MODULE - 2

for

PHYSICS LECTURERS

2016-17

PHYSICS OF SPHERICAL AND CIRCULAR SURFACES

स्वाध्यायान्मा प्रमदः

State Council of Educational Research and Training

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Module- 2

Contents

ABOUT THE MODULES.......

The series of Six Modules of physics at the Higher Secondary Stage has been developedwith a view that the school education is crucial and challenging as it is a transition fromgeneral science to discipline-based curriculum. The recommendations of National CurriculumFramework-2005 have been followed, keeping the disciplinary approach with rigour and depth,appropriate to the comprehension level of learners.It is expected that, these six modules will help teachers teaching XI and XIIth classes willdevelop an interest in the learners to study Physics as a discipline and inculcate in learnersthe abilities, useful concepts of Physics in real-life situations for making learning of Physicsrelevant, meaningful and interesting. The learner is expected to realize and appreciate theinterface of Physics with other disciplines.

RATIONALE

Physics is being offered as an elective subject at the higher secondary stage of school education.At this stage, the students take up Physics, as a discipline, To achieve the primary aim of theCurriculum - to create interest in the learmer, to pursue their future careers in basic sciences-physics. This demands sufficient conceptual background of Physics which would eventuallymake them competent to meet the challenges of academic and professional courses after the higher secondary stage.

The six modules is an effort in reforming and updating the Physics curriculum based on thefeedback received from the teachers during earlier INSET programmes organised by SCERTtime to time. The educational and curricular concerns and issues provided in the NationalCurriculum Framework-2005, is addressed to a greater extent.

SALIENT FEATURES

• Emphasis on basic conceptual understanding of content.

• Promoting process-skills, problem-solving abilities and applications of Physicsconcepts/content, useful in real-life situations for making Physics learning morerelevant, meaningful and interesting.

• Emphasis on Numerical analysis.

• Emphasis on Technical Educational Movie – Analysis from Physics and scientificapproach

• Emphasis on Physics-related technological/industrial aspects to cope up with changingdemand of society committed to the use of Physics, technology and informatics.

• Providing logical sequencing of the concepts and their linkages for better learning andmatching the concepts/content with comprehension level of the learners.

• Reducing the curriculum load by eliminating overlapping of concepts/content withinthe discipline of Physics or with other disciplines; reducing the descriptive portion andproviding suitable formulation/depth of treatment appropriate to the comprehensionlevel of learners, making room for contemporary core -topics and emerging curriculärareas in Physics.iv

• The content are so sequenced as to provide different dimensions of Physics as adiscipline. Each Module has been arranged with a topic, content related practical work(one core experiment, two activities to be evaluated)• There is an imperative need for evaluating the learners through Continuous andComprehensive Evaluation of various concepts covered in a Unit.

With this background, the Physics curriculum at the higher secondary stage attempts to:

• Strengthen the concepts developed at the secondary stage to provide firm ground workand foundation for further learning Physics at the tertiary level more effectively andlearning the relationship with daily-life situations;

• Develop conceptual competence in the learners and make them realize and appreciatethe interface of Physics with other disciplines;

• Expose the learners to different processes used in Physics-related industrial andtechnological applications;

• Develop process-skills and experimental, observational, manipulative, decision-making and investigatory skills in the learners;

• Promote problem-solving abilities and creative thinking to develop interest in thelearners in the study of Physics as a discipline;

• Understand the relationship between nature and matter on scientific basis, developpositive scientific attitude, and appreciate the contribution of Physics towards theimprovement of quality of life and human welfare;

• Physics teaching-learning at the higher secondary stage enables the learners tocomprehend the contemporary knowledge and develop aesthetic sensibilities andprocess skills. The experimental skills and process-skills developed together withconceptual Physics knowledge prepare the learners for more meaningful learningexperiences and contribute to the significant improvement of quality of life. Thelearners would also appreciate the role and impact of Physics and technology, andtheir linkages with overall national development.

PGT-PHYSICS	
S.No.	**TITLE**
Module-	**Micro Level Understanding of Physics in Macroscopic View** • Free Body Diagram and Resolution of Vector • Electrostatic Properties of Dielectrics/Conductors

1	• Potentiometer • Open Ended Questions • Marking Scheme and Question Paper
Module-2	**Physics of Spherical and Circular Surfaces** • Rolling Friction • Concept of COG and COM • Experiment to find Focal Length of Mirror • Experiment to find Focal Length of a Convex Lens • Open Ended Questions • Marking Scheme and Question Paper.
Module-3	**Study of Interaction among Particles and Waves** • Superposition of Waves • Magnetism in Action • Fun with Pendulum • Open Ended Questions • Marking Scheme and Question Paper
Module-4	**Energy Transport with and without Molecules** • Heat Transfer • Thermodynamics • Communication Systems • Resonance of Air Columns • Use of Media in Enhancing Physics Teaching-Learning Strategies • Learning Outcome - How Teachers can Educate their Students on the Science of 'Interstellar' • Marking Scheme and Question Paper
Module-5	**Study and Application of Matter and Electricity** • Fluids in Motion and Energy Conservation • Electrical Capacitance • Sonometer (Experiment) • Use of Media in Enhancing Physics Teaching • Marking Scheme and Question Paper
Module-6	**Particle Motion to Wave Motion** • Projectile Motion • Qualitative Analysis of Wave Optics • Capillary Rise Method • Use of Media in Enhancing Physics Teaching-Learning Strategies • Marking Scheme and Question Paper

Abstract of the six Modules

Module: 1 – Micro Level Understanding of Physics in Macroscopic View

Mathematics as a field influences Physics to a greater extent. On the contrary, one can alsosay that Physics adds meaning to Mathematics. This module requires a greater mathematicalstrength to understand and impart in a classroom situation. It covers the free body diagramwhere many forces are involved, resolution of vectors-force, indication of electric field indielectric and conductors. These topics demand utmost dedication and will to learn and applyin the situations that evolve in due course. Activity on potentiometer is taken for in depthstudy with hands-on-tools to overrule the practical problems faced in the laboratory. Thissegment will enhance your skills in the experimentation and thereby the theory also will getstrengthened. Applications and computational skills for problem solving have been stressedin the question papers now-a-days. Rather than solving a single question with values if onecan generalize the problem the student can in fact do a lot of numerical questions and willenhance his confidence in Physics. This will also encourage the student to take up Physicsas a subject in higher classes. You also stand out to gain a greater insight into physics bylearning to analyse and interpret the data.

Happy using the module and Learning the content the way it is said.

