauss's method, LU Factorization, Gauss-Jordon method, Gauss-Seidel method and ill-conditioned equations with application to physical problems.

6. Ordinary Differential Equations: Euler, Runge-Kutta methods with application to physics problems, e.g., square-well potentials, radioactive decay and the two-body problem.

Time Allocation: Lectures: 3 hrs/week. Tutorial: 1 hr/week Lab: Associated Practical Computing Class.

Assessment: Labs: 30%, Tests: 20%, Final Examination: 50%

Pre-requisites: P251, P252, M211, M212 Co-requisite: P351

Prescribed Texts:

1. J. R. Hanly, Essential C++ for Engineers and Scientists, 2^{nd} ed.,Addison Wesley, New York, 2002. ISBN: 13:9780201884951
2. P. L. DeVries, A First Course in Computational Physics, John Wiley and Sons, New York, 1994. ISBN: 13:978-0471548690
3. M. L. DeJong, Introduction to Computational Physics, Addison Wesley Publishing, New York, 1991. ISBN: 0-19-852522-2

Recommended Texts:

1. H. M. Deitel and P. J. Deitel, C++: How to Program, 4^{th} ed., Pearson Education, Delhi, 2004. ISBN 13:978-0131016217
2. Microsoft cooperation: Microsoft C# Language Specifications 1^{st} ed., Microsoft Press, Washington, 2001. 13:978-0735614482
3. E. Kreyszig, Advanced Engineering Mathematics, John Wiley and Sons, 1988. ISBN 10:0471726451

P361: ELECTROMAGNETIC THEORY

Rationale:

Electromagnetism deals with relationship between electric current and magnetism. It is one of the pillars of classical physics and forms part of any undergraduate curriculum in Physics.

Objectives:

At the end of this course, a student should be able to:

(i) calculate electric fields in vacuum and in a dielectric medium due to stationary charges.
(ii) establish and use mathematical relationships between electric current and magnetism in vacuum as well as inside magnetic materials.
(iii) use Maxwell's equations to establish the existence, properties and behaviour of electromagnetic waves in vacuum and in media.

Course Content:

Review of Vectors and Vector Calculus: Dot and vector products, time derivative. Vector operators: gradient, divergence, curl and Laplacian. Line, surface and volume integrals. Green's theorem, Stoke's theorem. Vector operators in spherical and cylindrical coordinates.

Electrostatic Fields I: Electrostatic Fields in Vacuum - Coulomb's Law, electric field intensity, electric potential, electric field outside and inside macroscopic bodies, Gauss's Law, Poisson's and Laplace's equation, conductors, electric dipole, potential energy of a charge distribution, energy density in an electric field.

Electrostatic Fields II: Dielectric Materials - Electric polarization, electric field at an exterior point, bound charge densities, polarization current density, electric susceptibility, electric displacement, relative permittivity and Poisson's equation for dielectrics, the free and the bound charge density, calculation of electric fields involving dielectrics, potential energy of a charge distribution in the presence of dielectrics.

Electrostatic Fields III: General Methods for Solving Laplace and Poisson's Equations - Continuity conditions, the Uniqueness theorem, method of images. Solution of Laplace equation in rectangular coordinates.

Magnetic Fields I: Steady Currents and Nonmagnetic Materials: The Biot-Savart Law, magnetic induction due to straight and circular wires, force on a point charge moving in a magnetic field, divergence of magnetic induction, vector potential, curl of magnetic induction, Ampere's circuital Law and applications, magnetic dipole.

Magnetic Fields II: Induced Electromotance and Magnetic Energy - Faraday's induction Law and applications, induced electromotance in a moving system, mutual and self inductance, energy stored in a magnetic field, self-inductance for a volume distribution of current.

Magnetic Fields III: Magnetic Materials - Magnetization, magnetic induction at an exterior point, the magnetic field intensity H, Ampere's circuital law, magnetic susceptibiliy and relative permeability, equivalent current density and the free current density, hysteresis, boundary conditions, magnetic field calculations.

Maxwell's Equations - charge conservation, the Lorentz condition, nonhomogeneous wave equations for V and A, curl of B, Maxwell's equations.

Propagation of Electromagnetic Waves - Plane electromagnetic waves in free space, Poynting vector, the E and H vectors in homogeneous, isotropic, linear and stationary media, propagation of plane electromagnetic waves in nonconductors and conductors, skin effect.

Time Allocation:

Lectures: 3 hrs/week Tutorial: 1 hr /week Lab: Associated practical lab: 3 hrs/week

Assessment:

Continuous Assessment 40%, Final Examination 60%

Prerequisites: P261

Prescribed Books:

1. P. Lorrain and D. Corson, Electromagnetic Fields and Waves, W H Freeman and Company, San Francisco, 1970. 13:978-0471571322
2. R. K. Wangness, Electromagnetic Fields, John Wiley and Sons, New York,1986. ISBN: 978:0-471-81186-2

P332: STATISTICAL AND THERMAL PHYSICS

Rationale

The basic laws governing dynamics are Newton’s second law in classical mechanics and the Schrödinger wave equation in quantum mechanics. Their application is however restricted to only the simplest physical systems because of mathematical complications which arise primarily from the many-body nature of most practical systems. Statistical mechanics is the study of systems comprising many particles by means of the laws of statistics and probability. In P332, the fundamental principles of equilibrium statistical mechanics are studied and are illustrated by means of simple examples. Many important concepts are developed for the first time and some old ones rigorously justified or derived. This lays the groundwork for the study of more complex systems which cannot be treated in this course, and it leads to the study of non-equilibrium statistical mechanics at postgraduate level.

Objectives

At the end of this course, the student should have learned:

1. The connection between the laws of thermodynamics and the microscopic structure of matter.
2. How to use statistical mechanics to calculate the properties of simple systems.
3. How to derive many of the results of kinetic theory and thermodynamics by means of the standard tools of statistical mechanics such as the partition function.
4. The student should be ready to move on to the study of more advanced concepts and more complex physical systems in subsequent courses.

Course Content

Probability and Statistics: The random walk problem, the binomial distribution, the Gaussian distribution, the Poisson distribution

Statistical Description of Systems of Particles: Statistical formulation of the mechanical problem

Statistical Thermodynamics: Irreversibility at the attainment of equilibrium, thermal interaction between macroscopic systems, general interaction between macroscopic systems, general interaction between macroscopic systems

Macroscopic Parameters and Their Measurement

Simple Applications of Macroscopic Thermodynamics: Properties of ideal gases, general relations for a homogeneous substance, free expansion and throttling processes, heat engines and refrigerators

Basic Methods of Statistical Mechanics: Ensembles representative of situations of physical interest, approximation methods

Simple Applications of Statistical Mechanics: Ideal monatomic gas, the equipartition theorem, paramagnetism

Equilibrium Between Phases or Chemical Species: General equilibrium conditions, equilibrium between phases, chemical equilibrium of systems with several components

Quantum Statistics of Ideal Gases: Maxwell-Boltzmann, Bose-Einstein, Fermi-Dirac statistics, black-body radiation.

Time Allocation:

Lectures: 3 hrs/week, Tutorial: 1 hr/week

Lab: Associated laboratory of 3 hrs/week.

Assessment:

Continuous assessment: 40%, Final Examination: 60%

Pre-requisites: P231, P272, M211, M212

Prescribed Texts

1. F. Reif, Fundamentals of Statistical and Thermal Physics, McGraw-Hill, 1981. ISBN: 0-07-085615-X
2. B. N. Roy, Fundamentals of Classical and Statistical Thermodynamics, Wiley, 2002. ISBN: 13:978-0470843161

Recommended Texts

1. M. W. Zemansky, Heat and Thermodynamics, McGraw-Hill, 1957. ISBN: 978-0070170599
2. F. W. Sears, Thermodynamics, McGraw-Hill, 1963. ISBN: 13:020106894

P341: INTRODUCTION TO ELECTRONICS

Rationale:

The electronics syllabus has the primary objective of enabling the student to acquire the theoretical and practical skills that are necessary for the acquisition of instrumentation techniques utilised in advanced experimental Physics. This basic course will equip the student with the skills necessary for understanding the principles of transducer physics as applied in instrumentation electronics. It is an essential preamble to the knowledge of the application of electronics in Industry, Science and Technology.

Objectives:

At the end of attending the course, the student should:

1) have acquired an understanding of basic electronic concepts needed for the analysis of electrical circuits.

2) have been introduced to the basic devices used in electronics and the physical principles, in particular semiconductor theory, responsible for the electrical properties of these devices.

3) have been introduced to standard electronic circuits and circuits utilized in measurements of physical quantities in physics experiments.

Course Content:

Kirchhoff's current and voltage Laws. Thevenin's and Norton's theorem. Impedance matching. Feedback theory. A.C. circuit theory: Complex representation of a.c. current, voltage and electrical components. Introduction to Laplace and Fourier series. Passive filters and RLC circuits.

Semiconductor devices and circuits: Physics of semiconductors. P-N junction diode. Diode rectifier circuits. Bipolar transistor theory. d.c. transfer characteristics. a.c. characteristics and the hybrid model of the transistor. Transistor circuits: a.c. amplifier, differential amplifier, switch. J-FET transistor.

Operational amplifier: Ideal op-amp characteristics. Op-amp as amplifier; inverting, non-inverting, difference and instrumentation amplifiers. Op-amp mathematical circuits; summing, logarithmic, multiplication, differentiation and integration circuits. Data acquisition circuits; sample-and-hold, peak detector, A/D converter.

Measurement systems: General measurement system. Sensors and transducers.

Associated Laboratory: P341

Time Allocation: Lectures: 3 hrs/week. Tutorial: 1 hr/week Lab: 4 hrs/week

Assessment: Labs: 30%, Tests: 20%, Final Examination: 50%
Pre-requisites: P261, P212

Prescribed Texts:

1. J. J. Brophy, Basic Electronics for Scientists, 5th ed., McGraw-Hill,University of Utah, 1990. ISBN: 13:978-0070081475
2. J. Millman and C. Halkias, Integrated Electronics, McGraw-Hill, Tokyo, 1971. ISBN: 13:978-0708549391

Recommended Texts:

1. R. J. Higgins, Electronics with Digital and Analog Integrated Circuits, Prentice Hall, Englewood Cliffs, N.J. 1983.

P342: DIGITAL ELECTRONICS I

Rationale:

Digital electronics is a vital component of control circuits in most machines and communication installations. It has given us gadgets like cell phones, pocket calculators, digital watches, heart pace makers, computers, automatically controlled production processes, to name a few. Digital electronics is an essential part of our daily life.

Objectives:

At the end of attending the course, the student should acquire basic knowledge and skills in digital electronics. It introduces the fundamental concepts that are so essential to in advanced digital electronics principles. Greater depth of coverage of digital electronics is to be emphasized due to the increasing importance of computer technology for the analysis, control and simulation of physics experiments.

Course Content:

Basics: Logic gates: Basic logic gates and their truth tables; TTL construction of logic gates. Binary arithmetic: Binary number system. Conversion from decimal to binary. Addition and subtraction of binary numbers. Boolean algebra: Boolean identities; De Morgan's laws; Conversion of Boolean equations to truth tables and vice versa.

Digital circuits: Binary arithmetic circuits; addition and subtraction. Flip-Flops: S-R, J-K, D and T flip-flops. Counters and shift registers: Serial to parallel conversion; Parallel to serial conversion; Parallel to parallel conversion; Binary ring and ripple counters. Digital Memory: Introduction to stacks; RAM and ROM. A/D and D/A converters. Decoders: 4-16, BCD, Hexadecimal. Demultiplexer and Multiplexer. Introduction to the microprocessor.

