THE AMERICAN COLLEGE
RESEARCH DEPARTMENT OF PHYSICS
Programme for M. Phil. PHYSICS (w. e. f. 2019-20 onwards)

Semester	Course No.	Course Title	Hours/Wk	Credits	Marks
I	MPP 6613	Research Methodology	6	6	100
	MPP 6615	Advanced Topics in Physics	6	6	100
	MPP 6617	Vacuum Technology & Thin Films	6	6	100
II	MPP 6600	Dissertation		6	200
				24	500

Programme Specific Outcome

On completion of the programme, students will be able to

PSO1 : Demonstrate a coherent understanding of the academic field of Physics, and its linkage with related disciplinary subjects;

PSO2 : Demonstrate the ability to use Physics skills such as formulating, identifying, and applying appropriate methodologies to solve and interpret a wide range of problems associated with Physics;

PSO3 : Extrapolate from what one has learned and apply their competencies to solve different kinds of non-familiar problems, rather than replicate curriculum content knowledge and apply one's learning to real life situations;

PSO4 : Design and execute projects to experience the aspects of research and to provide lucid summation of the scientific literature on a chosen topic;

PSO5 : Analyse and interpret data collected using appropriate methods, including the use of suitable software and customized worksheets, and relating the conclusions to relevant theories of Physics;

PSO6 : Demonstrate professional behaviour such as (i) being objective, unbiased and truthful in all aspects of work; and (ii) appreciation of intellectual property, environmental and sustainability issues;

PSO7 : Develop communication skills, both written and oral, for specialized and non-specialized audience;

PSO8 :Acquire subject knowledge and skills of the calibre sought by industry, professional career and public service, as well as providing academic teachers and researchers of the future;

PSO9 : Demonstrate relevant generic skills and global competencies such as (i)skills of independent investigation of physics-related issues and problems; (ii)ability to construct logical arguments using correct technical language related to physics;

PSO10 : Acquire knowledge and skills, including, "learning how to learn", that are necessary for participating in learning activities throughout life.

PSO to PO Mapping for MPhil - Physics

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
PSO1	X	X	X		X		X		X	
PSO2	X	X		X		X	X		X	
PSO3	X	X		X	X	X		X		
PSO4	X	X		X		X		X		X
PSO5	X	X	X		X		X		X	
PSO6	X	X		X			X		X	X
PSO7	X	X	X		X			X	X	
PSO8	X	X		X	X		X	X		
PSO9	X	X		X		X		X	X	
PSO10	X	X		X		X		X		X

Mapping of Courses with Programme Specific Outcomes (PSOs)

Courses	PSO 1	PSO 2	PSO 3	PSO 4	PSO 5	PSO 6	PSO 7	PSO 8	PSO 9	PSO 10
MPP 6613	X	X				X		X	X	X
MPP 6615	X	X				X		X	X	X
MPP 6617	X	X				X		X	X	X
MPP 6600	X	X	X	X	X	X	X			

MPP 6613 **RESEARCH METHODOLOGY** **6 hrs/6Cr.**

This course provides technical computational skills to synthesis and simulates research level physics problems. It also gives hands on training to pursue research in physics through case studies.

At the end of the course, students will be able to

i. Solve simultaneous equations using Gauss elimination and Gauss Jordon equation and determine the values of integration by trapezoidal and Simpson's rules.
ii. Compute the interpolated values using various methods.
iii. Write programmes in C++ to elucidate physics problems in electromagnetism and quantum mechanics.

iv. Use Math CAD and MATLAB softwares for carrying out mathematical computations.
v. Disseminate the packages like Ms Excel, power point, Corel draw, LaTeXetc and apply them for documentation.
vi. Interpret the results and write a research article from various characterization techniques like XRD, Raman and SEM.

Unit I: Numerical Methods

Methods of solving algebraic and transcendental equations – Newton-Raphson methods; Method of solving set of simultaneous equations – Gauss Elimination and Gauss Jordan method; Numerical integration- Simpson's rule, Gaussian quadrature; Solving differential equation – Runge-kutta method; Solving Eigen value equation – Jacobi method, Power method.