Module 2 – Physics of Spherical and Circular Surfaces

This module attempts to help teachers to integrate scientific practices into the learning of Physics.A sound knowledge and understanding of the core observations, concepts and quantitativetheoretical structures that constitute our contemporary understanding of the concept is aimedat here. This module emphasize on problem solving skills with nuances and generalization.Care has been taken to cover all areas in the numerical practice across the modules.Here an introduction to magnetic effect of current, Ampers' circuital law, its applicationare discussed in detail besides the most important aspect of transportation - rolling motion.The simple way by which Rolling can be introduced within the limitations of CBSE BoardSyllabus is followed. The activities of optics and optical benches are taken from the practicalside as many students fail to make an image without Parallax. The methods that will beshown hands-on will facilitate the teacher and in-turn he student in their care.

Happy using the module and Learning the content the way it is said.

Module 3 – Study of Interaction among Particles and Waves

Magnetism and Waves are two topics that fail to induce any interest in the student becauseof the way it is introduced. So a lucid style and a comparative approach on the interactionof waves is done efficiently. Numerical questions are open ended and are to be solved withcare such that a similar twisted questions are done with ease. The numerical session ingroups will enhance the teaching ability as the teachers in the group may provide multipleapproach to the same query or situation. In a way one may also understand the defect in ourorgans like the eye and ear.

A normal ear retains the sound for about 1/10 of a second.

A human eye can observe an event if 24 frames are shown per second.

A simple experiment which may provide a lot of scope for the guided projects is a Simplependulum. This is dealt with in detail so that the many students can be given one aspect ofthe experiment for the investigatory project.

Happy using the module and Learning the content the way it is said.

Module 4 – Energy Transport with and without Molecules

A great philosopher has said "Change is a constant in life". Keeping these words in mind,we as teachers keep learning and implementing in the classes the best of the teachingpractices and the simplified ways and means to understand any topic. The topics of Heat andThermodynamics, Communication systems and some experiments on Resonance are onthe neglected list over a period of time. The student tries to do the minimum work on theseareas and the absence of intent hinders the learning process. The fundamental aspects ofthe topics transfer of Heat and Thermodynamics is dealt with in a manner that will ease thedifficulty in learning. The degrees of freedom in different molecular formation can be donewith ease with idea incorporated here. The experiment on the Resonance tube apparatus istaken for a complete demonstration and this will ease the difficulty in performing them inthe school. The content of the chapter – Communication Systems is available in plenty. Buthow to make the student to understand the same is a difficult task which was expressed bythe teachers in the previous INSET programme. The content may look the same way as therest but as you attend the session you may feel the way the content be used for the student toscore full marks allotted for the chapter. Following a regular pattern may make a boredom.To avoid there should be certain traits we need to imbibe as teachers from time to time.For the first time incorporating Movie Session for learning new traits to be used in class,learn the scientific ways of improving Observation and Interpretation skills and the waytechnological tools can be used in the teacher training programme is done. The movie that isto be shown here partly is to bring certain changes in your classroom so that the good traitsfrom the reel world is a reality and helps the student community. The attempt by SCERT inproviding Freedom for the content developers in bringing necessary variations in the regulartopics that has been provided will make this module a unique one.

Happy using the module and Learning the content the way it is said.

Module 5 – Study and Application of Matter and Electricity

Time and again there has been a difficulty felt in the classroom in dealing with someinteresting but felt hard topics in the class XI and XII Physics syllabus. Some of theseareas include Bernoulli's theorem and Capacitance. They play a great role in the scoringpattern of the student and to a greater extent induce interest in our subject. An attempt ismade here to simplify and apply to a greater extent in the classroom. Why a ball spinnedaround rises up in the sky when the student is playing cricket is an unanswered questionin his mind. The module here with you is an answer to bring the spinning ball into theclassroom. Various other examples like the quantifying the volume of water that is beingreceived from a canal outside Delhi will bring reality to classrooms. The capacitors as aenergy storage device and their combinations in various circuits have revolutionised the fieldof communication. Unless and until the student is informed of the daily use of capacitor six while doing the topic of Electrostatics - Capacitance it is difficult to make them mentallyprepared for conceptualisation. The numerical questions given as practice questions are toprepare the student through the teachers for the board examination. In the practical partthere is apprehension in the handling of Sonometer. This induced us to build a sessionon Sonometer. The session will be hands-on on the stage with the recording of resultshighlighting the intricacies of the practical handling of Sonometer. One may understandthat simple recording is not doing experiment but to understand the nuances of the topic isof prime focus. Following a regular pattern in the teaching –learning process may make aboredom. To avoid there should be certain traits we need to imbibe as teachers from timeto time. For the first time incorporating Movie Session for learning new traits to be used inclass, learn the scientific ways of improving Observation and Interpretation skills and theway technological tools can be used in the teacher training programme is done. The moviethat is to be shown here partly is to bring certain changes in your classroom so that thegood traits from the reel world is a reality and helps the student community. The attempt bySCERT in providing Freedom for the content developers in bringing necessary variations inthe regular topics that has been provided will make this module a unique one.

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Module 6 – Particle Motion to Wave Motion

To take interest, identify, acknowledge ,unfolding curiosities ,seeking for explanationsand reasons is the real fun of Science. Bringing down the observations to find theoreticaljustification and explanations to the observations makes the difficult part of the subject.Perception is the key reference of interpreting the world around . Inculcating the ability ofqualitative understanding and idea is another bless that the students deserve to be served.Throwing a ball while playing a simple game makes it move along a curved path that mostpeople know, the purpose is to create fascination and curiosity of the level that the child feelsto interrogate every specification that the child observes and seeks for a theory that supportsthe same. The projectile motion faces lack of connect of how the various parameters likehorizontal range , maximum height serves to make student's life easy.The topic aims toextend and connect the theoretical findings with its applications in the real world to enablestudents to appreciate the value of the various derivations ,their findings and understandingfrom the same. To make someone realize the existence of something for which first handexperience is difficult to attain is a task,which if accomplished is a real achievement.Waveoptics being one of the most mind opening experience to realize the possibilities of whatyou observe in nature, the qualitative description of the same has been taken up in themodule.The purpose stays as basic as to widen the vision and possibilities that a studentcan incorporate to extract understanding and knowledge from nature.For the things there inbooks and theories are hard to experience and trust in real life , experiencing that perceptionbeing existing for real people gives a better idea of authentic existence of the same . Moviesbased on Scientific ideology to avail critical thinking to the learners , so as to go downthe the line to the thought process of the person who had thought about this edge of theScientific development and progress is another concern of the module.

Happy using the module and Learning the content the way it is said.