Associated Laboratory: P342

Time Allocation: Lectures: 3 hrs/week. Tutorial: 1 hr/week Lab: 4 hrs/week

Assessment: Labs: 30%, Tests: 20%, Final Examination 50%
Pre-requisites: P261, P341

Prescribed Texts:

1. H. Taub and D. Schilling, Digital Integrated Electronics, McGraw-Hill, ISBN: 0-07-062921-8

Recommended Texts:

1. J. J. Brophy, Basic Electronics for Scientists, 5th ed., McGraw-Hill, University of Utah, 1990.
   ISBN:13:978-00781475
2. R. J. Higgins, Electronics with Digital and Analog Integrated Circuits, Prentice Hall, Englewood Cliffs, N. J. 1983.

P401: COMPUTATIONAL PHYSICS II

Rationale:

Computational physics is physics done by means of computational methods. It is much more than ``Physics Using Computers.'' The essential point in computational physics is not the use of machines, but the systematic application of numerical techniques in place of, and in addition to, analytical methods, in order to render accessible to computation as large a part of physical reality as possible. In all quantifying sciences the advent of computers rapidly extended the applicability of numerical methods. In the case of physics it triggered the evolution of an entirely new field with its own goals and problems. Computational physicists have developed new numerical techniques (Monte Carlo and molecular dynamics simulation, fast Fourier transformation), discovered unexpected physical phenomena (Alder vortices, shear thinning), and posed new questions to theory and experiment (chaos, strange attractors, cellular automata, neural nets, spin glasses, etc.). This course is not a short course in computing science, nor in programming. It focuses specifically on methods for solving physics problems. Students taking this course will be expected to be familiar with basic programming.

Objectives:

This course aims to give the student a thorough grounding in the main computational techniques used in modern physics. It is particularly important in this course that the students should *learn by doing.* The course is therefore designed such that a significant fraction of the students' time is spent actually programming specific physical problems while learning abstract techniques.

Course Content:

1. Programming languages: Advanced programming in Higher level languages which are currently used in Physics e.g. C++ and C#.
Introduction to software tools: Scientific and graphics packages.

2. Introduction to statistical concepts: Random variables, probability, density functions and frequency functions, co-variance and correlation coefficients.
Common distributions: Gaussian, Poisson, Fermi-Dirac, and Bose-Einstein.

3. Monte Carlo Methods: Integration, particle transport and Monte Carlo Error Analysis.

4. Curve fitting: Interpolation and non-linear least squares.

5. Fast Fourier Transforms: FFTs as applied to physics problems.

6. Matrix eigenvalue problem and diagonalisation procedures: Calculation of energy levels as eigenvalues with applications to some Physics problems e.g. atomic structure calculations and molecular orbital theory (Huckel Method) and defect energy levels in Solid State Physics.

7. Approximation methods: Perturbation and variational methods with reference to simple physical applications.

8. Non-linear Dynamics: Chaos and fractals with reference to some simple Physics problems.

Time Allocation: 3 hrs/week. Tutorial: 1 hr/week Laboratory: Associated Practical Computing Class.

Assessment: Labs: 30%, Tests: 20%, Final Examination: 50%

Pre-requisites: P302, P351

Recommended Texts:

1. J. R. Hanly, Essential C++ for Engineers and Scientists, 2nd ed., Addison Wesley Publishing Co, New York, 2002. ISBN: 10:020188495X
2. W. H. Press, B. P. Flannery, S. A. Teukolsky and W. T. Vetterling, Numerical Recipes, The Art of Scientific Computing, Cambridge Univ. Press, Cambridge, 1990. ISBN: 978-0521431088
3. P. L. DeVries, A First Course in Computational Physics, John Wiley and Sons, New York, 1994. ISBN: 13:978-0471548690
4. Harvey Gould & Jan Tobochnik, An Introduction to Computer Simulation Methods, Parts I & II, Addison Wesley, New York, 1987. ISBN: 0-8053-7758-1

Further references:

1. H. M. Deitel and P. J. Deitel, C++ How to Program, Fourth Edition, Pearson Education, Patparganj, Delhi, 2004. ISBN: 13:978-0131016217
2. Microsoft C# Language Specifications, Microsoft Press, Microsoft Corporation, Redmond, Washington, 2001. ISBN: 978-0070081475
4. E. Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons, 1988). ISBN: 0471726451

P485: PHYSICS OF RENEWABLE ENERGY RESOURCES AND ENVIRONMENT

Rationale

The world heavily relies for its energy needs on the use of oil, coal and gas, collectively termed as fossil fuels. However, continued use of fossil fuels is leading to a very serious environmental problem – climate change. It is now accepted that a major shift towards increased use of renewable sources of energy is required in order to mitigate this problem. Indeed the growth in the renewable energy sector has been a phenomenal 30-40% per annum during the last decade. With the maximum solar resource in the world, Africa - including Zambia - is uniquely poised to exploit this natural gift to best advantage. Other renewable sources of energy also abound in parts of Africa. Institutions of higher learning can play an important role by building high level capacity in this field.

Objectives:

At the end of this course, a student should be able to:

(i) measure as well as to estimate the solar radiation incident on a horizontal surface.
(ii) use the physical principles of heat transfer, optics and photovoltaic conversion to understand, calculate, assess and optimize the performance of solar-energy devices.
(iii) use physical principles to understand, calculate, assess and optimize the working of other renewable-energy devices.
(iv) use basic physical principles to explain the behaviour of the atmosphere and the causes of climate change.

Course Content:

Solar Radiation Fundamentals: Radiation Laws, The Sun, Sun-earth geometry, solar constant, extraterrestrial radiation, spectral distribution, attenuation of solar radiation by the atmosphere, solar radiation on the ground; direct, diffuse and global radiation; solar radiation on horizontal and inclined surfaces, measurement of solar radiation.

Solar Energy Utilization: Fundamentals of heat transfer; conduction, convection and radiation in specific-shaped bodies. Optics of collectors, reflection and refraction at dielectric interfaces, transmittance and reflectance of single and multiple glazings, optical efficiency of a glazing-absorber system, anti-reflecting coatings for glazings, selective absorber coatings; concentrators; solar heating panels, performance and time constant under stagnant conditions, operational characteristics of flat-plate collector; solar heating system; arrays; heat exchangers and heat pumps; thermodynamic conversion of solar energy to work, solar powered mechanical engines, solar-driven cooling; direct conversion of solar energy to electricity, intrinsic and extrinsic semiconductors, the p-n junction, junction photovoltaic spectral response of photocurrent, theoretical efficiency of photovoltaic devices, photovoltaic arrays and systems.

Other Renewable Sources of Energy: Wind power: Types of wind turbines, design considerations and applications. Biomass: Photosynthesis principle, physical characteristics of biomass residues, thermoconversion (pyrolysis), gasification, biological conversion (anaerobic, fermentation). Hydropower: Principles of hydropower extraction and hydropower turbines. Ocean thermal energy conversion (OTEC): Principle and efficiency of OTEC, sea thermal power plants. Geothermal power. Tidal power.

Physics of the Atmosphere: The atmosphere, hydrostatic equation, adiabatic lapse rate, blackbody radiation, radiative transfer, absorption and emission of radiation, radiative equilibrium in a grey atmosphere, energy systems of the earth, global radiation budget, equilibrium temperature, the greenhouse effect and climate change. Absorption of radiation by ozone and the problem of ozone depletion.

Time Allocation:

Lectures: 3 hrs per week, Tutorial: 1 hr per week , Laboratory: 1 laboratory per week

Assessment:

Continuous Assessment: 40%,   Final examination 60%

Pre-requisites: P231, P361

Recommended Texts

1. S. Wieder, An Introduction to Solar Energy for Scientists and Engineers, John Wiley & Sons, 1982. ISBN: 13-978-0471060482
2. J.T. Houghton, The Physics of the Atmosphere, Cambridge University Press, 1977. ISBN: 13:9780521011221

3. J. Twidell and J. Weir, Renewable Energy Resources, ELBS, 1988. ISBN: 13:978-0429253303

Supplementary Reading

1. H. P. Garg, Treatise on Solar Energy, Vol 1, John Wiley & Sons, 1982. ISBN: 10:096014810300168X
2. J. A. Duffie and W. A. Beckman, Solar Engineering of Thermal Processes, John Wiley & Sons, 1980. ISBN: 13:978-04715610567
3. A. Henderson-Sellers and P. J. Robinson, Contemporary Climatology, Longman Scientific & Technical, 1986. ISBN: 13:978-0470206645
4. M. Iqbal, Introduction to Solar Radiation, Academic Press, 1983. OSTI 10:5596615

P411: NUCLEAR EXPERIMENTAL TECHNIQUES

Rationale:

In today's world Radiation Physics applications play an important role in everyday life, ranging from medicine to industrial production. It is, therefore, important that students of Physics are furnished with knowledge of the principles underlying these applications. This course is designed to offer exposure to introductory nuclear instrumentation or radiation measurements. The knowledge is needed by those who may pursue studies in Nuclear Physics, Medical Physics, and Nuclear Engineering.

Objectives:

On completion of the course, the student should be able to understand the working principles as well as to utilize nuclear equipment such as various radiation detectors, amplifiers, multi-channel analyser etc, and the effect of radiation on human health.

Course Content:

Basic nuclear physics, radioactivity, equilibrium, age of rocks, nuclear energy level diagrams, activation analysis, types of radiation, electron interactions with matter, gamma ray interactions, ionisation of gases, radiation detection methods, counting techniques, introduction to theory and practice of dosimetry.

Associated Laboratory: P411/P412

Time Allocation: Lectures: 3 hrs/week. Tutorial: 1 hr/week Laboratory: 1 laboratory per week

Assessment: Continuous assessment: 40%, Final Examination 60%

Pre-requisites: P351, P341, P342

Recommended Texts:

1. G. F. Knoll, Radiation Detection and Measurement, 2nd ed., John Wiley, 1989. ISBN: 0-471-81504-7

Supplementary Texts:

1. N. Tsoulfanidis, Measurement and Detection of Radiation, McGraw-Hill Book Company, 1983. ISBN: 0-07-065397-6.

2. W. R. Leo, Techniques for Nuclear and Particle Physics Experiments, Springer Verlag, Berlin-Heidelberg-New York, ISBN: 3-540-17386-2
3. E. Segre, Nuclei and Particles, The Benjamin/Cumming Publishing Co., 1977. ISBN: 10:0805386009

P412: NUCLEAR PHYSICS

Rationale:

The course aims at understanding of basic and fundamental concepts used in nuclear physics.

Objectives:

At the end of the course, the student should be able to have enough background knowledge in nuclear physics so as to enable him/her to pursue higher studies in nuclear physics or related subjects.

Course Content:

1. Elements of Nuclear Structure and Systematics: Nomenclature and conventions.

Nuclear Radii: Electromagnetic radius, nuclear radius, brief survey of methods of determining nuclear radius. Values of spin, magnetic moments of nuclei, Schmidt lines, and electric quadrupole moments of nuclei.

Semi-empirical mass formula, spontaneous fission, Q-value calculations for alpha and beta decay.

Two-body systems and Nuclear Forces: Bound state of deuteron, magnetic moment of deuteron and non-central forces. Nucleon-nucleon scattering at low energies: scattering cross sections, phase shift, scattering length, effective range, spin dependence of scattering cross-sections, charge independence of scattering cross-sections.

Scattering in ortho- and para-hydrogen. Nucleon-nucleon scattering at high energies: a brief summary and discussion. Meson theory of nuclear forces.