Unit II: Statistical Methods

Interpolation – Lagrange's interpolation, Finite differences, Newton's forwards, central and backward interpolation, divided difference, Curve fitting – Linear least square fit, non linear fit, parabola, exponential and logarithmic; hypothesis testing; t-test, F-test, analysis of variance.

Unit III: Technical computing – programming

Develop programs and simulations in C++ to solve problems of mechanics, electromagnetism, quantum mechanics, statistical mechanics and electronics.

Unit IV: Technical computing – package

Usage of MATHCAD and MATLAB to solve physics problems, Interactive and iterative computations, Vectors and matrices, Mathematical and statistical functions, differential equations, integrations, symbolic computations, Graphs, Fourier analysis and FFT, interpolation, minimization.

Unit V: Presentation packages

Usage of MS Excel, MS Power point, Corel Draw, LaTex to prepare presentation of technical report, Type setting text, Special characters and symbols, cross references, footnotes, type setting mathematical formulae, creating bibliography, indexing, presentation with pdfscreens, producing mathematical graphics, page layout of document classes; Scientific articles, long report, book, slides.

Unit: 6 Case studies

Interpretation of characteristics Spectrums(XRD, SEM, IR, RAMAN, UV); Literature on recent topics – preparing report on recent development of a specific field of research- study and analysis of selected published research papers using cross reference.

References:

1. Demidovich B. P., Maron I. A., Computational Mathematics, MIR Publishers(1981)(unit I and II)

2. Steve Bain, Nick Wilkinson, corel DRAW 12, Osborne/McGraw Hill(2004)(Unit V)

3.WilliamH.Pressetal, Numerical Recipes in C++, 2Ed, Cambridge University press(2002)(Unit III)

4. MATHCAD User's Guide, Mathsoft, Inc., Cambridge,USA(1997)(Unit IV)

5. Using MATLAB, The Math works, Inc., USA(1996)(Unit IV)

6. R. Rajaram, Object Oriented programming and C++, New Age international(1997)(Unit III)

7. The Not so short introduction to LaTex 2E, Tobias Oetiker et al, The Free software foundation, Inc., Cambridge USA (2004)(UnitV)

8. A.R. Varma and srivastava, Crystallography applied to solid state physics, New Age publication (2005)(Unit IV)

Bloom's Taxonomy	**CO1**	**CO2**	**CO3**	**CO4**	**CO5**
K1: Remembering					
K2: Understanding	**2**				
K3: Applying	**3**	**3**		**3**	**3**
K4: Analyzing		**4**	**4**	**4**	
K5: Evaluating	**5**	**5**		**5**	**5**
K6: Creating	6		6		
Mean					4.0

MPP 6615 **ADVANCED TOPICS IN PHYSICS** **6 hrs/6Cr.**

The frontier areas of Physics are highlighted here so that the student will get experience in the up to date knowledge in Physics. A variety of topics such as Astrophysics, Solid-state Theory, Advanced Quantum Mechanics and Nonlinear dynamics are dealt with.

At the end of the course, students will be able to

i. ascertain the evolution of universe using various models
ii. discuss the approximations in solid state theory and superconductivity
iii. explain canonical formation and quantization of fields
iv. elucidate the symmetry in quantum mechanics
v. classify the types of oscillators and equilibrium points

vi. explain the types of bifurcations

Unit –I: Astrophysics and Cosmology

Origin and evolution of universe, early relativistic cosmology – the origin of light elements-cosmic microwave background – law of red shift – red shift – models of universe –dark energy – active galactic nuclei – creation centre and black holes.

Unit – II: Solid – state Theory

The Self-consistent – Field approximation – Hartree and Hartree – Fock approximations – Energy band calculations – OPW method, pseudo potential theory – $\bar{k} \cdot \bar{p}$ method – tight binding approximation – Superconductivity – Cooper pairs, BCS theory – Ginsburg – Landau theory.

