Physics

Expert Committee Report
on
Multi-Disciplinary Programme as per NEP-2020

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Introduction:

The NEP-2020 offers an opportunity to effect a paradigm shift from a teacher-centric to a student-centric higher education system in India. It is based on Outcome Based Education, where the Graduate Attributes are first kept in mind to reverse-design the Programs, Courses and Supplementary activities to attain the attributes and learning outcomes. The learning outcomes-based curriculum framework for a degree in B.Sc. (Honours) Physics is intended to provide a comprehensive foundation to the subject, and to help students develop the ability to successfully continue with further studies and research in the subject. The framework is designed to equip students with valuable cognitive abilities and skills so that they are successful in meeting diverse needs of professional careers in a developing and knowledge-based society. The curriculum framework takes into account the need to maintain globally competitive standards of achievement in terms of the knowledge and skills in Physics, as well develop scientific orientation, enquiring spirit, problem solving skills and values which foster rational and critical thinking.

Graduate attributes in Physics: Some of the characteristic attributes a graduate in Physics should possess are:

- Disciplinary knowledge and skills:
- Skilled communicator:
- Critical thinker and problem solver:
- Sense of inquiry:
- Team player/worker:
- Skilled project manager:
- Digitally Efficient:
- Ethical awareness / reasoning:
- National and international perspective:
- Lifelong learners

Options for Study

- The programmes are flexible enough to allow liberty to students in designing them according to their requirements. Students may choose a single Major, one Major with a Minor, and one Major with two Minors. Teacher Education or Vocational courses may be included in place of Minor/s. Below listed are the various options students may choose from.
- One Major subject/discipline along with Languages, Generic Electives, Ability Enhancement, Skill Development and Vocational courses including Extracurricular Activities.
- One Major and one Minor subject/discipline along with Languages, Generic Electives, Ability Enhancement, Skill Development and Vocational courses including Extracurricular Activities
- Two Major subject/disciplines along with Languages, Generic Electives, Ability Enhancement, Skill Development and Vocational courses, including Extracurricular Activities (subject to fulfilling the requirements as stated in 3.i and 3.ii)
- One Major subject/discipline and one Vocational course along with Languages, Generic Electives, Ability Enhancement and Skill Development and courses including Extracurricular Activities.
- One Major Discipline and One Education Discipline along with Languages, Generic Electives, Ability Enhancement and Skill Development Courses including Extracurricular Activities.

Progressive Certificate, Diploma, Bachelor Degree or Bachelor Degree with Honours Provided at the End of Each Year of Exit of the Four-year Undergraduate Programme/Five-year Integrated Master's Degree Programme

Exit with:	**Credits Required**
Certificate at the Successful Completion of the First Year (Two Semesters) of the multidisciplinary Four-year Undergraduate Programme/Five-year Integrated Master's Degree Programme	44 - 48
A **Diploma** at the Successful Completion of the Second Year (Four Semesters) of the multidisciplinary Four-year Undergraduate Programme/Five-year Integrated Master's Degree Programme	88 - 96
Basic Bachelor Degree at the Successful Completion of the Third Year (Six Semesters) of the multidisciplinary Four- year Undergraduate Programme/Five-year Integrated Master's Degree Programme	132 - 144
Bachelor Degree with Honours in a Discipline at the Successful Completion of the Fourth Years (Eight Semesters) of the multidisciplinary Four-year Undergraduate Programme/Five-year Integrated Master's Degree Programme	176 - 192
Master's Degree in a Discipline at the Successful Completion of the Fifth Years (Ten Semesters) of the Five- year Integrated Master's Degree Programme	224- 240

Aims of UG program in Physics.

The aims and objectives of our UG educational programs in sciences in general and Physics in particular should be structured to

- create the facilities and environment in all the educational institutions to consolidate the knowledge acquired at +2 level and to motivate and inspire the students to create deep interest in Physics, to develop broad and balanced knowledge and understanding of physical concepts, principles and theories of Physics.