Nuclear Models: Shell model, Collective nuclear model and rotational levels.

2. Nuclear Decay:

Alpha decay: basic theory, Gamow factor, Geiger-Nuttal law.
Beta decay: beta spectrum and Fermi-theory (without derivation), nature of weak interaction, parity non conservation and helicity. Electron capture. Gamma decay: selection rules, transition probabilities, internal conversion, nuclear isomerism, Coulomb excitation and nuclear fluorescence.

3. Nuclear Reactions:

Conservation laws for nuclear reactions. Particle induced nuclear reactions-general features of cross-sections.

Optical model - an introduction.

Associated Laboratory: P411/P412

Time Allocation: Lectures: 3 hrs/week. Tutorial: 1 hr/week Laboratory: 1 laboratory per week

Assessment: Continuous Assessment: 40%, Final Examination 60%

Pre-requisites: P351, M911, M912. Co-requisites: P455.

Recommended Texts:

1. H. Enge, Introduction to Nuclear Physics, Addison Wesley,1966. ISBN: 0201018705
2. E. Segre , Nuclei and Particles, Benjamin/Cummings Publishing Co., 1977 ISBN: 100805386009
3. W. N. Cottingham and D. A.Greenwood, An Introduction to Nuclear Physics, Cambridge University Press, ISBN: 0 521 319609
4. H. von Buttlar, Nuclear Physics: An Introduction, Academic Press,1969. ISBN: 10: 0127245502
5. B. L. Cohen, Concepts of Nuclear Physics, McGraw-Hill, 1971. ISBN: 10: 0070115567

Supplementary Texts:

1. E. B. Paul, Nuclear and Particle Physics, North Holland, 1969. ISBN: 13:978-0720401462
2. J. M. Blatt and V. Weisskopf, Theoretical Nuclear Physics, Dover Publications New Edition, 1991. ISBN: 13:978-0486668277
3. M. A. Preston, Physics of the Nucleus. Addison & Wesley. 1967. ISBN: 13-9781124160276
4. R. R. Roy and B. P. Nigam, Nuclear Physics: Theory and Experiment, New Age International, 1996. ISBN: 13:978-0852267882

P421: SOLID STATE PHYSICS I

Rationale:

Solid-state physics, the largest branch of condensed matter physics, is the study of rigid matter or solids. The course P421 treats this subject and addresses the most important properties of solids. The bulk of this course’s theory and experiment is focused on the study of the physical structural properties of solids, as well as the thermal, electrical and electronic properties. The emphasis on solids is largely because the periodicity of the atoms in a crystal facilitates mathematical modelling of the substance

The framework of most solid-state physics theory is the Schrödinger wave formulation of non-relativistic quantum mechanics. Bloch’s theorem, which characterizes the wave functions of electrons in a periodic potential, is an important starting point for much analysis. This course gives a comprehensive introduction to some major areas of solid-state physics.

Objectives:

Upon completion of this course, a student should be able to:

1. describe crystal structures in terms of the direct and reciprocal lattices and the unit cell, calculate the cohesive energy of these structures and understand (in outline) how they are determined experimentally;
2. understand lattice vibrations and relate them to the thermal properties of solids;
3. derive the free electron model and show how this can provide an explanation for many features of metallic behaviour;
4. appreciate the strengths and weaknesses of the free electron model and explain the effect of the lattice on the behaviour of electrons in solids both from the point of view of the nearly-free electron model, the tight-binding model and the Kronig-Penny model;
5. explain the fundamental features of semiconductors and relate this to simple semiconductor devices.
6. design and construct laboratory experiments to study and analyse the various above properties.

Course Content:

Crystal structure. Crystal diffraction and the reciprocal lattice. Crystal binding. Lattice vibrations. Thermal properties of solids. Free electron Fermi gas. Energy bands. Semiconductors.

Associated Laboratory.

Time Allocation: 3 one-hour lectures/week.
1 hr tutorial/week.
1 three-hour laboratory/week

Assessment:

Continuous assessment: 40%:	Assignments	-	5%
	Tests	-	20%
	Labs	-	15% (*To depend on the number of labs*)

Final Examination 60%

Pre-requisites: P351, P332, P361, M91, and M912.

Prescribed Textbooks:

1. C. Kittel, Introduction to Solid State Physics, 6th ed., J. Wiley & Sons, New York, 1986. ISBN: 13:978-0471490241
2. J. S. Blakemore, Solid State Physics, 2nd ed., Cambridge University Press, 1985. ISBN: 13:978-0521313919

Recommended Texts:

1. M. T. Dove, Structure and Dynamics – An Atomic View of Materials, Oxford University Press Inc., New York, 2003. ISBN: 13:978-0198506775
2. J. Singleton, Band Theory and Electronic Properties of Solids, Oxford University Press Inc., New York, 2001. ISBN: 13:978-0198506454
3. N. W. Ashcroft and D. N. Mermin, Solid State Physics, Harcourt College Publishers, Orlando, 1976. ISBN: 13:978-0030839931
4. S. O. Pillai, Solid State Physics 5ed, New Age International Publishers, New Delhi, 2003. ISBN: 13:978-8122403817
5. H. V. Keer, Principles of the Solid State, New Age International Publishers, New Delhi, 2000. ISBN: 10: 047022052X
6. A. J. Dekker, Solid State Physics, Prentice-Hall, 1962. ISBN: 13: 978-0333004623

P422: SOLID STATE PHYSICS II

Rationale:

This course follows up on the study of the physical properties of solids by looking at the electronic properties, and then moving on to the optical and magnetic properties of solids. In addition, it covers Fermi surfaces, superconductivity and defects and dislocations in solids. Just like the sister course P421, this course is generally concerned with understanding how the structure of a solid material and the dynamics of its constituent atoms determine its properties and behaviour.

Objectives:

After completing this course, a student should be able to,

1. to construct and explain the basic features of Fermi surfaces;
2. describe optical processes involving plasmons, polaritons, polarons and excitons and be able to analyse the various spectral features of solids.
3. show understanding of the dielectric properties of solids and their importance in determination of electrical and optical properties like refractive index and extinction coefficient and be able to use the Kramers-Krognig relations in optical analysis.
4. have the necessary background material in diamagnetism, paramagnetism, ferromagnetism and anti-ferromagnetism and be capable describing these phenomena.
5. explain the fundamental theoretical and practical features of superconductors, point defects and dislocations in solids
6. design and construct laboratory experiments to study and analyse the various above properties.
7. show how solid-state physics plays a vital part both in other areas of physics and more generally in science, technology and industry.

Course Content:

Fermi surfaces. Plasmons, polaritons and polarons. Optical properties of solids and excitons. Superconductivity. Dielectrics and ferroelectrics. Magnetic properties of solids. Defects in solids.

Associated Laboratory.

Time Allocation: 3 one-hour lectures/week.
1 hr tutorial/week.
1 three-hour laboratory/week

Assessment:

Continuous assessment: 40%: Assignments 5%, Tests 20%, Labs 15% (*To depend on number of labs*), Final Examination 60%

Pre-requisites: P421, P351, P332, P361, MP415

Prescribed Textbooks:

1. C. Kittel, Introduction to Solid State Physics, 6^{th} ed., J. Wiley & Sons, New York. 1986. ISBN: 10:471490245
2. J. S. Blakemore, Solid State Physics, 2^{nd} ed., Cambridge University Press. 1985. ISBN: 521313910

Recommended Texts:

1. M. Fox, Optical Properties of Solids, Oxford University Press Inc., New York, 2001. ISBN: 13:978-0198506113
2. J. Singleton, Band Theory and Electronic Properties of Solids, Oxford University Press Inc., New York, 2001. ISBN: 13:978-0198506454
3. S. Blundell, Magnetism in Condensed Matter, Oxford University Press Inc., New York, 2001. ISBN: 13:978-0198505914
4. N. W. Ashcroft and D. N. Mermin, Solid State Physics, Harcourt College Publishers, Orlando, 1976. ISBN: 13:978-0030839931
5. S. O. Pillai, Solid State Physics, 5^{th} ed., New Age International Publishers, New Delhi, 2003. ISBN: 13:978-8122403817

6. H. V. Keer, Principles of the Solid State Physics, New Age International Publishers, New Delhi, 2000. ISBN: 10:812240466
7. A. J. Dekker, Solid State Physics, Macmillan & Co. Ltd, London, 1960. ISBN: 10:9880333918333

P441: ANALOG ELECTRONICS II

Rationale

Operational amplifiers play a vital role in modern electronics design. The latest op amps have powerful new features, making them more suitable for use in many products requiring weak signal amplification, such as medical devices, communications technology, optical networks, and sensor interfacing. This course covers basic concepts, the theories and practices used for analyzing operational amplifier circuits. It follows up on the ideas introduced in P341, but treated at an advanced level.

Objectives

To provide

1. the basic principles of common operational amplifier and linear integrated circuit configurations.
2. analysis of operational amplifier circuits and their application to physics
3. more advanced linear integrated circuit applications.

Course Content

1. Introduction to operational amplifiers: Basic operational amplifier circuit; Open loop opamp configurations-the differential amplifier, the inverting amplifier and the non-inverting amplifier; Opamp parameters

2. Operational amplifiers with feedback: Block diagram representation of feedback configurations; Voltage series feedback amplifier; Voltage shunt feedback amplifier; Differential amplifiers-differential amplifier with one opamp, differential amplifier with two opamps, output resistance and bandwidth of differential amplifiers with feedback.

3. The practical operational amplifier: offset voltage compensating network design. Thermal drift - error voltage. Effect of variation in power supply voltages on offset voltage. Change in input offset voltage and input offset current with time, other temperature and supply voltage sensitive parameters and noise.

4. Frequency response of an operational amplifier: compensating networks; frequency response of internally compensated and non-compensated opamps; high frequency opamp equivalent circuit; circuit stability; frequency compensation techniques, slew rate equation, effect of slew rate in applications

5. General linear applications and linear simulation: DC and AC amplifiers, the peaking amplifier, summing, scaling and averaging amplifiers; integrators and differentiators; mathematical function circuits used to perform physical dynamic simulations, solution to a damped harmonic oscillator.

6. Active filters and oscillators: First order and second order low pass Butterworth filters; First order and second order high pass Butterworth filters; Higher order filters, Band pass filters-wide band pass filter and narrow band pass filter; Oscillators - Phase shift oscillator, Wien Bridge oscillator, Square wave generator; Comparators- basic comparators, comparator characteristics, zero crossing detectors. Schmitt trigger.

Associated laboratory.

Time allocation: 3 one-hour lectures/week, 1 one hour tutorial per week, 1 three-hour lab/week

Assessment: Continuous Assessment 50%, (30 % laboratory work, 10 % Test 1, 10 % Test 2), Final examination 50%.

Pre-requisite: P341

Prescribed Texts

1. S. Franco, Design with Operational Amplifiers and Analog Integrated Circuits, 3rd ed., McGraw-Hill Science/Engineering/Math, 2001. ISBN 13: 978-0072320848

2. W. Jung, Op Amp Applications Handbook (Analog Devices Series), Newnes, 2004. ISBN-10: 0750678445, ISBN-13: 978-0750678445,.

P442: DIGITAL ELECTRONICS II

Rationale

This course provides the fundamentals of both digital electronics and microprocessors, thereby helping students to become proficient in both hardware and software principles. The course deals with the applications, organization, architecture, and design of microprocessor systems.

Objectives

At the end of this course, the student should be able to

1. analyse digital circuits using advanced techniques.
2 show understanding of the basic computer architecture of a microprocessor-based system of measurement
3 use advanced linear integrated circuits in a variety of applications.