Unit – III: Quantum Field Theory

Canonical formation and quantization for fields – Klein Gordon field – Second quantization of the Dirac field – Quantization of the electromagnetic field.

Unit – IV: Symmetry in Quantum Mechanics

Rotation and angular momentum – SO(3), SU(2) and Euler rotations –Density operators – Representation of the rotational operators – Symmetries conservation laws and degeneracies – Lattice translation as a discrete symmetry – Time reversal discrete symmetry – Young tableaux-permutation symmetry – Application to particle physics.

Unit –V: Non linear dynamics –I

Linear and non-linear oscillators – autonomous and non-autonomous systems – classification of the equilibrium points (2-D case)-Limit cycle motion.

Unit – VI : Non-linear dynamics-II

Bifurcations and on set of chaos in dissipative systems, Saddle- Node, Pitch Fesk, Transcritical and Hopf Bifurcations – Logistic map – onset of Chaos : sensitive dependence on initial conditions – Lyapunov Exponent.

References:

1. V.B. Bhatia " Text Book of Astronomy and Astrophysics with element of Cosmology, Narosa Publishing House, New Delhi(2001),(Unit I)
2. F.H.Hoyle, G.Burbidge and J.V.Narlikar " A different approach of Cosmology", Cambridge University press (2000)(Unit I)
3. Walter A. Harrison , Solid State Theory, McGraw Hill Book company(1970) (Chapter II and V: Unit II)

4. James D.Bjorken, Sidney D.Drell, Relativistic, quantum fields, McGraw Hill Book Company(1965)(Chapter 11,12,13,14: Unit V)
5. J.J.Sakurai, Modem Quantum Mechanics, Addition Wesley(1999)(Chapter 3,4; unit III and IV)
6. Greiner Muller, Quantum Mechanics – Symmetries, Springer(1994)(Unit IV)
7. M.Lakshmanan&S.Rajasekar, Nonlinear Dynamics, Springer(2003)(Chapter 2,3,and 4: Unit V and VI)

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K1: Remembering					
K2: Understanding	**2**				
K3: Applying	**3**	**3**		**3**	**3**
K4: Analyzing		**4**	**4**	**4**	
K5: Evaluating	**5**	**5**		**5**	**5**
K6: Creating	6		6		
Mean					

MPP 6617 **VACUUM TECHNOLOGY & THIN FILMS** **6 hrs/6Cr.**

This course will provide a broad overview of modern thin film deposition methods and vacuum techniques, their possibilities and limitations. Hands-on demonstrations and experiments will help the students to understand the possibilities of each deposition method and stimulate discussions. Essential fundamental aspects, as well as the technology of thin-film are discussed in this course and highlighted with real examples. The students will learn how to test and characterize film structure and related properties after deposition.

At the end of the course, students will be able to

i. discuss the kinetic theory of gases and different types of vacuum pumps and pressure gauges;
ii. explain the methods of thin film process and coating;
iii. elucidate the theories of nucleation and types of nucleation;
iv. describe the optical, electrical and mechanical properties of thin films;
v. enumerate the different characterization techniques for thin film coating and explain the different applications of thin films

Unit – I: Vacuum technology

Kinetic theory of gases-molecular velocities, Pressure units, mean free path, gas impingement on surfaces. Gas transport and pumping- gas flow regimes, conductance, pumping speed. Vaccum pumps – rotary roots blower, diffusion , turbo molecular, cryo, and sputter ion pump. Vaccum system components and operation.Vaccum leak and testing. Different types of pressure gauges.

Unit – II : Thin film process and methods

Evaporation rate, vapour pressure, evaporation of single and multi component materials, evaporation of alloys. Types of evaporation process and applications –thermal evaporation, electron beam, CVD and its types, PLD,Sputtering- plasma reactions in plasma – Physics of sputtering, sputter yield, DC, AC, reactive sputtering and RF sputtering, sputtering of alloys.

Unit – III : Nature of thin films

Nucleation and growth of thin films – thermodynamic aspects, kinetic process in growth and nucleation, Growth of single layer and multilayer films. Phase diagrams, Homogeneous and heterogeneous nucleation. Steps in film formation. Capilarity theory and atomistic models of nucleation. Experimental studies of nucleation and epitaxy.