- learn, design and perform experiments in the labs to demonstrate the concepts, principles and theories learned in the classrooms.

- develop the ability to apply the knowledge acquired in the classroom and laboratories to specific problems in theoretical and experimental Physics.

- expose the student to the vast scope of Physics as a theoretical and experimental science with applications in solving most of the problems in nature spanning from 10^{-15} m to 10^{26}m in space and 10^{-10} eV to 10^{25}eV in energy dimensions.

- emphasize the discipline of Physics to be the most important branch of science for pursuing the interdisciplinary and multidisciplinary higher education and/or research in interdisciplinary and multidisciplinary areas.

- to emphasize the importance of Physics as the most important discipline for sustaining the existing industries and establishing new ones to create job opportunities at all levels of employment.

In view of opening the new windows in higher education and research and opening job opportunities at all levels from technicians to innovator scientists and engineers, two undergraduate programs are offered in our universities and other higher education institutions (HEI) at the entry level of our higher education system.

The progressive curriculum proposed shall position knowledge and skills required on the continuum of novice problem solvers (at entry level of the program) to expert problem solvers (by the time of graduation):

- At the end of first year – Ability to solve well defined problems
- At the end of second year – Ability to solve broadly defined problems
- At the end of third year – Ability to solve complex problems that are ill-structured requiring multi-disciplinary skills to solve them
- During fourth year – Experience of workplace problem solving in the form of internship or Research Experience preparing for higher education or Entrepreneurship Experience

Proposed Curriculum Framework for Multidisciplinary Four- year Undergraduate Programme/ Five-year Integrated Master's Degree Programme

Year	Objective	Nature of Courses	Outcome	No. of courses
1st year – 1st & 2nd Semesters	Understanding and Exploration	1. Major Core Courses 2. Minor/Related Discipline 3. Languages, 4. Ability Enhancement Compulsory Courses 5. Skill Enhancement/ Development Courses	Understanding of Disciplines Language Competency Gaining perspective of context/Generic skills Basic skills sets to pursue any vocation	1+1 1+1 2+2 1+1 1+1
Exit option with Certification				
2nd Year - 3rd & 4th Semesters	Focus and Immersion	1. Major Core Courses 2. Minor/ Related Discipline 3. Ability Enhancement 4. Skill based Vocational 5. Extra Curricular Activities	Understanding of disciplines Gaining perspective of context Skill sets to pursue vocation Development of various domains of mind &personality	2+2 1+1 1+1 1+1 1+1
Exit Option with Diploma				
3rd Year - 5th & 6th Semesters	Real time Learning	1. Major Discipline Core and Elective Courses 2. Minor Discipline/ Generic or Vocational Electives /Field based Learning/ Res. Project	In depth learning of major and minor disciplines, Skill sets for employability. Exposure to discipline beyond the chosen Subject Experiential learning/ Res.	2+2 1+1 1+1
Exit option with Bachelor Degree				
4th Year - 7th&8th Semesters	Deeper Concentration	Major Discipline Core and Elective courses Research/Project Work with Dissertation	Deeper and Advanced Learning of Major Discipline Foundation to pursue Doctoral Studies & Developing Research competencies	4+4
Bachelor Degree with Honours				
5th Year - 9th & 10th Semesters	Master of the subject	Major Discipline Core and Elective courses/Research/Project Work with Dissertation	Deeper and Advanced Learning of the Major Discipline towards gaining proficiency over the subject	4+4/6+6
Master's Degree				

MODEL FOUND APPROPRIATE AND ADOPTED

IIA. Model Program Structures for the Under-Graduate Programs in Universities and Colleges in Karnataka