Course Content

1. Number systems and digital circuit design:**-** Review of basic logic gates, Boolean algebra, Arithmetic circuits-half adder and full adder, two's compliment adder/subtractor circuit, AND-OR-INVERT gate, Minterms and maxterms, Karnaugh mapping.

2. Computer languages and microprocessors: components of a computer; Microprocessor architecture-microprocessor initiated operations, bus architecture, Internal data operations, registers and flags, externally initiated operations, pin configuration.

3. Microprocessor and computer memory: Memory interfacing, Semiconductor memory and its types: ROM-Masked ROM, PROM, EPROM, EEPROM, Flash memory. RAM-DRAM and SRAM, Cache memory. Memory organization, memory map.

4. Introduction to basic instructions: Instruction classification-data transfer operations, arithmetic operations, logical operations, Branching operations, Machine control operations, Addressing modes; Illustrative programs.

5. Programming techniques: Looping, counting, indexing, 16-bit arithmetic instructions, Addition and subtraction using unsigned binary numbers, 2's complement numbers and BCD numbers, Logical and arithmetic shifts, programming examples.

6. Programming for interfacing: Interrupts-Maskable and non-maskable interrupts, hardware and software interrupts, interrupt call locations. PUSH and POP instructions, programming practice using subroutines. Data transfer schemes: methods of data transfer, Programmed controlled I/O: Handshaking and Polling.

Associated laboratory

Time allocation: 3 one-hour lectures/week, 1 one hour tutorial per week, 1 three-hour lab/week

Assessment: Continuous Assessment 50% (30 % laboratory work, 10 % Test 1, 10 % Test 2), Final examination 50%

Pre-requisite: P342

Prescribed Texts:

1. W. Kleitz, Digital and Microprocessor Fundamentals: Theory and Application, 4/E, Prentice Hall, 2003. ISBN-10: 0130932175, ISBN-13: 9780130932174

2. J. Quinn, 6800 Microprocessor, Prentice Hall, 1997. ISBN-10: 0675205158, ISBN-13: 978-0675205153

P455: QUANTUM MECHANICS II

Rationale

This course is essentially a continuation of P351, Quantum Mechanics I. Further topics are introduced in order to further develop the theory and to give the students an improved mastery of the subject. Together with P351, P455 aims to give students all the elements of elementary quantum mechanics.

Objectives

At the end of this course, the student should be able to:

1. Use approximation methods to solve quantum systems that are close to exactly solved systems.
2. Add two angular momenta.
3. Construct a description of systems of non-interacting bosons or fermions. The basic principles of quantum mechanics
4. Employ basic theory to solve problems involving the interaction of radiation with matter.

Course Content

Approximation Methods in Quantum Theory; perturbation theory; time-independent theory; non-degenerate theory; degenerate theory; the Stark effect; time dependent theory; harmonic perturbations; transition probabilities; the variation method; the Wentzel-Kramers-Brillouin (WKB) approximation; tunnelling; the helium atom.

The Harmonic Oscillator: Treatment by algebraic methods.

Angular Momentum: angular momentum and rotations; general angular momentum; matrix representation; addition of angular momentum.

Many-particle Systems: systems of identical particles; bosons and fermions; spin-1/2 particles in a box; the Fermi gas.

The Interaction of Quantum Systems with Radiation: the electromagnetic field and its interaction with radiation; perturbation theory for harmonic perturbations and transition rates; spontaneous emission; selection rules for electric dipole transitions; line intensities, widths and shapes; the spin of the photon and helicity; photoionisation; photodisintegration.

Time Allocation:

Lectures: 3 hrs/week: Tutorial: 1 hr/week

Assessment:

Continuous assessment: 30%: Final Examination: 70%

Pre-requisites: P351

Prescribed Texts:

1. B. H. Bransden and C. J. Joachain, Introduction to Quantum Mechanics, Longman, 1989. ISBN: 13-978-0582 444 980

P452: SELECTED TOPICS IN THEORETICAL PHYSICS

Rationale

This occasional course is designed for exceptional students who have identified an academic career as their goal. The course contains material that prepares them for postgraduate studies. The exact content of the course will vary somewhat from one instance of its being offered to another, and there are a number of optional topics to be chosen to suit a particular student group's intended future choice of area of study. It is expected that Analytical Mechanics will be included among the chosen topics and that the topics chosen will be treated to some depth. It is expected that a minimum of two and a maximum of three topics will be chosen. The content of each topic is left to the lecturer of the day.

Objectives:

At the end of this course, the student should be able to:

1. Relate the different formulations of classical mechanics to one another;
2. Use the appropriate formulation of classical mechanics to solve a particular problem;
3. Distinguish between the laws of nature on the basis of Lorentz covariance;
4. Describe dynamical systems relativistically;
5. Use Maxwell's equations to solve various systems involving stationary and moving charges.
6. Use whatever other theory is taught in practical applications.

Course Content

Analytical Mechanics: Lagrangian and Hamiltonian mechanics; Poisson brackets; canonical transformations; the Hamilton-Jacobi equation; Lorentz transformations; four vectors; Lorentz covariance; Lagrangian and Hamiltonian mechanics for continuous systems, Noether's theorem.

Advanced topics in electrodynamics: Charges in electromagnetic fields; Maxwell's equations; multipole expansions; radiation of moving charges.

or
Gravitation and Cosmology (i.e., The general theory of relativity and its application to cosmology)

or
Quantum Optics

or
Quantum Field Theory for Bosons and Fermions

or
Relativistic Quantum Mechanics: Klein-Gordon equation, The Dirac equation

Associated laboratory course**:** none

Time allocation:

3 one-hour lectures/week, 1 one-hour tutorial

Assessment:

Continuous Assessment: 30% (Two tests 20%, Assignments 10%), Final Examination 70%

Pre-requisites: P251, P252, P361, P351

Co-requisite: P455

Prescribed Texts:

1. H. Goldstein, Classical Mechanics (Addison-Wesley, 1950). ISBN: 13:978-0201657029
2. J. D. Jackson, Electrodynamics, Wiley 3rd ed., 1998. ISBN: 13-9780471309321
3. Gravitation and Cosmology: Space, Time and Cosmology, Blocks 3 and 4, Open University, Milton Keynes, 2001, Block 3 ISBN: 0 7492 8160X, Block 4 ISBN: 0 7492 8161 8
4. D. F. Walls and G.J. Milburn, Quantum Optics, Springer Verlag, ISBN 3 540 58831 0
5. M. O. Scully and M. S. Zubairy, Quantum Optics, Cambridge University Press, ISBN: 0 521 43595 1)
6. P. L. Knight and L. Allen, Concepts of Quantum Optics*,* Pergamon Press, Oxford, 1993. ISBN: 13-978-0080291604
7. J.D. Bjorken and S.D. Drell, Quantum Field Theory, McGraw-Hill, New York.
8. J.D. Bjorken and S. D. Drell, Relativistic Quantum Mechanics, McGraw-Hill, New York, ISBN 07 005 493 2
9. W. Greiner, Relativistic Wave Equations, 3rd ed., Butterworth-Heinmann, 1981. ISBN: 13-978-0750635394

P475: APPLIED OPTICS

Rationale

The various branches of optics such as laser physics, holography and fiber optics have many applications in science and technology. The laser has given physics a powerful instrument for investigating the interaction of light with matter and is used in communications, surveying, meteorology, cutting and welding, surgery, combustion studies and in such devices as laser printers and compact disc players. Holography is widely used in inspection and testing and is also useful in information storage and in interferometry. Fiber optics now plays a key role in optical communication and offers broadband transmission of data. Optical devices and components are increasingly replacing electronic components in communications and in the computer industry. P475 aims to equip the students with the physics to understand the principles underlying these advances.

Objectives:

At the end of this course, the student should

1. Understand the fundamentals of laser physics and many of the diverse applications of lasers
2. Understand the principles and applications of Fourier optics
3. Have grasped the principles of holography as well as the applications
4. Have understood the basic principles of non-linear and fibre optics

Course Content

1. Laser Physics: Basic properties of lasers: Population inversion, Einstein coefficients, spontaneous and stimulated emission, momentum transfer, life time, laser pumping and threshold conditions. Types of lasers: the He-Ne laser. Applications: earth drift and rotation, counting of atoms, isotope separation, fusion, communication. Lasers in astronomy, biology, chemistry, industry, the military and medicine.

2. Fourier Optics: Introduction Fraunhofer and Fresnel diffraction, effect of a thin lens on an incident field, lens as a Fourier-transforming element, point spread function of a thin lens, frequency analysis, spatial frequency filtering. Applications: Character recognition, cross-correlation, phase-contrast microscopy.

3. Holography: General equations of holography, sources of illumination for holography, various types of holograms: plane hologram, volume hologram, point source hologram, Fourier-transform hologram. Properties of holograms, the hologram as an optical element. Applications in interferometry, inspection and testing, microscopy and image processing.

4. Non-linear and fiber optics: Harmonic generation, phase matching, conjugate phase mirror, optical mixing, parametric generation of light, cladding, clad optical fiber, inter-modal dispersion, graded index, single mode fiber, step index multi-mode fiber, waves at an interface. Fresnel's equations: derivation, interpretation, total internal reflection by an absorbing medium. Applications: Real time holography and optical communication.

Time Allocation:

Lectures 3 hrs/week, Tutorial: 1 hr/week, Laboratory: 1 session/week

Assessment:

Continuous assessment: 40%, Final Examination 60%

Pre-requisites: P272, P351, P361, M911, M912
Prescribed Texts:

1. A. K. Ghatak and K. Thyagarajan, Contemporary Optics, Plenum Publishing Corporation, New York, 1984.

2. B. B. Laud, Lasers and Non-linear Optics, J. Wiley & Sons, New York, 1987.

Recommended Texts:

1. P. Hariharan, Optical Holography, Cambridge Univ. Press, Cambridge, 1987. ISBN: 13-978-051439657
2. N. S. Kapany and J. J. Burke, Optical Waveguides, Academic Press, New York, 1972.

3. J. N. Butters, Holography and its Technology, Peter Peregrinus, 1971. ISBN: 13-978-0901223104
4. E. K. Kasper and S. A. Feller, The Complete Book of Holograms, Dover Publications, 2001. ISBN: 13-978-0486415802
5. C. B. Hitz and J. Ewing. Laser Technology, Wiley & Sons, Auflage 3rd Sub ISBN: 13-978-0780353732
6. H. M. Smith, Principles of Holography, J. Wiley & Sons, New York, 1975. ISBN: 13-978-0471083405

MP415: MATHEMATICAL METHODS FOR PHYSICS

Rationale:

Physics is the first cousin of mathematics, and a good repertoire of mathematical techniques is essential to proper mastery of physics. The physics major degree recognises this and tries to give the students adequate mathematics training. However, despite the best efforts of the program, it is true that the students encounter more mathematics in physics than they are formally taught. This course is designed to address the need of physics students for exposure to the mathematical techniques they will need in their studies of Nuclear Physics (P412), Solid State Physics II (P422), Quantum Mechanics II (P452) and at postgraduate level.

Objectives:

On completion of the course, students should be able to:

1. use the complex number systems, analytic functions, complex integration-calculus of residues and some elementary introduction to analytic continuation in various areas of physics and mathematics;

2. solve sets of linear equations, and determine eigenvalues and eigenvectors of matrices.

3. use the special functions of mathematics and physics and their properties in the solution of practical problems in physics.

4. use the calculus of variations to derive minimum action and to use this principle to solve eigenvalue problems.