PHYSICS (Code No. 042)

Senior Secondary stage of school education is a stage of transition from general education to discipline-based focus on curriculum. The present updated syllabus keeps in view the rigour and depth of disciplinary approach as well as the comprehension level of learners. Due care has also been taken that the syllabus is comparable to the international standards. Salient features of the syllabus include:

- Emphasis on basic conceptual understanding of the content.
- Emphasis on use of SI units, symbols, nomenclature of physical quantities and formulations as per international standards.
- Providing logical sequencing of units of the subject matter and proper placement of concepts with their linkage for better learning.
- Reducing the curriculum load by eliminating overlapping of concepts/content within the discipline and other disciplines.
- Promotion of process-skills, problem-solving abilities and applications of Physics concepts.

Besides, the syllabus also attempts to

- strengthen the concepts developed at the secondary stage to provide firm foundation for further learning in the subject.
- expose the learners to different processes used in Physics-related industrial and technological applications.
- develop process-skills and experimental, observational, manipulative, decision making and investigatory skills in the learners.
- promote problem solving abilities and creative thinking in learners.
- develop conceptual competence in the learners and make them realize and appreciate the interface of Physics with other disciplines.

PHYSICS (Code No. 042)
COURSE STRUCTURE
Class XI (Theory) (2016-17)

Time: 3 hrs. **Max Marks: 70**

		No. of Periods	Marks
Unit-I	**Physical World and Measurement**	10	23
	Chapter-1: Physical World		
	Chapter-2: Units and Measurements		
Unit-II	**Kinematics**	24	
	Chapter-3: Motion in a Straight Line		
	Chapter-4: Motion in a Plane		
Unit-III	**Laws of Motion**	14	
	Chapter-5: Laws of Motion		

Unit-IV	**Work, Energy and Power**	**12**	**17**
	Chapter–6: Work, Energy and Power		
Unit-V	**Motion of System of Particles and Rigid Body**	**18**	
	Chapter–7: System of Particles and Rotational Motion		
Unit-VI	**Gravitation**	**12**	
	Chapter–8: Gravitation		
Unit-VII	**Properties of Bulk Matter**	**24**	**20**
	Chapter–9: Mechanical Properties of Solids		
	Chapter–10: Mechanical Properties of Fluids		
	Chapter–11: Thermal Properties of Matter		
Unit-VIII	**Thermodynamics**	**12**	
	Chapter–12: Thermodynamics		
Unit-IX	**Behaviour of Perfect Gases and Kinetic Theory of Gases**	**08**	
	Chapter–13: Kinetic Theory		
Unit-X	**Oscillations and Waves**	**26**	**10**
	Chapter–14: Oscillations		
	Chapter–15: Waves		
Total		**160**	**70**

Unit I: Physical World and Measurement — 10 Periods

Chapter–1: Physical World

Physics-scope and excitement; nature of physical laws; Physics, technology and society.

Chapter–2: Units and Measurements

Need for measurement: Units of measurement; systems of units; SI units, fundamental and derived units. Length, mass and time measurements; accuracy and precision of measuring instruments; errors in measurement; significant figures.

Dimensions of physical quantities; dimensional analysis and its applications.

Unit II: Kinematics — 24 Periods

Chapter–3: Motion in a Straight Line

Frame of reference, Motion in a straight line: Position-time graph, speed and velocity.

Elementary concepts of differentiation and integration for describing motion, uniform and non-uniform motion, average speed and instantaneous velocity, uniformly accelerated motion, velocity - time and position-time graphs.

Relations for uniformly accelerated motion (graphical treatment).

Chapter–4: Motion in a Plane

Scalar and vector quantities; position and displacement vectors; general vectors and their notations; equality of vectors; multiplication of vectors by a real number; addition and subtraction of vectors; relative velocity; Unit vector; resolution of a vector in a plane, rectangular components, Scalar and Vector product of vectors.

Motion in a plane, cases of uniform velocity and uniform acceleration-projectile motion, uniform circular motion.

Unit III: Laws of Motion — 14 Periods

Chapter–5: Laws of Motion

Intuitive concept of force; Inertia; Newton's first law of motion; momentum and Newton's second law of motion; impulse; Newton's third law of motion.

Law of conservation of linear momentum and its applications.

Equilibrium of concurrent forces; Static and kinetic friction; laws of friction; rolling friction; lubrication.

Dynamics of uniform circular motion: Centripetal force, examples of circular motion (vehicle on a level circular road, vehicle on a banked road).

Unit IV: Work, Energy and Power — 12 Periods

Chapter–6: Work, Engery and Power

Work done by a constant force and a variable force; kinetic energy; work-energy theorem; power.

Notion of potential energy; potential energy of a spring; conservative forces: conservation of mechanical energy (kinetic and potential energies); non-conservative forces: motion in a vertical circle; elastic and inelastic collisions in one and two dimensions.

Unit V: Motion of System of Particles and Rigid Body — 18 Periods

Chapter–7: System of Particles and Rotational Motion

Centre of mass of a two-particle system; momentum conservation and centre of mass motion.

Centre of mass of a rigid body; centre of mass of a uniform rod.

Moment of a force; torque; angular momentum; law of conservation of angular momentum and its applications.

Equilibrium of rigid bodies; rigid body rotation and equations of rotational motion; comparison of linear and rotational motions.

Moment of inertia; radius of gyration; values of moments of inertia for simple geometrical objects (no derivation). Statement of parallel and perpendicular axes theorems and their applications.

Unit VI: Gravitation — 12 Periods

Chapter–8: Gravitation

Kepler's laws of planetary motion, universal law of gravitation.

Acceleration due to gravity and its variation with altitude and depth.

Unit VII: Properties of Bulk Matter — 24 Periods

Chapter-9: Mechanical Properties of Solids

Elastic behaviour; Stress-strain relationship; Hooke's law; Young's modulus; bulk modulus; shear modulus of rigidity; Poisson's ratio; elastic energy.

Chapter-10: Mechanical Properties of Fluids

Pressure due to a fluid column; Pascal's law and its applications (hydraulic lift and hydraulic brakes); effect of gravity on fluid pressure.

Viscosity; Stokes' law; terminal velocity; streamline and turbulent flow; critical velocity; Bernoulli's theorem and its applications.

Surface energy and surface tension; angle of contact; excess of pressure across a curved surface; application of surface tension ideas to drops, bubbles and capillary rise.

Chapter-11: Thermal Properties of Matter

Heat; temperature; thermal expansion; thermal expansion of solids, liquids and gases; anomalous expansion of water; specific heat capacity; Cp, Cv - calorimetry; change of state - latent heat capacity.

Heat transfer-conduction, convection and radiation; thermal conductivity; qualitative ideas of Blackbody radiation; Wein's displacement Law; Stefan's law; Green house effect.