Bachelor of Arts (Basic/ Hons.)/ Bachelor of Science (Basic/ Hons.) in subjects with practical, with one major and one minor Sem.		**Discipline Core (DSC) (Credits) (L+T+P)**	**Discipline Elective(DSE) / Open Elective (OE) (Credits) (L+T+P)**	**Ability Enhancement Compulsory Courses (AECC), Languages (Credits) (L+T+P)**	**Skill Enhancement Courses (SEC)**		**Total Credits**
Skill based (Credits) (L+T+P)				**Value based (Credits) (L+T+P)**			
I	Discipline A1(4+2) Discipline B1(4+2)	OE-1 (3)	L1-1(3), L2-1(3) (4 hrs each)	SEC-1: Digital Fluency (2) (1+0+2)	Physical Education for fitness(1)(0+0+2)	Health & Wellness (1) (0+0+2)	25
II	Discipline A2(4+2) Discipline B2(4+2)	OE-2 (3)	L1-2(3), L2-2(3) (4 hrs each)	Environmental Studies (2)	Physical Education - Yoga(1) (0+0+2)	NCC/NSS/R&R(S&G)/ Cultural (1) (0+0+2)	25
Exit option with Certificate (50 credits)							
III	Discipline A3(4+2) Discipline B3(4+2)	OE-3 (3)	L1-3(3), L2-3(3) (4 hrs each)	SEC-2: Artificial Inte-lligence (2)(1+0+2)	Physical Education- Sports skills(1)(0+0+2)	NCC/NSS/R&R(S&G)/Cultural (1) (0+0+2)	25
IV	Discipline A4(4+2) Discipline B4(4+2)	OE-4 (3)	L1-4(3), L2-4(3) (4 hrs each)	Constitution of India (2)	Physical Education -Games (1) (0+0+2)	NCC/NSS/R&R(S&G)/Cultural (1) (0+0+2)	25
Exit option with Diploma (100 credits) OR Choose any one of the core subjects as Major and the other as Minor							
V	Discipline A5(3+2) Discipline A6(3+2) Discipline B5(3+2)		Vocational-1 (3)	SEC-3: SEC such as Cyber Security (2) (1+0+2)			20
VI	Discipline A7(3+2) Discipline A8(3+2) Discipline B6(3+2)		Vocational-2 (3) Internship (2)	SEC-4: Professional Communication (2)			22
Exit option with Bachelor of Arts, B.A./ Bachelor of Science, B.Sc. Basic Degree (142 credits) or continue studies with the Major							
VII	Discipline A9(3+2) Discipline A10(3+2) Discipline A11(3)	Discipline A, E-1 (3) Discipline A, E-2 (3) Res.Methodology (3)					22
VIII	Discipline A12(3+2) Discipline A13(3) Discipline A14(3)	Discipline A, E-3(3) Research Project (6)*					20
Award of Bachelor of Arts Honours, B.A. (Hons.)/ Bachelor of Science Honours, B.Sc. (Hons) degree in a discipline (184 credits)							

Curriculum Structure Major Discipline Core Physics

Semester- I to Semester - 10

SEM	DSC	Core Papers
Sem-1 :	A1	Mechanics & Properties of Matter (Select one Open Elective from the Pool)
Sem -2 :	A2	Electricity and Magnetism (Select one Open Elective from the Pool)
Sem-3 :	A3	Wave motion and optics (Select one Open Elective from the Pool)
Sem-4:	A4	Thermal Physics & Electronics (Select one Open Elective from the Pool)
Sem-5 :	A5 A6	1. Classical Mechanics and Quantum Mechanics- I 2. Elements of Atomic, Molecular Physics
Sem -6 :	A7 A8	1. Elements of Nuclear Physics and Nuclear Instruments 2. Element of Condensed Matter Physics & Devices
Sem-7	A9 A10 A11	1. Mathematical Methods of Physics – I 2. Classical Electrodynamics. 3. Experimental methods of Physics 4. Research Methodology (Select Two DSE subjects from the pool I shown below)
Sem-8	A12 A13 A14	1. Classical Mechanics and Quantum Mechanics-II 2. Statistical Mechanics 3. Astrophysics & Astronomy 4. Research Project* (Select Two DSE subjects from the pool II shown below) *In lieu of the research Project, two additional elective papers/ Internship may be offered.
Sem-9	A15	1. Mathematical Methods of Physics – II (Select One DSE subjects from the pool III shown below) 2. Research Project
Sem-10	A17	1. Quantum Mechanics – III (Select One DSE subjects from the pool IV shown below) 2. Research Project