Course content:

A. Complex Analysis and Applications: Complex numbers and functions of a complex variable: Linear functions. Integrals and power series: The Laurent series. Analytic continuation. Linear Algebra:

B. Linear Algebra. Introduction to vector spaces. Real symmetric, real skew-symmetric and orthogonal matrices. Systems of linear equations.. Rank of a matrix. Homogeneous system $\mathbf{Ax} = 0$ and non-homogeneous system $\mathbf{Ax} = \mathbf{b}$. Solutions of linear equations by determinants. Eigenvalues and eigenvectors. Determination of eigenvectors. Hermitian, skew-Hermitian, unitary matrices and their eigenvalues. Diagonalization of matrices.

C. Special Functions: .Series solution of differential equations.

Time Allocation: Lectures: 4 hrs/week. Tutorial: 1 hr/week

Assessment: Continuous assessment: 30% (Tests 20, Assignments 10), Final examination 70%

Pre-requisites: M911/912.

Recommended Texts:

1. E. Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons, 1988. ISBN: 10:0471726451
2. G. Arfken, Mathematical Methods for Physicists, Academic, 1993. ISBN: 13:978-0120598

Supplementary Reading:

1. R. V. Churchill and J. W. Brown, Complex Variables and Applications, 4th ed., MacGraw-Hill, 1984. ISBN: 13:978-0070108554,
2. A. O. Morris, Linear Algebra: An Introduction, Van-Nostrand, 1978. ISBN: 13:978-0442305413
3. J. B. Conway, Functions of One Complex Variable, Springer-Verlag, 1978. ISBN: 13:978-0387900029

P495: SPECIAL PROJECT

Rationale:

A student graduating in Physics has done a number of theory and associated laboratory courses. At the same time (s)he is expected to have acquired the skills to undertake the investigation of a Physics problem on his own. The purpose of this course is to give a student hands on training in doing a small research project.

Objective:

At the end of this course, the student is expected to have learned how to investigate a scientific problem, collect and analyze data, and present the results to his/her peers in the field in the form of a research report.

Course content:

A half-course equivalent project based on individual student-staff agreement with Board of Studies approval. Projects are available in Solid State Physics, Nuclear Physics, Electronics, Applied Optics, Computational Physics, and Energy and the Environment.

Pre-requisite: Consent of Head of Department

Post Graduate Programmes

Ph.D. in Physics

The Department of Physics is currently offering Ph.D. programmes to suitably qualified students. Students are advised to check with the Department about the availability of supervisor(s) and facilities in the fields of their choice.

M. Sc. in Physics

The M.Sc. in Physics consists of two parts: Part 1 contains one compulsory course and three optional courses while Part 2 consists of a dissertation (theoretical or experimental) in a specialisation linked to research interests within the department. At present, this is in a suitable area of Nuclear Physics, Condensed Matter Physics, Computational Physics, Instrumentation, Solar Energy Application, and Physics of Atmosphere and Climate. The whole programme is designed for two (2) years of full-time study.

The following courses are offered:

		Semester I	Semester II
Compulsory Courses	Mathematical Methods for Physics	MP5011	MP5022
Optional Courses	Computational Physics and Modelling	PHY5911	PHY5922
	Nuclear Physics	PHY5111	PHY5122
	Condensed Matter Physics	PHY5211	PHY5222
	Theoretical Physics	PHY5311	PHY5322
	Instrumentation	PHY5431	PHY5422
	Solar Energy and Applications	PHY5811	
	Solar Energy Materials		PHY5822
	Physics of the Atmosphere and Climate	PHY5831	PHY5832

It is anticipated that the candidate would supplement his/her knowledge in the given subject if he/she did not take the pre-requisites in his/her undergraduate studies. These would not count towards his/her M.Sc. A candidate is required to pass Part I before proceeding to Part II.

The optional courses can be combined in the following manner:

	Semester I	Semester II
Computational Physics and Modelling	PHY5911	PHY5922
Nuclear Physics	PHY5111	PHY5122
Theoretical Physics	PHY5311	PHY5322
Computational Physics and Modelling	PHY5911	PHY5922
Condensed Matter Physics	PHY5222	PHY5211
Theoretical Physics	PHY5311	PHY5322
Computational Physics and Modelling	PHY5911	PHY5922
Theoretical Physics	PHY5311	PHY5322
Instrumentation	PHY5431	PHY5422
Computational Physics and Modelling	PHY5911	PHY5922
Theoretical Physics	PHY5311	PHY5322
Solar Energy and Applications Solar Energy Materials	PHY5811	 PHY5822

Computational Physics and Modelling	PHY5911	PHY5922
Theoretical Physics	PHY5311	PHY5322
Physics of the Atmosphere and Climate	PHY5831	PHY5832
Computational Physics and Modelling	PHY5911	PHY5922
Instrumentation	PHY5431	PHY5422
Solar Energy and Applications Solar Energy Materials	PHY5811	 PHY5822
Computational Physics and Modelling	PHY5911	PHY5922
Instrumentation	PHY5431	PHY5422
Physics of the Atmosphere and Climate	PHY5831	PHY5832
Computational Physics and Modelling	PHY5911	PHY5922
Solar Energy and Applications Solar Energy Materials	PHY5811	 PHY5822
Physics of the Atmosphere and Climate	PHY5831	PHY5832
Nuclear Physics	PHY5111	PHY5122
Theoretical Physics	PHY5311	PHY5322
Instrumentation	PHY5431	PHY5422
Nuclear Physics	PHY5111	PHY5122
Theoretical Physics	PHY5311	PHY5322
Solar Energy and Applications Solar Energy Materials	PHY5811	 PHY5822
Nuclear Physics	PHY5111	PHY5122
Theoretical Physics	PHY5311	PHY5322
Physics of the Atmosphere and Climate	PHY5831	PHY5832
Condensed Matter Physics	PHY5211	PHY5222
Theoretical Physics	PHY5311	PHY5322
Instrumentation	PHY5431	PHY5422
Condensed Matter Physics	PHY5211	PHY5222
Theoretical Physics	PHY5311	PHY5322
Solar Energy and Applications Solar Energy Materials	PHY5811	 PHY5822
Condensed Matter Physics	PHY5211	PHY5222
Theoretical Physics	PHY5311	PHY5322
Physics of the Atmosphere and Climate	PHY5831	PHY5832
Theoretical Physics	PHY5311	PHY5322
Solar Energy and Applications Solar Energy Materials	PHY5811	 PHY5822
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Instrumentation	PHY5431	PHY5422
Solar Energy and Applications Solar Energy Materials	PHY5811	 PHY5822
Physics of the Atmosphere and Climate	PHY5831	PHY5832

It should be noted that the combinations offered are subject to the availability of staff and the background of the student.

PHY 5011: MATHEMATICAL METHODS FOR PHYSICS I

Rationale:

The power of physics lies in the mathematical expression of physical law. Applications of physics involve mathematical techniques of varying degrees of complexity. It is therefore essential for a student to have a solid foundation in mathematics. These first and second semester courses aim at providing a strong mathematical foundation to students in areas not usually covered at the undergraduate level.

Objectives:

By the end of the course the student should be able to

1. recognise the main partial differential equations of physics and know the method of solution for given initial and boundary conditions.
2. apply the methods of solution to partial differential equations that might arise in the student's area of specialization.
3. use Green' s functions to solve physical problems.
4. use the techniques and concepts of the calculus of variations.

Course Content:

1.Partial differential equations: One-dimensional wave equation (vibrating string); Heat equation (one-dimensional finite and infinite bar, two-dimensional time-independent case – the Laplace equation); Two-dimensional wave equation (rectangular, membrane); Use of polar coordinates and a circular membrane (Bessel's equation); Laplace equation in spherical polar coordinates, Legendre's equation; Laplace transforms applied to partial differential equations; Fourier transforms applied to partial differential equations.

2. Eigen functions, eigenvalues and Green's functions: Some examples of eigenvalue problems; use of Green's functions to solve inhomogeneous problems; Green's functions in electrodynamics.

3. Integral equations: Classification; Degenerate Kernels; Neuman and Friedholm series; Schmidt-Hilbert theory; Integral equations in dispersion theory.

4. Integral transforms: Laplace transforms: Inverse transforms, linearity, Laplace transforms of derivatives and integrals, shifting s-axis and t-axis, unit step function, Dirac's delta function, convolution, systems to differential equations. Fourier transforms, sine and cosine transforms

5. Calculus of Variations: Euler-Lagrange equation. Generalizations of the basic problem. Connection between the eigenvalue problem and the calculus of variations.

Associated laboratory: none

Time allocation: 3 one-hour lectures/week, 1 one-hour tutorial
Assessment: Continuous Assessment 30%, Two tests 20%
Assignments 10%). Final Examination 70%

Prescribed texts:

1. E. Kreyszig, Advanced Engineering Mathematics, 6th ed., John Wiley, New York, 1988. ISBN: 0 471 62787 9.
2. J. Mathews and R. L. Walker, Mathematical Methods for Physics, 2nd ed., Pearson, Delhi, 1970, ISBN: 81 297 0543 5
3. M. L. Boas, Mathematical Methods in the Physical Sciences, John Wiley & Sons, 1983. ISBN: 13:978-0471099604

4. M. Spiegel, Vectors – With Tensor Analysis, Schaum Series, McGraw-Hill, 1974. ISBN: 0071108076

PHY 5022: MATHEMATICAL METHODS FOR PHYSICS II

Rationale

This course is basically a continuation of PHY5011. Further mathematical methods for use in physics are introduced.

Objectives

At the end of this course, the student should be able to:

1. to apply tensor concepts to physical problem.
2. to apply group theory to physical problems

Course Content

1. Tensor Analysis: Curves in three-space, Frenet formulae, General tensor analysis;

2. Group Theory: Groups and group representations (finite and continuous): Definitions, subgroups and classes, Group representations, characters, physical applications, infinite groups, irreducible representations of SU(2) and O(3.), Physical applications

Associated laboratory: none

Time allocation: 3 one-hour lectures/week, 1 one-hour tutorial
Assessment: Continuous Assessment 30%, Two tests 20%
Assignments 10%). Final Examination 70%

Prescribed texts:

1. E. Kreyszig, Advanced Engineering Mathematics, 6th ed., John Wiley, New York, 1988. ISBN: 0 471 62787 9.
2. J. Mathews and R. L. Walker, Mathematical Methods for Physics, 2nd ed., Pearson, Delhi, 1970, ISBN: 81 297 0543 5
3. M. L. Boas, Mathematical Methods in the Physical Sciences, John Wiley & Sons, 1983. ISBN: 13:978-0471099604
4. M. Spiegel, Vectors – With Tensor Analysis, Schaum Series, McGraw-Hill, 1974. ISBN: 0071108076

PHY5911: COMPUTATIONAL PHYSICS AND MODELLING I

Rationale

The ubiquitous presence of computers has meant that every student has at his or her disposal a powerful computational tool. The field of computational physics has developed as a response to the need to exploit this tool to solve problems which in a previous era were much more difficult to deal with. Old algorithms for problem solving have been revised while new ones continue to be developed. In this course, the student will be introduced to many of these, so that should he or she need them they will be at hand.

Objectives

At the end of this course, the student

1. Should know how to model a physical system mathematically, with a view to solving it.
2. Should know how to use various numerical methods to solve problems which are not amenable to analytic solution.
3. Have deepened his or her understanding of numerical methods initially introduced in P302 and P401.
4. Should be ready for more advanced study in numerical analysis and modelling.