Unit VIII: Thermodynamics — 12 Periods

Chapter-12: Thermodynamics

Thermal equilibrium and definition of temperature (zeroth law of thermodynamics); heat, work and internal energy. First law of thermodynamics; isothermal and adiabatic processes.

Second law of thermodynamics: reversible and irreversible processes; Heat engine and refrigerator.

Unit IX: Behaviour of Perfect Gases and Kinetic Theory of Gases — 08 Periods

Chapter-13: Kinetic Theory

Equation of state of a perfect gas; work done in compressing a gas.

Kinetic theory of gases - assumptions, concept of pressure. Kinetic interpretation of temperature; rms speed of gas molecules; degrees of freedom, law of equi-partition of energy (statement only) and application to specific heat capacities of gases; concept of mean free path, Avogadro's number.

Unit X: Oscillations and Waves — 26 Periods

Chapter-14: Oscillations

Periodic motion - time period, frequency, displacement as a function of time, periodic functions.

Simple harmonic motion (S.H.M) and its equation; phase; oscillations of a loaded spring-restoring force and force constant; energy in S.H.M. Kinetic and potential energies; simple pendulum derivation of expression for its time period.

Free, forced and damped oscillations (qualitative ideas only), resonance.

Chapter-15: Waves

Wave motion: Transverse and longitudinal waves, speed of wave motion, displacement relation for a progressive wave, principle of superposition of waves, reflection of waves, standing waves in strings and organ pipes, fundamental mode and harmonics, Beats, Doppler effect.

PRACTICALS — Total Periods: 60

The record, to be submitted by the students, at the time of their annual examination, has to include:

- Record of at least 15 Experiments [with a minimum of 6 from each section], to be performed by the students.
- Record of at least 5 Activities [with a minimum of 2 each from section A and section B], to be demonstrated by the teachers.
- Report of the project to be carried out by the students.

EVALUATION SCHEME

Time Allowed: Three hours — **Max. Marks: 30**

Two experiments one from each section	8+8 Marks
Practical record (experiment and activities)	6 Marks
Investigatory Project	3 Marks
Viva on experiments, activities and project	5 Marks
Total	**30 Marks**

SECTION-A

Experiments

1. To measure diameter of a small spherical/cylindrical body and to measure internal diameter and depth of a given beaker/calorimeter using Vernier Callipers and hence find its volume.
2. To measure diameter of a given wire and thickness of a given sheet using screw gauge.
3. To determine volume of an irregular lamina using screw gauge.
4. To determine radius of curvature of a given spherical surface by a spherometer.
5. To determine the mass of two different objects using a beam balance.
6. To find the weight of a given body using parallelogram law of vectors.
7. Using a simple pendulum, plot its L-T^2 graph and use it to find the effective length of second's pendulum.
8. To study variation of time period of a simple pendulum of a given length by taking bobs of same size but different masses and interpret the result.
9. To study the relationship between force of limiting friction and normal reaction and to find the co-efficient of friction between a block and a horizontal surface.
10. To find the downward force, along an inclined plane, acting on a roller due to gravitational pull of the earth and study its relationship with the angle of inclination θ by plotting graph between force and sinθ.

Activities

(for the purpose of demonstration only)

1. To make a paper scale of given least count, e.g., 0.2cm, 0.5 cm.
2. To determine mass of a given body using a metre scale by principle of moments.
3. To plot a graph for a given set of data, with proper choice of scales and error bars.
4. To measure the force of limiting friction for rolling of a roller on a horizontal plane.
5. To study the variation in range of a projectile with angle of projection.
6. To study the conservation of energy of a ball rolling down on an inclined plane (using a double inclined plane).
7. To study dissipation of energy of a simple pendulum by plotting a graph between square of amplitude and time.

SECTION-B

Experiments

1. To determine Young's modulus of elasticity of the material of a given wire.
2. To find the force constant of a helical spring by plotting a graph between load and extension.
3. To study the variation in volume with pressure for a sample of air at constant temperature by plotting graphs between P and V, and between P and 1/V.
4. To determine the surface tension of water by capillary rise method.
5. To determine the coefficient of viscosity of a given viscous liquid by measuring terminal velocity of a given spherical body.
6. To study the relationship between the temperature of a hot body and time by plotting a cooling curve.
7. To determine specific heat capacity of a given solid by method of mixtures.
8. To study the relation between frequency and length of a given wire under constant tension using sonometer.
9. To study the relation between the length of a given wire and tension for constant frequency using sonometer.
10. To find the speed of sound in air at room temperature using a resonance tube by two resonance positions.

Activities

(for the purpose of demonstration only)

1. To observe change of state and plot a cooling curve for molten wax.
2. To observe and explain the effect of heating on a bi-metallic strip.
3. To note the change in level of liquid in a container on heating and interpret the observations.
4. To study the effect of detergent on surface tension of water by observing capillary rise.
5. To study the factors affecting the rate of loss of heat of a liquid.
6. To study the effect of load on depression of a suitably clamped metre scale loaded at (i) its end (ii) in the middle.
7. To observe the decrease in presure with increase in velocity of a fluid.

Practical Examination for Visually Impaired Students
Class XI

Note: Same Evaluation scheme and general guidelines for visually impaired students as given for Class XII may be followed.

A. Items for Identification/Familiarity of the apparatus for assessment in practicals(All experiments)

Spherical ball, Cylindrical objects, vernier calipers, beaker, calorimeter, Screw gauge, wire, Beam balance, spring balance, weight box, gram and milligram weights, forceps, Parallelogram law of vectors apparatus, pulleys and pans used in the same 'weights' used, Bob and string used in a simple pendulum, meter scale, split cork, suspension arrangement, stop clock/stop watch, Helical spring, suspension arrangement used, weights, arrangement used for measuring extension, Sonometer, Wedges, pan and pulley used in it, 'weights' Tuning Fork, Meter scale, Beam balance, Weight box, gram and milligram weights, forceps, Resonance Tube, Tuning Fork, Meter scale, Flask/Beaker used for adding water.

B. List of Practicals

1. To measure diameter of a small spherical/cylindrical body using vernier calipers.
2. To measure the internal diameter and depth of a given beaker/calorimeter using vernier calipers and hence find its volume.
3. To measure diameter of given wire using screw gauge.
4. To measure thickness of a given sheet using screw gauge.
5. To determine the mass of a given object using a beam balance.
6. To find the weight of given body using the parallelogram law of vectors.
7. Using a simple pendulum plot L-T and L-T^2 graphs. Hence find the effective length of second's pendulum using appropriate length values.
8. To find the force constant of given helical spring by plotting a graph between load and extension.
9. (i) To study the relation between frequency and length of a given wire under constant tension using a sonometer.
   (ii) To study the relation between the length of a given wire and tension, for constant frequency, using a sonometer.
10. To find the speed of sound in air, at room temperature, using a resonance tube, by observing the two resonance positions.