** The Topics of 5th Sem and above need to be revisited*

Open Electives

Sl.No.	1 to 4 Semester Pool 1
1.	Energy Sources
2.	Climate Science
3.	Astronomy
4.	Medical Physics
5.	Optical Instruments
6.	Sports Science
7.	Nanotechnology
8.	Electrical Instruments
9.	Electronic Instruments
10.	History of Physics
11.	Physics in daily life
12.	Space Missions

Discipline Specific Electives for 7 to 10 Semesters

	7th Sem Electives Pool I (Select any two)		8th Sem Electives Pool II (Select any two)
A.	Condensed Matter Physics-1	A.	Atomic & Molecular Physics-1
B.	Nuclear and Particle Physics	B.	Materials Physics & Nano materials
C.	Theoretical and Computational Physics-I	C.	Lasers and non-linear optics
D.	Biophysics	D.	Plasma Physics
E.	Astronomy and Astrophysics	E.	Physics of Semiconductor devices

	9th Sem Electives (Specialization papers) Pool III		10th Sem Electives (Specialization papers) Pool IV
A.	Condensed Matter Physics-2	A.	Condensed Matter Physics-3
B.	Nuclear and Particle Physics-2	B.	Nuclear and Particle Physics-3
C.	Atomic & Molecular spectroscopy-1	C.	Atomic & Molecular spectroscopy-2
D.	Materials Physics & Nanophysics –1	D.	Materials Physics & Nanophysics -2
E.	Theoretical and Computational Physics-I	E.	Theoretical and Computational Physics-2
F.	Astronomy and Astrophysics-1	F.	Astronomy and Astrophysics-2

Detailed Syllabus for Semester I & II

Course Content Semester – I

Course Title: Mechanics and Properties of Matter	Course Credits:4
Total Contact Hours: 52	Duration of ESA: 3 hours
Formative Assessment Marks:	Summative Assessment Marks:
Model Syllabus Authors:	

Course Outcomes (COs):

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

(Write 3-7 course outcomes. Course outcomes are statements of observable student actions that serve as evidence of knowledge, skills and values acquired in this course)

1. will learn fixing units, tabulation of observations, analysis of data (graphical/analytical)
2. will learn about accuracy of measurement and sources of errors, importance of significant figures.
3. will know how g can be determined experimentally and derive satisfaction.
4. will see the difference between simple and torsional pendulum and their use in the determination of various physical parameters.
5. will come to know how various elastic moduli can be determined.
6. will measure surface tension and viscosity and appreciate the methods adopted.
7. will get hands on experience of different equipment.

Course Articulation Matrix: Mapping of Course Outcomes (COs) with Program Outcomes (POs)

Course Outcomes (COs) / Program Outcomes (POs)	**1**	**2**	**3**	**4**	**5**	**6**
1. will learn fixing units, tabulation of observations, analysis of data (graphical/analytical)	**x**	**x**				
2. will learn about accuracy of measurement and sources of errors, importance of significant figures.	**x**	**x**				
3. will know how g can be determined experimentally and derive satisfaction.	**x**					
4. will see the difference between simple and torsional pendulum and their use in the determination of various physical parameters.	**x**					
5. will come to know how various elastic moduli can be determined.	**x**					
6. will measure surface tension and viscosity and appreciate the methods adopted.	**x**					
7. will get hands on experience of different equipment.	**x**					

Course Articulation Matrix relates course outcomes of course with the corresponding program outcomes whose attainment is attempted in this course. Mark 'X' in the intersection cell if a course outcome addresses a particular program outcome.