Course Content

Numerical Differentiation and Integration: Numerical integration and Richardson extrapolation, Gaussian quadrature, Romberg integration, adaptive quadrature, Sard's theory of approximating functionals, Bernoulli polynomials and the Euler-Maclaurin formula

Approximating Functions: Hermite interpolation, spline interpolation, best approximation by Chebyshev theory, continued fractions, trigonometric interpolation and fast Fourier transform, adaptive approximation

Solution of Nonlinear Equations: The secant method, fixed points and functional iteration, zeros of polynomials, homotopy and continuation methods

Linear Systems: LU factorization, matrix inversion, solution by iteration, ill-conditioning, norms, Doolittle's method, Cholesky' method, Neumann series and iterative refinement, the methods of steepest descent and conjugate gradient, analysis of errors

Eigenvalues and Eigenvectors: Inclusion of eigenvalues, Eigenvalues by the power method, tridiagonalization and the QR algorithm, Singular-value decomposition and pseudo-inverses

Time Allocation:

Lectures: 3 hrs/week, Tutorial: 1 hr/week

Lab: Associated laboratory of 3 hrs/week

Assessment:

Continuous assessment: 40%, Final examination: 60%

Pre-requisites: P302, P401, MP415

Prescribed Texts:

1. E. Kreyszig, Advanced Engineering Mathematics, J. Wiley and Sons, 2006. ISBN: 9971-51-283-1
2. D. Kincaid and W. Cheney, Numerical Analysis, Brooks/Cole, 1991. ISBN: 0-534-13014-3
3. R. L. Burden and J. D. Faires, Numerical Analysis, PWS-Kent, 1989. ISBN: 0-53491-585-X

PHY5922: COMPUTATIONAL PHYSICS AND MODELLING II

Rationale

This course is a continuation of PHY5911 and is also aimed at equipping the student with the techniques needed to solve physical problems which are not amenable to analytic treatment. As many physical problems yield differential equations when modelled, the emphasis in this course is on numerical solution of differential equations.

Objectives

At the end of this course, the student

1. Should be well-equipped to solve differential equations by numerical methods.
2. Should know how to model a physical system mathematically, with a view to solving it.
3. Should know how to use various numerical methods to solve problems which are not amenable to analytic solution.
4. Have deepened his/her understanding of numerical methods initially introduced in P302 and P401 and PHY5911
5. Should be ready for more advanced study in numerical analysis and modelling.

Course Content

Numerical Solution of Ordinary Differential Equations: Existence and uniqueness of solutions, the Taylor-series method, Runge-Kutta methods, multi-step methods, local and global errors; stability, systems of higher-order differential equations, boundary-value problems, linear differential equations, stiff equations.

Numerical Solution of Partial Differential Equations: Parabolic equations, problems without time dependence, first-order partial differential equations, quasi-linear second-order equations, other methods for hyperbolic equations, multi-grid methods, fast methods for Poisson's equation

Linear Programming and Related Topics: Convexity and linear inequalities, linear programming, the simplex algorithm

Time Allocation:

Lectures: 3 hrs/week, Tutorial: 1 hr/week

Lab: Associated laboratory of 3 hrs/week

Assessment:

Continuous assessment: 40%, Final examination: 60%

Pre-requisites: PHY5911

Prescribed Texts

1. E. Kreyszig, Advanced Engineering Mathematics, J. Wiley and Sons, 2006. ISBN: 9971-51-283-1
2. D. Kincaid and W. Cheney, Numerical Analysis, Brooks/Cole, 1991). ISBN: 0-534-13014-3
3. R. L. Burden and J. D. Faires, Numerical Analysis, PWS-Kent, 1989. ISBN: 0-53491-585-X

PHY5111: NUCLEAR PHYSICS I

Rationale

The courses in nuclear physics at fourth year, P411 and P412, serve to introduce the student to the subject. The courses at postgraduate level serve to deepen the understanding of the material already encountered and introduce new and important concepts. In this course, the emphasis is on nuclear reactions.

Objectives

At the end of this course, the student

1. Should know how to use the numerous models for nuclear reactions in their regimes of applicability.
2. Should be ready for more advanced study in nuclear physics.

Course Content

Introduction to Nuclear Reactions: Types of reactions, energy and mass balance, cross-sections, nuclear sizes from neutron scattering, Coulomb scattering and Rutherford's formula, electrons scattering, Coulomb excitation, polarization, angular correlations, partial waves, identical particles

Elementary Scattering Theory: Form of the wave function, differential cross sections, the Schrödinger equation, partial waves, total cross section and the optical theorem, collisions with spin, R-matrix and boundary-matching theories, classical and semi-classical descriptions

Models of Nuclear Reactions: Partial waves and strong absorption, effects of the Coulomb field, diffraction models and strong-absorption scattering, strong-absorption models for inelastic scattering, the optical model for elastic scattering, direct reactions, compound nucleus resonances, continuum statistical theory of the compound nucleus, reactions between heavy ions

Time Allocation:

Lectures: 3 hrs/week, Tutorial: 1 hr/week

Assessment:

Continuous assessment: 30%, Final examination: 70%

Pre-requisites: P411, P412, P455, MP415

Prescribed Texts

1. G. R. Satchler, Introduction to Nuclear Reactions, Macmillan Press, 1980. ISBN: 0-333-25907-6
2. E. Segre, Nuclei and Particles, Benjamin/Cummings Publishing. ISBN: 10:0805386009

PHY5122: NUCLEAR PHYSICS II

Rationale

This course introduces the student to further advanced concepts in nuclear physics. It concentrates on particle physics, a very vibrant area of physics, which for many serves as the bridge to such active areas of research as string theory. The course therefore helps to prepare the student for research in some of the most topical questions of modern-day physics.

Objectives

At the end of this course, the student

1. Be conversant with the basic concepts of elementary particle physics.

2. Should be ready for more advanced study in such areas as string theory and particle cosmology.

Recommended Course Content

Interactions of particles with matter, and detectors

SU(2), SU(3), models of mesons and baryons

QED, weak interactions, parity violation, lepton-nucleon scattering, and structure functions

QCD, gluon field and color

W and Z fields, electro-weak unification, the CKM matrix

Nucleon-nucleon interactions, properties of nuclei, single and collective particle models

Electron and hadron interactions with nuclei

Relativistic heavy ion collisions, and transition to quark-gluon plasma

Time Allocation:

Lectures: 3 hrs/week, Tutorial: 1 hr/week

Assessment:

Continuous assessment: 30%, Final examination: 70%

Pre-requisites: PHY5111, PHY5311
Co-requisite: PHY5322

Prescribed Texts

1. F. Halzen and D. Martin, Quarks and Leptons, Wiley Text Books, New York, 1984. ISBN: 0471887412.

2. S. M. Wong, Introductory Nuclear Physics, 2nd ed., Wiley-Interscience, New York, 1998. ISBN: 0471239739.

Recommended Texts

1. D. Griffith, Introduction to Elementary Particles, Wiley Text Books, 1987. ISBN: 0471603864.

2. B. Povh, Particles and Nuclei: An Introduction to the Physical Concepts, 3rd ed., Springer-Verlag, Berlin; New York, 2002. ISBN: 3540438238.

3. J. J. Sakurai, Modern Quantum Mechanics, 2nd ed., Addison-Wesley, Reading, Mass., 1994. ISBN: 0201539292.

PHY 5211: CONDENSED MATTER PHYSICS I

Rationale:

This course is intended for graduate students and covers advanced topics in condensed matter physics. Here a combined use of the statistical mechanics and the quantum theory lie at the heart of this course. The student is grilled to look at those topics based on classical methods and those demanding a quantum treatment. One can also look at this course as P421 but treated at an advanced level. We discuss the theoretical treatment of the physics of solids,

The intention of this course is to make students understand at an advanced level the microscopic and macroscopic properties of solids and be conversant with the mathematical formulations of these properties towards certain physical applications.

Objectives:

After completing this course, a student should have:

1. a thorough understanding of the scientific characteristics that make solids stand out as one of the key states of matter;
2. a deep grasp of the fundamental theories, both classical and quantum mechanical, underlying the structural, thermal, electronic, optical, electrical and magnetic properties of solids (metals, semimetals, semiconductors, insulators, dielectrics, etc.);
3. the knowledge to identify special key features of solids that are amenable to theoretical and experimental manipulation for technological use;

Course Content:

Elementary excitations, crystal structure - symmetry- translational, rotational, energy bands - APW, OPW, pseudopotential and LCAO schemes, theory of electron dynamics, scattering processes.

Time Allocation:

3 one-hour lectures/week, 1 hr tutorial/week.

Assessment:

Continuous assessment: 30%: Assignments 10%, Tests 20%, Final examination 70%

Pre-requisites:

P421, P422, P455, MP415.

Co-requisites:

Prescribed Textbooks:
1. N. W. Ashcroft and D. N. Mermin, Solid State Physics, Harcourt College Publishers, Orlando, 1976. ISBN: 13:978-0030839931
2. M. T. Dove, Structure and Dynamics – An Atomic View of Materials, Oxford University Press Inc., New York, 2003. ISBN: 10:0198506775
3. J. Singleton, Band Theory and Electronic Properties of Solids, Oxford University Press Inc., New York, 2001. 10:0198506457

Recommended Texts:

1. S.O. Pillai, Solid State Physics 5ed, New Age International Publishers, New Delhi, 2003. ISBN: 10:8122403816
2. H. V. Keer, Principles of the Solid State, New Age International Publishers, New Delhi, 2000. ISBN: 10:812240466
3. J. Dekker, Solid State Physics, Macmillan & Co. Ltd, London, 1960. ISBN: 10:9880333918333
4. S.L. Kakani and S. Kakani, Modern Physics, Viva Books Private Ltd., New Delhi, 2006. 4100

PHY 5222: CONDENSED MATTER PHYSICS II

Rationale**:**

This course is a continuation of Condensed Matter Physics II and covers advanced topics in condensed matter. However, here we treat specialised topics that are directed towards background studies in areas of research that are to be the subject of the dissertation.

Objectives:

After completing this course, a student should be able to:

1. show a good understanding of the material properties of metals, insulators, semiconductors and superconductors that are responsible for the importance of these solids used in technological applications;
2. quantitatively describe the thermodynamic, optical, electrical and transport properties of these novel materials;
3. show a good grasp of the fundamental characteristics of those magnetic materials important in applied science;
4. understand the interaction of matter with electromagnetic radiation;
5. identify special features of solids that are amenable to theoretical and experimental manipulation for technological use;

Course Content**:**

Matter-electron interactions, Stability of structures, Metals, Insulators and semiconductors, Phonon measurements, Impurities and disorder, Collective phenomena, Superconductivity, etc.

Method of Teaching:

Time Allocation :	3 one-hour lectures/week. 1 hr tutorial/week.

Assessment:

Continuous assessment: 30%:	Assignments	-	10%
	Tests	-	20%
Final Examination 70%			

Pre-requisites**:** PHY 5211

Prescribed Textbooks:

1. N. W. Ashcroft and D. N. Mermin, Solid State Physics, Harcourt College Publishers, Orlando, 1976. ISBN: 13:978-0030839931
2. M. T. Dove, Structure and Dynamics – An Atomic View of Materials, Oxford University Press Inc., ew York, 2003. ISBN: 10:0198506775
3. J. Singleton, Band Theory and Electronic Properties of Solids, Oxford University Press Inc., New York, 2001. ISBN: 10:0198506457

Recommended Texts:

1. S.O. Pillai, Solid State Physics 5ed, New Age International Publishers, New Delhi, 2003. ISBN: 10:8122403816
2. H. V. Keer, Principles of the Solid State, New Age International Publishers, New Delhi, 2000. ISBN: 10:812240466
3. J. Dekker, Solid State Physics, Macmillan & Co. Ltd, London, 1960. ISBN: 10:9880333918333
4. S.L. Kakani and S. Kakani, Modern Physics, Viva Books Private Ltd., New Delhi, 2006. 4100

PHY 5311: THEORETICAL PHYSICS I

Rationale:

Even where a student is specializing in a particular applied area of physics, an understanding of the main theoretical areas of physics is essential for three reasons. First, by stimulating and exerting his or her mind, the student improves his ability to solve problems in his/her area of specialization. Second, the study of theoretical physics will improve the student's mathematical skills. Third, theory and techniques in one area of physics can often be adapted to other at first very different areas of physics.