Note: The above practicals may be carried out in an experiential manner rather than recording observations.

Prescribed Books:

1. Physics Part-I, Textbook for Class XI, Published by NCERT
2. Physics Part-II, Textbook for Class XI, Published by NCERT
3. The list of other related books and manuals brought out by NCERT (consider multimedia also).

PHYSICS (Code No. 042)
QUESTION PAPER DESIGN
CLASS - XI (2016-17)

Time 3 Hours **Max. Marks: 70**

S. No.	Typology of Questions	Very Short Answer (VSA) (1 mark)	Short Answer-I (SA-I) (2 marks)	Short Answer -II (SA-II) (3 marks)	Value based question (4 marks)	Long Answer (LA) (5 marks)	Total Marks	% Weightage
1.	**Remembering- (Knowledge based** Simple recall questions, to know specific facts, terms, concepts, principles, or theories, identify, define, or recite information)	2	1	1	-	-	7	10%
2	**Understanding- (Comprehension -**to be familiar with meaning and to understand conceptually, interpret, compare, contrast, explain, paraphrase information)	-	2	4	-	1	21	30%
3	**Application -** (Use abstract - information in concrete situation, to apply knowledge to new situations, Use given content to interpret a situation, provide an example, or solve a problem)	-	2	4	-	1	21	30%
4	**Higher Order Thinking Skills - (Analysis & Synthesis-** Classify, compare, contrast, or differentiate between different pieces of information, Organize and/or integrate unique pieces of information from a variety of sources)	2	-	1	-	1	10	14%
5	**Evaluation -** (Appraise, judge, and/or justify the value or worth of a decision or outcome, or to predict outcomes based on values)	1	-	2	1	-	11	16%
	TOTAL	**5x1=5**	**5x2=10**	**12x3=36**	**1x4=4**	**3x5=15**	**70(26)**	**100%**

Question Wise Break Up

Type of Question	Mark per Question	Total No. of Questions	Total Marks
VSA	1	5	05
SA-I	2	5	10
SA-II	3	12	36
VBQ	4	1	04
LA	5	3	15
Total		**26**	**70**

1. Internal Choice: *There is no overall choice in the paper. However, there is an internal choice in one question of 2 marks weightage, one question of 3 marks weightage and all the three questions of 5 marks weightage.*

2. *The above template is only a sample. Suitable internal variations may be made for generating similar templates keeping the overall weightage to different form of questions and typology of questions same.*

CLASS XII (2016-17)
(THEORY)

Time: 3 hrs. **Max Marks: 70**

		No. of Periods	Marks
Unit-I	**Electrostatics**	**22**	**15**
	Chapter–1: Electric Charges and Fields		
	Chapter–2: Electrostatic Potential and Capacitance		
Unit-II	**Current Electricity**	**20**	
	Chapter–3: Current Electricity		
Unit-III	**Magnetic Effects of Current and Magnetism**	**22**	**16**
	Chapter–4: Moving Charges and Magnetism		
	Chapter–5: Magnetism and Matter		
Unit-IV	**Electromagnetic Induction and Alternating Currents**	**20**	
	Chapter–6: Electromagnetic Induction		
	Chapter–7: Alternating Current		
Unit-V	**Electromagnetic Waves**	**04**	**17**
	Chapter–8: Electromagnetic Waves		
Unit-VI	**Optics**	**25**	
	Chapter–9: Ray Optics and Optical Instruments		
	Chapter–10: Wave Optics		

Unit-VII	**Dual Nature of Radiation and Matter**	**08**	**10**
	Chapter–11: Dual Nature of Radiation and Matter		
Unit-VIII	**Atoms and Nuclei**	**14**	
	Chapter–12: Atoms		
	Chapter–13: Nuclei		
Unit-IX	**Electronic Devices**	**15**	**12**
	Chapter–14: Semiconductor Electronics: Materials, Devices and Simple Circuits		
Unit-X	**Communication Systems**	**10**	
	Chapter–15: Communication Systems		
Total		**160**	**70**

Unit I: Electrostatics — 22 Periods

Chapter-1: Electric Charges and Fields

Electric Charges; Conservation of charge; Coulomb's law-force between two point charges; forces between multiple charges; superposition principle and continuous charge distribution.

Electric field, electric field due to a point charge, electric field lines, electric dipole, electric field due to a dipole, torque on a dipole in uniform electric fleld.

Electric flux, statement of Gauss's theorem and its applications to find field due to infinitely long straight wire, uniformly charged infinite plane sheet and uniformly charged thin spherical shell (field inside and outside).

Chapter-2: Electrostatic Potential and Capacitance

Electric potential; potential difference; electric potential due to a point charge, a dipole and system of charges; equipotential surfaces; electrical potential energy of a system of two point charges and of electric dipole in an electrostatic field.

Conductors and insulators; free charges and bound charges inside a conductor. Dielectrics and electric polarisation; capacitors and capacitance; combination of capacitors in series and in parallel; capacitance of a parallel plate capacitor with and without dielectric medium between the plates; energy stored in a capacitor.

Unit II: Current Electricity — 20 Periods

Chapter–3: Current Electricity

Electric current; flow of electric charges in a metallic conductor; drift velocity; mobility and their relation with electric current; Ohm's law; electrical resistance; V-I characteristics (linear and non-linear), electrical energy and power; electrical resistivity and conductivity; Carbon resistors; colour code for carbon resistors; series and parallel combinations of resistors; temperature dependence of resistance.

Internal resistance of a cell; potential difference and emf of a cell; combination of cells in series and in parallel; Kirchhoff's laws and simple applications; Wheatstone bridge, metre bridge.

Potentiometer - principle and its applications to measure potential difference and for comparing EMF of two cells; measurement of internal resistance of a cell.

Unit III: Magnetic Effects of Current and Magnetism — 22 Periods

Chapter–4: Moving Charges and Magetism

Concept of magnetic field, Oersted's experiment.

Biot - Savart law and its application to current carrying circular loop.

Ampere's law and its applications to infinitely long straight wire. Straight and toroidal solenoids (only qualitative treatment); force on a moving charge in uniform magnetic and electric fields; Cyclotron.

Force on a current-carrying conductor in a uniform magnetic field; force between two parallel current-carrying conductors-definition of ampere, torque experienced by a current loop in uniform magnetic field; moving coil galvanometer-its current sensitivity and conversion to ammeter and voltmeter.