Unit- IV : Properties of thin films

Optical properties of thin films – reflection of light at a single, two, three surfaces.Tramsmittance, reflectance and absorption. Electrical properties- Transport phenomena in metals, Electron transfer by tunnelling – thermionic emission – transmission coefficient. Conduction and TCR if continuous and discontinuous metal films.Mechanical properties – tensile.nanoindentation, nano hardness, stress friction and wear testing – Adhesion test. Related problems and excercises.

Unit- V : Characterisation of thin films

Structural characterization : Film thickness – mechanical , interferometric, ellipsometry and electrical methods. LEED, HEED, AFM, STM, SEM. Chemical characterization – AES, EDAX, XPS. Electrical characterisation: Four probe and hall effect.

Unit – VI : Applications of thin films

Thin film resistors, capacitors, transistors, transparent conducting films, magnetic devices, nano films. Antireflection coating, beam splitter, mirror coatings, optical filters, absorption coatings, thin films for solar cells. Case study on any one of the above application.Hands on experiments-substrate cleaning methods, thin film coating, use of four-probe to find electrical energy gap, conductivity.Use of spectrophotometer – to find reflectance, transmission.Calculationof optical energy gap, refractive index and absorption coefficient.

References

1. Andrew Guthrie, Vaccum technology. John wiley and sons (1963)(unit I)
2. Ohring, M.Materials science of thin films,2ed, Academic press(2006)(unit 1,2,3,5)
3. K.L.Chopra, Thin film phenomena. M.C.Graw Hill K.L(1983)(unit 1,2,3,5)
4. T.J.Couts, Electrical Conduction in Thin Metal Film, Elsevier, New York(1978) (unit 4).
5. Hugo Anders, Thin Film in Optics, The focal press(1978) (unit 4,6)
6. I.Maessel&R.Glang, Hand Book of thin Film Technology, McGraw Hill (1970) , (unit 6)
7. Chopra &I.J.Kaur, Thin Film Solar cell. Plenum Press (1983).
8. V.V.Rao, T.B.Ghosh, K.L.Chopra, Vaccum Science and Technology, Allied Publishers (1999).
9. R.W.Berry&F.M.Hall&M.T.Harris, Thin film Technology, Van-Nostrand (1968).

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K2: Understanding	**2**				
K3: Applying	**3**	**3**		**3**	**3**
K4: Analyzing		**4**	**4**	**4**	
K5: Evaluating	**5**	**5**		**5**	**5**
K6: Creating	6		6		
Mean					

MPP 6600 **DISSERTATION** **6 Cr.**

At the end of the course, students will be able to

i. work independently, identify appropriate resources required for a project, and manage a project through to completion;

ii. apply analytic thought to a body of knowledge; analyze and evaluate evidence, arguments, and claims;establish hypotheses, predict cause-and-effect relationships;

iii. analyze, interpret and draw conclusions from quantitative/qualitative data;

iv. use ICT to accessa variety of relevant information sources; and use appropriate software for analysis of data;

v. demonstrate the ability to listen carefully, read and write analytically, and present complex information in a clear and concise manner to different groups.

Each student is to submit one projectin the second semester. Usually, a project is approved by the staff supervisor/ guide. Students shall maintain daily records and present at least two oral progress reports while doing the project. They shall submit the dissertation at the end of the semester. All the above process is reckoned for assessment. Topics shall usually be experimental by nature. However, theoretical types may also be admitted.

Evaluation Method for Project:

1. Project Proposal (Oral and written) 20%
2. Oral progress reports 20%
3. Continuous assessment 35%
4. Final Report 25%

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K1: Remembering					
K2: Understanding	**2**				
K3: Applying	**3**	**3**		**3**	**3**
K4: Analyzing		**4**	**4**	**4**	
K5: Evaluating	**5**	**5**		**5**	**5**
K6: Creating	6		6		
Mean					