Objectives:

At the end of this course, the student:

1. Be familiar with the main areas of theoretical physics. In particular, he should be conversant with the main ideas of relativistic quantum mechanics and quantum field theory.
2. Have developed his or her mathematical skills to the extent that he or she is able to tackle problems in his or her area of specialization with confidence.
3. Have acquired a broad range of techniques which may adapted to solve problems in his or her areas of specialization.

Course content:

1. Relativistic quantum mechanics: The Klein-Gordon equation; Problem of negative energy solutions; The Dirac equation; Nonrelativistic correspondence; Lorentz covariance of the Dirac equation; Solutions of the Dirac equation for a free particle; Zetterbewegung, The problem of negative-energy solutions; Hole theory.

2.Quantum field theory**:** Classical field theory, Quantization of scalar fields, Quantization of Dirac fields, Quantization of the electromagnetic field, Quantum electrodynamics, Renormalization, Symmetries and symmetry-breaking

Associated laboratory: none

Time allocation: 3 one-hour lectures/week, 1 one-hour tutorial

Assessment: Continuous Assessment 30%, Two tests 20%, Assignments 10%, Final examination 70%

Prescribed Texts:

1. J. D. Bjorken and S. D. Drell, Relativistic Quantum Mechanics, McGraw-Hill, New York. ISBN: 07 005 493 2
2. W. Greiner, Relativistic Quantum Mechanics: Wave Equations, Springer Verlag, Berlin, 2000. ISBN: 3540674578
3. A. Lahiri and P. B. Pal, A First Course of Quantum Field Theory, Narosa Publishing House, New Delhi, 2005. ISBN 81-7319-654-0

PHY 5322: THEORETICAL PHYSICS II

Rationale:

Since the field of theoretical physics is vast, one course cannot do justice to all the foundational topics which a student should ideally study. In this course, further important areas of theoretical physics are introduced. The exact contents of this course will to a large part be determined by the proposed specialisation of the student, especially with regard to his dissertation.
Objectives:

1. Gravitation and Cosmology:

Beginnings of General Relativity: Space and time in a rotating frame, Gravity and acceleration, Local inertial frame, universality of free fall, The equivalence principle, Experimental tests of the universality of free fall and the equivalence principle.

A Metric Theory of Gravity and the Field Equations of General Relativity: Geometry on various surfaces (parametric representation of curves and coordinate systems of such surfaces), Geodesic equations , special relativity as a metric theory, concept of curvature and Einstein's field equations, experimental tests of relativity.

The Big Bang: Light from galaxies, Distances of galaxies, Microwave background radiation, Angular distribution of the 3K background radiation, primordial nuclear abundances.

General Relativity and Cosmology: Distribution of clusters of galaxies, Robertson and Walker co-moving coordinates, The Robertson-Walker metric,
The Hubble parameter, Measurement of the scale factor R.

The Evolution of the Universe: Friedman-Robertson-Walker cosmology and predicted evolution of the universe, the age of the universe, density and composition of the universe, Inflation, A brief history of the universe.

2. Selected Topics in Foundations of Physics: Optional. Content to be chosen by lecturer.

3. Recent Experimental Tests of the Foundations of Quantum Mechanics**:** Optional. Content to be chosen by lecturer.

Associated laboratory: none

Time allocation: 3 one-hour lectures/week, 1 one-hour tutorial

Assessment:

Continuous assessment 30%, Two tests 20%, Assignments 10%. Final examination 70%

Prescribed texts:

1. J. D. Bjorken and S. D. Drell, Relativistic Quantum Mechanics (McGraw-Hill, New York), ISBN: 07 005 493 2
2. W. Greiner, Relativistic Wave Equations, 3rd ed., Butterworth – Heinemann, 1981. ISBN: 13978-0750635394
3. Gravitation and Cosmology: Space, Time and Cosmology, Blocks 3 and 4, Open University, Milton Keynes, 2001. Block 3 ISBN 0 7492 8160X, Block 4 ISBN: 0 7492 8161 8

PHY 5431: INSTRUMENTATION I

Rationale

Instrumentation is a branch of physics which deals with measurement of various physical quantities like temperature, pressure, flow, speed, sound, light intensity and control of the same in various industries. The use of sensors and electronic instrumentation is an essential element of all scientific and engineering activities. There is a high demand for graduates with specialist knowledge and training in this area leading to opportunities over a wide range of fields, from instrument and sensor production to chemical, aerospace and automotive engineering. This course provides students with practical, hands-on experience in the design, development and application of sensors and instrumentation systems.

Objectives

At the end of this course a student should be able to

(i) describe the construction and calibration procedure for a particular measurement instrument;
(ii) identify and quantify errors from calibration graphs and describe correction procedures for selected instruments;
(iii) select a suitable measurement instrument for a given process measurement;
(iv) describe the installation procedure for a selected measurement instrument in a particular industrial situation, and correctly interpret measurements obtained;
(v) solve numerical problems involving equations pertaining to pressure, level, temperature and flow measurements.

Course Content

1. Introduction to Instrumentation: Functional elements and characteristics of instruments; Introduction to instruments and their representation; System configuration-Block diagram representation of measurement systems; Static and dynamic characteristics of measurement systems; Need for calibration and standards; Instrument parameters: sensitivity, accuracy, resolution, span, range; Role of instruments in industrial processes.

2. Sensors and Transducers for Instrumentation**:** Transducer terminology, transducer classification, performance characteristics, criteria for transducer selection, principles of operation, specification and construction of following transducers; Displacement: potentiometer, capacitive, inductive, optical encoders-linear and rotatory; Chemical sensors: measurement of conductivity, pH and humidity; Optical sensors: PMT, photodiodes, CCD, LDR;

3. Pressure Measurements, Methods and Applications: Relationship between absolute, atmospheric and gauge pressures; Principle of operation and installation of the following pressure gauges: diaphragm gauges, bellows gauges, Bourdon gauges, strain gauges; Gauge calibration using manometers, dead-weight testers, portable field calibrators and comparators; Pressure transmitters: standard pneumatic and electrical signals.

4. Temperature Measurements, methods and applications: Metal resistance thermometers and thermistors: theory, types, industrial installation and applications; Resistance temperature

detector (RTD); Thermocouples: Seebeck effect, base metal and rare metal thermocouples, their metal combinations, operating ranges and uses; Law of Intermediate Metals and Law of Intermediate Temperatures; Practical application of these laws in the use of thermocouples; Installation techniques; Thermowells; Thermometer calibration procedures. Temperature measurement by radiation method - optical pyrometer; solid state transducer.

5. Flow Measurements, methods and applications: Volume and mass flow rate; Turbulent flow, streamlined flow and Reynolds number; The Continuity Equation, Bernoulli's Equation and application to differential pressure devices; Differential pressure primary elements: orifice plate, Venturi tube, Dall tube, flow nozzle and pitot-static tube; Installation procedures; Classification of flow meters:- mechanical flow meters, vortex flow meter, magnetic, ultrasound and coroilis flow meters; Variable area flow meters.

6. Analytical, Optical and Biomedical Instrumentation: Mass spectrometry. UV, visible and IR spectrometry. X-ray and nuclear radiation measurements. Optical sources and detectors, LED, laser, Photo-diode, photo-resistor and their characteristics. Interferometers, applications in metrology. Basics of fiber optics. Biomedical instruments, EEG, ECG and EMG. Clinical measurements. Ultrasonic transducers and Ultrasonography.

Practical: Minimum Eight experiments based on above syllabus.

Time Allocation: 3 hours per week, 1 tutorial per week, Three-hour practical session per week.

Assessment:

50% exam, 30% laboratory work, 10% Tests, 10% Assignments

Pre-requisite: P231, P441

Recommended Textbooks

1. A. S. Morris, Measurement and Instrumentation Principles, Butterworth-Heinemann, 2001. ISBN: 0750650818
2. L. Michalski, Temperature Measurement, John Wiley & Sons, 2001. ISBN: 0471867799
3. D. W. Spitzer, Industrial Flow Measurement, 3rd ed., ISA, 2000. ISBN: 1556178719
4. T. A. Hughes, Measurement and Control Basics, 3rd ed., ISA, 2002. ISBN: 155617764X

Additional Reading/Textbooks

1. B. G. Liptak, Instrument Engineers' Handbook– Process Measurement and Analysis, Vol 1, 4th ed., ISA, 2003. ISBN: 0849310830

3. W. Buchanan, Industrial Instrumentation and Control, Butterworth- Heinemann, 1999. ISBN: 0340719222

PHY 5422: INSTRUMENTATION II

Rationale

Microprocessor based systems are suitable for dedicated applications in industries such as process control, control of machines and equipment, instrumentations and so on. This course is very useful to students who want to develop microprocessor based automatic industrial control, appliances control, measuring instruments etc.

Objectives

At the end of this course a student should

(i) be able to select suitable memories and input/output devices for his task and interface them to the microprocessor;
(ii) gain knowledge in measurement, display and control of some electrical and physical quantities;
(iii) be able to transfer skills to other applications.

Course Content

1. **Microprocessors and computers**
   Microprocessor and computer architecture, CPUs, Buses, expansion slots, I/O units, RAM and ROM memories, storage media, Interrupts, 8, 16, 32, and 64-bit processors and processing speed.

2. **Real-Time Systems**
   Event driven activities , I/O Devices, Serial devices and parallel devices, Peripheral, serial buses, Multitasking in Real-Time Systems using JAVA, Scheduling, Synchronization, Watchdog timers, multi-threaded real-time data acquisition,

3 **Software Platform for Microprocessor based data acquisition system.**
   Real-Time operating system (e.g. Linux) , Programming a microprocessor based system using a higher level language, .g., JAVA. Introduction to Databases (e.g. using SQL). Distributed data acquisition systems using the TCP/IP protocol based networking (e.g., Ethernet). Creating a Graphical User Interface

Practical: Minimum Eight experiments based on above syllabus.

Time Allocation: 3 hrs/week
1 tutorial /week
3 hr practical session/week

Evaluation Criteria: The final score will be:
50% of written exam
30% laboratory work
20% Test/Assignments

Pre-requisite: P401, P442

Prescribed Textbooks

1. Programming Embedded Systems, O'Reilly Media, Inc.; 2nd edition (October 1, 2006), **ISBN-10:** 0596009836.
2. 'Real-Time Programming - A guide to 32-bit Embedded Development', Grehan, Moote and Cyliax, Addison Wesley, 1998.

3. Electronic Design of Microprocessor-based Electronic Instruments and Control Systems By Abund Ottokar Wist, Z. H. Meiksin, Prentice Hall, Original from the University of Michigan,digitized Dec 18, 2006.