Chapter–5: Magnetism and Matter

Current loop as a magnetic dipole and its magnetic dipole moment; magnetic dipole moment of a revolving electron; magnetic field intensity due to a magnetic dipole (bar magnet) along its axis and perpendicular to its axis; torque on a magnetic dipole (bar magnet) in a uniform magnetic field; bar magnet as an equivalent solenoid; magnetic field lines; earth's magnetic field and magnetic elements.

Para-, dia- and ferro - magnetic substances, with examples. Electromagnets and factors affecting their strengths; permanent magnets.

Unit IV: Electromagnetic Induction and Alternating Currents — 20 Periods

Chapter-6: Electromagnetic Induction

Electromagnetic induction; Faraday's laws, induced EMF and current; Lenz's Law, Eddy currents.

Self and mutual induction.

Chapter–7: Alternating Current

Alternating currents, peak and RMS value of alternating current/voltage; reactance and impedance; LC oscillations (qualitative treatment only); LCR series circuit; resonance; power in AC circuits, power factor; wattless current.

AC generator and transformer.

Unit V: Electromagnetic waves — 04 Periods

Chapter–8: Electromagnetic Waves

Basic idea of displacement current, Electromagnetic waves, their characteristics, their Transverse nature (qualitative ideas only).

Electromagnetic spectrum (radio waves, microwaves, infrared, visible, ultraviolet, X-rays, gamma rays) including elementary facts about their uses.

Unit VI: Optics — 25 Periods

Chapter-9: Ray Optics and Optical Instruments

Ray Optics: Reflection of light; spherical mirrors; mirror formula; refraction of light; total internal reflection and its applications; optical; fibres; refraction at spherical surfaces; lenses; thin lens formula; lensmaker's formula; magnification, power of a lens; combination of thin lenses in contact; refraction and dispersion of light through a prism.

Scattering of light - blue colour of sky and reddish apprearance of the sun at sunrise and sunset.

Optical instruments: Microscopes and astronomical telescopes (reflecting and refracting) and their magnifying powers.

Chapter-10: Wave Optics

Wave optics: Wave front and Huygen's principle; reflection and refraction of plane wave at a plane surface using wave fronts. Proof of laws of reflection and refraction using Huygen's principle. Interference; Young's double slit experiment and expression for fringe width, coherent sources and sustained interference of light; diffraction due to a single slit; width of central maximum; resolving power of microscope and astronomical telescope, polarisation; plane polarised light; Brewster's law; uses of plane polarised light and Polaroids.

Unit VII: Dual Nature of Radiation and Matter — 08 Periods

Chapter-11: Dual Nature of Radiation and Matter

Dual nature of radiation; Photoelectric effect; Hertz and Lenard's observations; Einstein's photoelectric equation-particle nature of light.

Matter waves-wave nature of particles ; de-Broglie relation; Davisson-Germer experiment (experimental details should be omitted; only conclusion should be explained).

Unit VIII: Atoms and Nuclei — 14 Periods

Chapter-12: Atoms

Alpha-particle scattering experiment; Rutherford's model of atom; Bohr model, energy levels, hydrogen spectrum.

Chapter-13: Nuclei

Composition and size of nucleus; Radioactivity; alpha, beta and gamma particles/rays and their properties; radioactive decay law.

Mass-energy relation; mass defect; binding energy per nucleon and its variation with mass number; nuclear fission; nuclear fusion.

Unit IX: Electronic Devices — 15 Periods

Chapter-14: Semiconductor Electronics: Materials, Devices and Simple Circuits

Energy bands in conductors; semiconductors and insulators (qualitative ideas only)

Semiconductor diode - I-V characteristics in forward and reverse bias; diode as a rectifier;

Special purpose p-n junction diodes: LED, photodiode, solar cell and Zener diode and their characteristics; zener diode as a voltage regulator.

Junction transistor; transistor action; characteristics of a transistor and transistor as an amplifier (common emitter configuration); basic idea of analog and digital; signals Logic gates (OR, AND, NOT, NAND and NOR).

Unit X: Communication Systems **10 Periods**

Chapter–15: Communication Systems

Elements of a communication system (block diagram only); bandwidth of signals (speech, TV and digital data); bandwidth of transmission medium. Propagation of electromagnetic waves in the atmosphere, sky and space wave propagation, satellite communication. Need for modulation, amplitude modulation.

PRACTICALS (Total Periods 60)

The record to be submitted by the students at the time of their annual examination has to include:

- Record of at least 15 Experiments [with a minimum of 6 from each section], to be performed by the students.
- Record of at least 5 Activities [with a minimum of 2 each from section A and section B], to be demonstrated by the teachers.
- The Report of the project to be carried out by the students.

Evaluation Scheme

Time Allowed: Three hours **Max. Marks: 30**

Two experiments one from each section	8+8 Marks
Practical record [experiments and activities]	6 Marks
Investigatory Project	3 Marks
Viva on experiments, activities and project	5 Marks
Total	**30 marks**

SECTION–A

Experiments

1. To determine resistance per cm of a given wire by plotting a graph for potential difference versus current.
2. To find resistance of a given wire using metre bridge and hence determine the resistivity (specific resistance) of its material.
3. To verify the laws of combination (series) of resistances using a metre bridge.
4. To verify the laws of combination (parallel) of resistances using a metre bridge.
5. To compare the EMF of two given primary cells using potentiometer.
6. To determine the internal resistance of given primary cell using potentiometer.
7. To determine resistance of a galvanometer by half-deflection method and to find its figure of merit.
8. To convert the given galvanometer (of known resistance and figure of merit) into a voltmeter of desired range and to verify the same.
9. To convert the given galvanometer (of known resistance and figure of merit) into an ammeter of desired range and to verify the same.
10. To find the frequency of AC mains with a sonometer.

Activities

(For the purpose of demonstration only)

1. To measure the resistance and impedance of an inductor with or without iron core.
2. To measure resistance, voltage (AC/DC), current (AC) and check continuity of a given circuit using multimeter.
3. To assemble a household circuit comprising three bulbs, three (on/off) switches, a fuse and a power source.
4. To assemble the components of a given electrical circuit.
5. To study the variation in potential drop with length of a wire for a steady current.
6. To draw the diagram of a given open circuit comprising at least a battery, resistor/rheostat, key, ammeter and voltmeter. Mark the components that are not connected in proper order and correct the circuit and also the circuit diagram.