Content		Hrs
Unit - 1		
Chapter No. 1	**Topics** to be covered/taught/learnt: **Units and measurements:** System of units (CGS and SI), measurement of length, mass and time, dimensions of physical quantities, dimensional formulae. Minimum deviation, errors.	
	Text Book : Units/sections to be Referred:	
Chapter No. 2	Topics to be Covered **Momentum and Energy**: Work and energy, Conservation of momentum (linear). Conservation of energy with examples. Motion of rockets.	
	Text Book : Units/sections to be Referred:	
Chapter No. 3	Topics to be Covered **Special Theory of Relativity:** Constancy of speed of light. Postulates of Special Theory of Relativity. Length contraction. Time dilation. Relativistic addition of velocities.	
	Text Book : Units/sections to be Referred:	
Topics for self study(If any)		
	Suggested Activities	
Activity No. 1	1. Activity: i). Students can measure diameters of small balls of different size and estimate their volumes. ii). Students can measure lengths of nails of different size. iii). Students can measure volume of a liquid iv). Students can measure distances and put the result both in CGS and SI units in 2, 3 and 4 significant figures. Ask them to mention the precession of the measurement. v). students can estimate standard deviations wherever possible.	
	Reference : Weblink/Youtube/Book	
Activity No. 2	Activity: Students can try and understand conservation of energy in every day examples. For example: i) What happens in solar conservation panels ii) Pushing an object on the table it moves iii) Moving car hits a parked car causes parked car to move. In these cases, energy is conserved. How? Understand and verify if possible.	
	Reference : Weblink/Youtube/Book	

Unit - 2		
Chapter No. 4.	**Laws of Motion:** Newton's Laws of motion. Dynamics of single and a system of particles. Centre of mass.	
	Text Book : Units/sections to be Referred:	
Chapter No. 5.	Topics to be covered Topics to be covered **Dynamics of Rigid bodies**: Rotational motion about an axis, Relation between torque and angular momentum, Rotational energy. moment of inertia: M I of a rectangular Lamina and solid cylinders. Flywheel, Theory of compound pendulum and determination of g.	
	Text Book : Units/sections to be Referred:	
Chapter No. 6.	Topics to be covered **Gravitation:** Law of Gravitation. Motion of a particle in a central force field (motion is in a plane, angular momentum is conserved, areal velocity is constant). Kepler's laws (statements). Satellite in a circular orbit.	
	Text Book : Units/sections to be Referred:	
Topics for self study(If any)	**Chapter 7**: Geosynchronous orbits. Basic idea of global positioning system (GPS).	
	Suggested Activities	
Activity No. 3	Activity: Moment of inertia is an abstract concept. It simply gives a measure of rotational inertia of a rigid body and it is proportional to the product of the square of radius, r of the body and its mass, m. Students by referring to websites, can construct and perform simple experiments to verify that MI α mr^2.	
	Reference : www.khanacademy.org, www.pinterest.com, www.serc.cerleton.edn	
Activity No. 4	Activity: Prepare suitable charts and give seminar talks in the class.	
	Reference : Weblink/Youtube/Book	

Unit - 3		
Chapter No. 8	Topics to be covered **Elasticity:** Hooke's law - Stress-strain diagram, elastic moduli-relation between elastic constants, Poisson's Ratio-expression for Poisson's ratio in terms of elastic constants. Work done in stretching and work done in twisting a wire-Twisting couple on a cylinder. Torsional pendulum-Determination of rigidity modulus and moment of inertia - q, η and σ by Searle's method	
	Text Book : Units/sections to be Referred:	
Topics for self study(If any)		
	Suggested Activities	
Activity No. 5	Activity: Arrange a steel spring with its top fixed with a rigid support on a wall and a meter scale along side. Add 100 g load at a time on the bottom of the hanger in steps. This means that while putting each 100g load, we are increasing the stretching force by 1N. Measure the extension for loads up to 500g. Plot a graph of extension versus load. Shape of the graph should be a straight line indicating that the ratio of load to extension is constant. Go for higher loads and find out elastic limit of the material.	
	Reference : Weblink/Youtube/Book	
Activity No.6	Activity: Repeat the above experiment with rubber and other materials and find out what happens after exceeding elastic limit. Plot and interpret.	
	Reference : Weblink/Youtube/Book	