4. INSTRUMENTATION REFERENCE BOOK, Walt Boyes, Principal in Spitzer and Boyes, LLC, 2002, ISBN-13: 978-0-7506-7123-1, ISBN-10: 0-7506-7123-8

Recommended Textbooks

1. Microprocessors and Microcomputer based System Design - Mohammed Rafiquzzaman

2. Slater, “Microprocessor Based Design: A Comprehensive guide to Effective hardware Design, PHI.

3. ARM9 Intel Manual.

PHY 5811: SOLAR ENERGY AND APPLICATIONS

Rationale:

The problem of climate change arising due to emissions of the greenhouse gases has now become a global agenda. The world is now rapidly moving towards increased use of renewable energy, including solar, in order to mitigate this problem. The goal of this course is to build high level capacity on some aspects of solar energy. This course is a follow up to the undergraduate course “Physics of Renewable Energy Resources and Environment (P485)”.

Objectives:

At the end of this course, a student should be able to carry out:

(i) assessment of the availability of various components of solar radiation on horizontal and inclined surfaces.
(ii) performance analysis of a liquid flat-plate collector.
(iii) performance analysis of a concentrating collector.
(iv) life-cycle cost analysis of solar energy systems.
(v) design and performance analysis of solar photovoltaic systems.

Course Content:

Solar Radiation: Basics of solar radiation. Radiation on horizontal and inclined planes. Solar radiation measuring instruments, pyrheliometric scales, calibration and quality control. Cloudless-sky atmosphere and its optics. Solar spectral and total radiation under cloudless sky. Solar radiation and cloudy skies. Estimation of solar radiation on horizontal and inclined planes - models and correlations for daily and hourly global diffuse /beam radiation.

Solar Collectors: General description of liquid flat-plate collectors, overall heat loss coefficient, steady state model of liquid flat-plate collectors, two-dimensional heat transfer steady state model, transient considerations, optimization of collector configuration, design of some important flat-plate collectors, performance analysis and test procedures. Flat-plate air collectors. Concentrating collectors. Applications. Photovoltaic systems: standard modules, series-parallel connection of cells, storage of energy, stand-alone systems, residential and centralised systems.

Time Allocation:

Lectures: 3 hrs/week Tutorial: 1 hr /week Lab: Associated practical lab: 3 hrs/week

Assessment:

Continuous Assessment 40%, Final examination 60%

Prerequisites: P485

Prescribed Texts

1. M. Iqbal, Introduction to Solar Radiation, Academic Press, Toronto, 1983, OSTI 10:5596615
2. H. P. Garg, A Treatise on Solar Energy. Vol. 1: Fundamentals of Solar Energy, John Wiley & Sons, Chichester, 1982. ISBN: 10: 096014810300168X

Recommended Texts:

1. J. A. Duffie and W. A. Beckman, Solar Engineering of Thermal Processes, John Wiley & Sons, New York, 1980. ISBN: 10:0471510564
2. P.C. Jain, T.B. Chibuye and P.O. Kruss (Editors), Renewable Energy (Special Issue). Proceedings of the Regional Workshop on Solar Radiation, Environment and Climate Change, held at the University of Zambia, 22-27 July, 1991, Pergamon Press (Oxford, 1993).
3. M. A. Green, Solar Cells Operating Principles: Technology and System Applications, Prentice Hall Inc., Englewood Cliffs, New York, 1982. ISBN: 13:978-0138222703

PHY 5822: SOLAR ENERGY MATERIALS

Rationale

This course covers thin film coatings and surface treatments for energy efficient spectrally selective materials of many different kinds that can be used for solar collectors, efficient windows, anti-reflectors, heat mirrors, just to mention a few. The desired spectral properties of these materials are introduced. The main thrust of this course is devoted to materials options, coating techniques (mainly physical and chemical deposition methods), characterization and experimental data of the optical properties, theoretical models for pertinent materials, and optimization studies with regard to practical applications. The goal is to bridge the gap between fundamental materials sciences and technological applications and to point out viable options for future research and development. The focus is on basic concepts and ideas rather than physical and mathematical details.

Objectives:

At the end of this course, a student should have:

(i) acquired sufficient knowledge in the basic technology of fabrication of solar energy conversion devices;
(ii) a good understanding of the advanced physical principles for the utilization of solar energy materials;
(iii) the ability to conduct quantitative evaluation of the performance of solar energy conversion devices; and
(iv) the knowledge to enable him/her formulate research in the growth and characterization of spectrally selective coatings.

Course Content:

Selective Surfaces: Thin Film Optics: Multilayers and the characteristic matrix, transparent and absorbing films. Optical characterization of thin films: Measurements of optical constants and film thickness determination; spectrophotometry and ellipsometry. Thin film technology: vacuum technology and thin film fabrication; vacuum deposition of thin films, electrochemical deposition, electroless deposition and spray pyrolysis. Applications: spectral selectivity, photothermal solar energy conversion; solar absorptance and thermal emittance; heat mirrors; transparent insulation; chromogenics; smart windows and supersmart window materials.

Photovoltaics: Physics of photovoltaics, interaction of light with semiconductors and the basic equations of device physics. Efficiency and its limiting factors: dark and illuminated characteristics, solar cell output parameters, effect of temperature and efficiency measurements. Solar cell materials and processing: monocrystalline, semicrystalline and amorphous silicon, heterojunction and thin film cells, CdS and GaAs solar cells.

Time Allocation:

Lectures: 3 hrs/week Tutorial: 1 hr/week

Lab: Associated practical lab: 3 hrs/week

Assessment:

Continuous Assessment 40%, Final examination 60%

Prerequisites: P421, P422, P485

Prescribed Texts:

1. R. J. Van Overstraeten and R. P. Mertens, Physics, Technology and Use of Photovoltaics, Adam Hilger, Bristol, 1986. ISBN: 10:0852744870
2. O. P. Agnihotri and B. K. Gupta, Solar Selective Surfaces, John Wiley & Sons, New York, 1981. ISBN: 13:978-0471060352
3. H. P. Garg, A Treatise on Solar Energy, Vol. 1: Fundamentals of Solar Energy, John Wiley & Sons, Chichester, 1982. ISBN: 10:096014810300168X

Recommended Texts:

1. M. A. Green, Solar Cell Operating Principles, Technology and System Applications, Prentice

Hall Inc., Englewood Cliffs, New York, 1982. 13:978-0138222703

PHY 5831: PHYSICS OF THE ATMOSPHERE AND THE CLIMATE I

Rationale:

It is well known that the increasing concentration of greenhouse gases in the atmosphere is leading to one of the most dreaded environmental problem of our time – climate change. There is need to build high level human resource in this new field and that is the aim of this course. This is founded on the fact that Physics plays a pivotal role in the understanding, modelling and prediction of climate.

Objectives

At the end of this course, a student should be able to:

(i) obtain/explain the processes and equations in the earth's climate system.
(ii) explain and use the techniques for observing and analysing the climate system.
(iii) obtain/explain physical principles and equations governing the transfer of radiation (solar and terrestrial) through the atmosphere.

Course Content:

Basics - Climate system: components, nature and variability; feedback processes. Basic equations for the atmosphere and oceans: equation of continuity, equations of motion, vorticity equation, thermodynamic energy equation, equation of state. Decompositions of the circulation. Data observation, processing and analysis. Radiation balance: solar and terrestrial radiation, radiative transfer, radiation balance of the atmosphere and at the earth's surface.

Observed Mean State of the Climatic System - Observed mean state of the atmosphere: mass and pressure, temperature structure, geopotential height structure, atmospheric circulation, kinetic energy, precipitation and evaporation. Observed mean state of the oceans: temperature structure, salinity structure, density structure, circulation. Observed mean state of the cryosphere.

Time Allocation:

Lectures: 3 hrs/week Tutorial: 1 hr/week

Associated practical lab: 3 hrs/week

Assessment:

Continuous Assessment 40%, Final examination 60%

Prerequisites: P485

Prescribed Texts:

1. J. P. Peixoto and A. H. Oort, The Physics of Climate, American Institute of Physics, New York, 1992. ISBN: 10:0883187124
2. J. T. Houghton, Physics of the Atmosphere, Cambridge University Press, Cambridge, 1977. ISBN: 10:0521011221

Recommended Texts:

1. J. T. Houghton, G. J. Jenkins and J. J. Ephraums, The Intergovernmental Panel on Climate Change (IPCC) Scientific Assessment, Cambridge University Press, Cambridge, 1990 and 1992. ISBN: 10:0521407206
2. P.C. Jain, T.B. Chibuye and P.O. Kruss (Editors), Renewable Energy (Special Issue). Proceedings of the Regional Workshop on Solar Radiation, Environment and Climate Change held at the University of Zambia, 22-27 July, 1991. Pergamon Press (Oxford, 1993).

PHY 5832: PHYSICS OF THE ATMOSPHERE AND THE CLIMATE II

Rationale:

It is well known that increasing concentrations of greenhouse gases in the atmosphere are leading to one of the most potentially catastrophic environmental problem – climate change. Study of this subject has grown greatly in recent years. There is need to build high levels of the human resource in this new field. Physics plays a pivotal role in the understanding, modelling and prediction of climate. This course, which builds upon the P5831: Physics of the Atmosphere and Climate I, teaches the physics of the atmosphere and the climate, and is designed to develop manpower in this field.

Objectives:

At the end of this course, a student should be able to:

1. formulate exchange processes and cycles in the climate.
2. use tools for climate simulation and modelling.
3. analyze physical factors influencing the earth's climate and vulnerability of human beings to climate change.

Recommended Course Content:

Exchange Processes and Cycles - Exchange processes between the earth's surface and the atmosphere: energy budget at the surface, momentum exchange, transfer of mechanical energy to oceans, exchange of sensible heat and water vapour. Angular momentum balance and observed cycle. The water cycle. Energetics: energy balance equations, observed energy balance. Ocean-atmosphere heat engine: availability of energy in the atmosphere and ocean, balance equations for kinetic and potential energy, observed energy cycle in the atmosphere and oceans. Entropy in the climate system: balance equation of entropy, observed entropy budget of the atmosphere.

Climate Variability and Modelling - Interannual and interdecadal variability in the climate system. Quasibiennial oscillation, ENSO phenomenon, interdecadal fluctuations and trends. Climate simulation: mathematical and physical structure of climate models, general circulation models, statistical dynamic models, use and application of models.

Climate Change and Impacts - Climate change: past climatic changes, natural and anthropogenic factors influencing climate, impact of climate change.

Time Allocation:

Lectures: 3 hrs/week Tutorial: 1 hr/week
Associated practical lab: 3 hrs/week

Assessment:

Continuous Assessment 40%, Final Examination 60%

Prerequisites: P485, P583

Prescribed Texts:

1. J. P. Peixoto and A. H. Oort, The Physics of Climate, American Institute of Physics, New York, 1992. ISBN: 10:0883187124
2. J. T. Houghton, Physics of the Atmosphere, Cambridge University Press, Cambridge, 1977. ISBN: 10:0521011221
3. W. M. Washington and C. L. Parkinson, An Introduction to Three-dimensional Climate Modelling, University Science Books, 2005. ISBN: 1-891389-35-1

Recommended Texts:

1. J. T. Houghton, G. J. Jenkins and J. J. Ephraums, The Intergovernmental Panel on Climate Change (IPCC) Scientific Assessment, Cambridge University Press, Cambridge, 1990 and 1992. ISBN: 13:978-051407205
2. P. C. Jain, T. Chibuye and P. D. Kruss (Editors), Renewable Energy (Special issue). Proceedings of the Regional Workshop on Solar Radiation, Environment and Climate Change held at the University of Zambia, 22-27 July, 1991, Pergamon Press, Oxford, 1993.