SECTION-B

Experiments

1. To find the value of *v* for different values of *u* in case of a concave mirror and to find the focal length.
2. To find the focal length of a convex mirror, using a convex lens.
3. To find the focal length of a convex lens by plotting graphs between *u* and *v* or between *1/u* and *1/v*.
4. To find the focal length of a concave lens, using a convex lens.
5. To determine angle of minimum deviation for a given prism by plotting a graph between angle of incidence and angle of deviation.
6. To determine refractive index of a glass slab using a travelling microscope.
7. To find refractive index of a liquid by using convex lens and plane mirror.
8. To draw the I-V characteristic curve for a p-n junction in forward bias and reverse bias.
9. To draw the characteristic curve of a zener diode and to determine its reverse break down voltage.
10. To study the characteristic of a common - emitter *npn* or *pnp* transistor and to find out the values of current and voltage gains.

Activities

(For the purpose of demonstration only)

1. To identify a diode, an LED, a transistor, an IC, a resistor and a capacitor from a mixed collection of such items.
2. Use of multimeter to (i) identify base of transistor, (ii) distinguish between npn and pnp type transistors, (iii) see the unidirectional flow of current in case of a diode and an LED, (iv) check whether a given electronic component (e.g., diode, transistor or IC) is in working order.
3. To study effect of intensity of light (by varying distance of the source) on an LDR.
4. To observe refraction and lateral deviation of a beam of light incident obliquely on a glass slab.
5. To observe polarization of light using two Polaroids.
6. To observe diffraction of light due to a thin slit.
7. To study the nature and size of the image formed by a (i) convex lens, (ii) concave mirror, on a screen by using a candle and a screen (for different distances of the candle from the lens/mirror).
8. To obtain a lens combination with the specified focal length by using two lenses from the given set of lenses.

Suggested Investigatory Projects

1. To study various factors on which the internal resistance/EMF of a cell depends.
2. To study the variations in current flowing in a circuit containing an LDR because of a variation in

   (a) the power of the incandescent lamp, used to 'illuminate' the LDR (keeping all the lamps at a fixed distance).
   (b) the distance of a incandescent lamp (of fixed power) used to 'illuminate' the LDR.
3. To find the refractive indices of (a) water (b) oil (transparent) using a plane mirror, an equi convex lens (made from a glass of known refractive index) and an adjustable object needle.
4. To design an appropriate logic gate combination for a given truth table.
5. To investigate the relation between the ratio of (i) output and input voltage and (ii) number of turns in the secondary coil and primary coil of a self designed transformer.
6. To investigate the dependence of the angle of deviation on the angle of incidence using a hollow prism filled one by one, with different transparent fluids.
7. To estimate the charge induced on each one of the two identical styrofoam (or pith) balls suspended in a vertical plane by making use of Coulomb's law.
8. To set up a common base transistor circuit and to study its input and output characteristic and to calculate its current gain.
9. To study the factor on which the self inductance of a coil depends by observing the effect of this coil, when put in series with a resistor/(bulb) in a circuit fed up by an A.C. source of adjustable frequency.
10. To construct a switch using a transistor and to draw the graph between the input and output voltage and mark the cut-off, saturation and active regions.
11. To study the earth's magnetic field using a tangent galvanometer.

Practical Examination for Visually Impaired Students of Classes XI and XII Evaluation Scheme

Time Allowed: Two hours **Max. Marks: 30**

Identification/Familiarity with the apparatus	5 marks
Written test (based on given/prescribed practicals)	10 marks
Practical Record	5 marks
Viva	10 marks
Total	**30 marks**

General Guidelines

- The practical examination will be of two hour duration.
- A separate list of ten experiments is included here.
- The written examination in practicals for these students will be conducted at the time of practical examination of all other students.
- The written test will be of 30 minutes duration.
- The question paper given to the students should be legibly typed. It should contain a total of 15 practical skill based very short answer type questions. A student would be required to answer any 10 questions.
- A writer may be allowed to such students as per CBSE examination rules.
- All questions included in the question papers should be related to the listed practicals. Every question should require about two minutes to be answered.
- These students are also required to maintain a practical file. A student is expected to record at least five of the listed experiments as per the specific instructions for each subject. These practicals should be duly checked and signed by the internal examiner.
- The format of writing any experiment in the practical file should include aim, apparatus required, simple theory, procedure, related practical skills, precautions etc.
- Questions may be generated jointly by the external/internal examiners and used for assessment.
- The viva questions may include questions based on basic theory/principle/concept, apparatus/ materials/chemicals required, procedure, precautions, sources of error etc.

Class XII

A. Items for Identification/ familiarity with the apparatus for assessment in practicals (All experiments)

Meter scale, general shape of the voltmeter/ammeter, battery/power supply, connecting wires, standard resistances, connecting wires, voltmeter/ammeter, meter bridge, screw gauge, jockey Galvanometer, Resistance Box, standard Resistance, connecting wires, Potentiometer, jockey, Galvanometer, Lechlanche cell, Daniell cell (simple distinction between the two vis-à-vis their outer (glass and copper) containers), rheostat connecting wires, Galvanometer, resistance box, Plug-in and tapping keys, connecting wires battery/power supply, Diode, Transistor, IC, Resistor (Wire-wound or carbon ones with two wires connected to two ends), capacitors (one or two types), Inductors, Simple electric/electronic bell, battery/power supply, Plug-in and tapping keys, Convex lens, concave lens, convex mirror, concave mirror, Core/hollow wooden cylinder, insulated wire, ferromagnetic rod, Transformer core, insulated wire.

B. List of Practicals

1. To determine the resistance per cm of a given wire by plotting a graph between voltage and current.
2. To verify the laws of combination (series/parallel combination) of resistances by ohm's law.
3. To find the resistance of a given wire using a meter bridge and hence determine the specific resistance (resistivity) of its material.
4. To compare the e.m.f of two given primary cells using a potentiometer.
5. To determine the resistance of a galvanometer by half deflection method.
6. To identify a
   (i) diode, transistor and IC
   (ii) resistor, capacitor and inductor, from a mixed collection of such items.
7. To understand the principle of (i) a NOT gate (ii) an OR gate (iii)an AND gate and to make their equivalent circuits using a bell and cells/battery and keys /switches.
8. To observe the difference between
   (i) a convex lens and a concave lens
   (ii) a convex mirror and a concave mirror and to estimate the likely difference between the power of two given convex /concave lenses.
9. To design an inductor coil and to know the effect of
   (i) change in the number of turns
   (ii) introduction of ferromagnetic material as its core material on the inductance of the coil.
10. To design a (i) step up (ii) step down transformer on a given core and know the relation between its input and output voltages.

Note: The above practicals may be carried out in an experiential manner rather than recording observations.