Unit - 4		
Chapter No. 9	Topics to be covered **Surface tension:** Definition of surface tension. Surface energy, relation between surface tension and surface energy, pressure difference across curved surface example, excess pressure inside spherical liquid drop, angle of contact.	
	Text Book : Units/sections to be Referred:	
Chapter No. 11	Topics to be covered: **Viscosity:** Streamline flow, turbulent flow, equation of continuity, determination of coefficient of viscosity by Poisulle's method, Stoke's method. Problems	
	Text Book : Units/sections to be Referred:	
Topics for self study(If any)	Capillarity determination of surface tension by drop weight method.	
	Suggested Activities	
Activity No.7	Activity: 1. Measure surface tension of water and other common liquids and compare and learn i) Why water has high ST? think of reasons. ii) Check whether ST is a function of temperature? You can do it by heating the water to different temperatures and measure ST. iii) Plot ST versus T and learn how it behaves. Mix some quantity of kerosene or any oil to water and measure ST. Check whether ST for the mixture is more or less than pure water. Think of reasons.	
	Reference : Weblink/Youtube/Book	
Activity No. 8	Activity: 2. Collect a set of different liquids and measure their viscosity. i) Find out whether sticky or non sticky liquids are most viscous. Think of reasons. ii) Mix non sticky liquid to the sticky liquid in defined quantities and measure viscosity. Find out viscosity is increasing or decreasing with increase of non-sticky liquid concentration. iii) Do the above experiment by mixing sticky liquid to the non sticky liquid. Find out change in viscosity with increase of concentration of sticky liquid. Think why anyone should know viscosity of the liquid.	
	Reference : Weblink/Youtube/Book	

Text Books

Sl No	Title of the Book	Authors Name	Publisher	Year of Publication
1	Mechanics by, New Eition	D. S. Mathur	S.Chand & Co.	2000
2	Mechancis and Relativity by 3rd Edition,	Vidwan Singh Soni,	PHI Learning Pvt. Ltd.	
3	Mechanics Berkeley Physics Course, Vol.1:	Charles Kittel, *et.al*.	Tata McGraw-Hill	2007
4	Properties of Matter	Brijlal & Subramanyam.		

References Books

Sl No	Title of the Book	Authors Name	Publisher	Year of Publication
1	Physics. 9th Edn,	Resnick, Halliday & Walter,	Wiley	2010
2	Physics	Halliday and Resnick,		

List of Experiments to be performed in the Laboratory

1.	Determination of g using bar pendulum (L versus T and L versus LT^2 graphs)
2.	Determination of moment of inertia of a Fly Wheel.
3.	Determination of rigidity modulus using torsional pendulum
4.	Verification of parallel and perpendicular axis theorems.
5.	Determine the Young's Modulus of a wire by bar bending method
6.	Determination of elastic constants of a wire by Searle's method
7.	Young's modulus by Koenig's method
8.	Modulus of rigidity (twisting)
9.	Viscosity by Stake's method
10.	Radius of capillary tube by mercury pellet method
11.	Hook's law verification
12.	Surface tension by drop weight method
13.	Critical pressure for stream line flow

Reference Book for Laboratory Experiments

Sl No	Title of the Book	Authors Name	Publisher	Year of Publication
1	Physics through experiments	B.Saraf	Vikas Publications	2013
2	A lab manual of Physics for undergraduate classes, 1st Edition,		Vikas Publications.	
3	BSc Practical Physics Revised Edition	CL Arora	S.Chand & Co.	2007
4	An advanced course in practical physics.	D. Chatopadhyay, PC Rakshit, B.Saha	New Central Book Agency Pvt Ltd.	**2002**

Formative Assessment	
Assessment Occasion	**Marks**
End of Unit-1 (Activity)	10
End of Unit-2 (Test)	10
End of Unit-3 (Activity)	10
Total	30