Prescribed Books:

1. Physics, Class XI, Part -I and II, Published by NCERT.
2. Physics, Class XII, Part -I and II, Published by NCERT.
3. The list of other related books and manuals brought out by NCERT (consider multimedia also).

PHYSICS (Code No. 042)
QUESTION PAPER DESIGN
CLASS - XII (2016-17)

Time 3 Hours **Max. Marks: 70**

S. No.	Typology of Questions	Very Short Answer (VSA) (1 mark)	Short Answer-I (SA-I) (2 marks)	Short Answer -II (SA-II) (3 marks)	Value based question (4 marks)	Long Answer (LA) (5 marks)	Total Marks	% Weightage
1.	**Remembering - (Knowledge based** Simple recall questions, to know specific facts, terms, concepts, principles, or theories, Identify, define, or recite, information)	2	1	1	-	-	7	10%
2	**Understanding - (Comprehension -**to be familiar with meaning and to understand conceptually, interpret, compare, contrast, explain, paraphrase information)	-	2	4	-	1	21	30%
3	**Application -** (Use abstract information in concrete situation, to apply knowledge to new situations, Use given content to interpret a situation, provide an example, or solve a problem)	-	2	4	-	1	21	30%
4	**Higher Order Thinking Skills - (Analysis & Synthesis-** Classify, compare, contrast, or differentiate between different pieces of information, Organize and/or integrate unique pieces of information from a variety of sources)	2	-	1	-	1	10	14%
5	**Evaluation -** (Appraise, judge, and/or justify the value or worth of a decision or outcome, or to predict outcomes based on values)	1	-	2	1	-	11	16%
	TOTAL	**5x1=5**	**5x2=10**	**12x3=36**	**1x4=4**	**3x5=15**	**70(26)**	**100%**

QUESTION WISE BREAK UP

Type of Question	Mark per Question	Total No. of Questions	Total Marks
VSA	1	5	05
SA-I	2	5	10
SA-II	3	12	36
VBQ	4	1	04
LA	5	3	15
Total		**26**	**70**

1. *Internal Choice: There is no overall choice in the paper. However, there is an internal choice in one question of 2 marks weightage, one question of 3 marks weightage and all the three questions of 5 marks weightage.*

2. *The above template is only a sample. Suitable internal variations may be made for generating similar templates keeping the overall weightage to different form of questions and typology of questions same.*

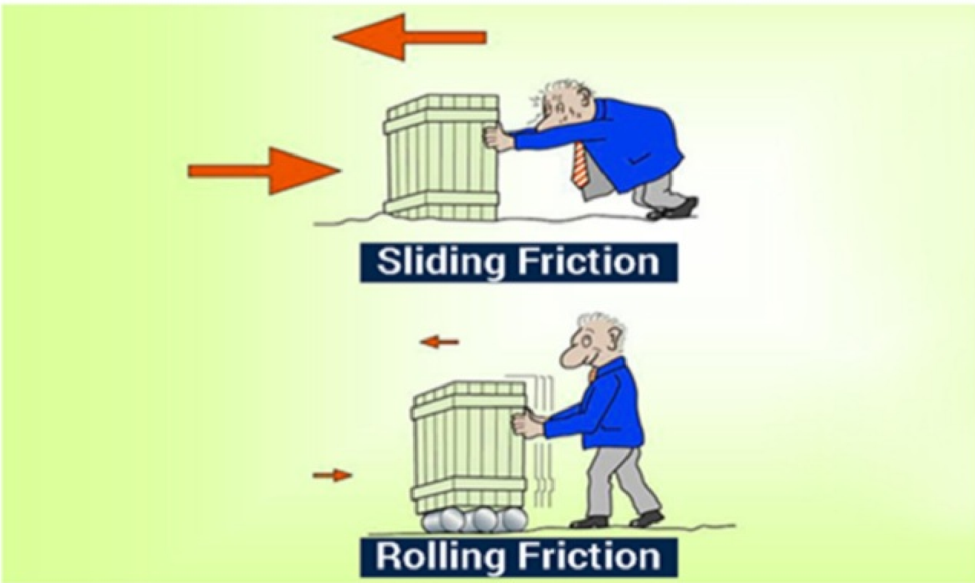
ROLLING FRICTION

For a moving solid body, there are two types of friction:

The force resisting the motion of a rolling body on a surface is known as Rolling friction orrolling resistance. This type of friction is experienced by a wheel or a bal rolling on the ground.

• There is another type of friction known as Sliding friction, which resists the movement ofa body which is pushed in such a way that only one surface of the body is in contact withthe surface it is moving on. It wil be experienced when, for example, a box is pushedacross a table.

Rolling friction is considerably weaker than Sliding friction.



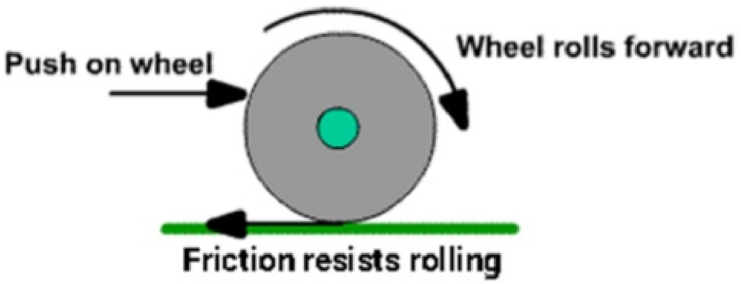
Cause of rolling friction

When an object is rolled on a surface, certain things happen:

1. The object is deformed at the point of contact with the surface.

2. The surface is deformed at the point of contact with the object.

3. Motion is created below the surface as a result of the above mentioned points.



The primary cause of this friction is that the energy of deformation is greater than the energyof recovery. Also, there is an adhesive force between the two surfaces which needs to beovercome constantly. The amount of friction is based on a variety of factors, such as,

•The quality of the sliding body

•The quality of the surface,

•Load

•Diameter of the rolling object

•Surface area of the body

Coefficient of rolling friction

Determining the coefficient of this friction is considerably more complex than that of sliding friction. **“Coefficient of Rolling Friction is the ratio of the force of rolling friction to thetotal weight of the object.”**

In empirical terms, the coefficient of rolling resistance can be expressed as:

$F_r = \mu_r W$,

where,

F_r is the resistive force of rolling resistance,

μ_r is the coefficient of rolling resistance, and

W is the weight of the rolling body

Examples of rolling friction in everyday life

• A basketbal rolled on the court wil eventual y come to a halt because of rolling friction.•

A bike with a broad tire wil burn more fuel because of the increased rolling friction.•

A ball rolled on a field wil go lesser distance than a bal rol ed on a concrete floor because it wil experience greater rolling friction on the former surface.

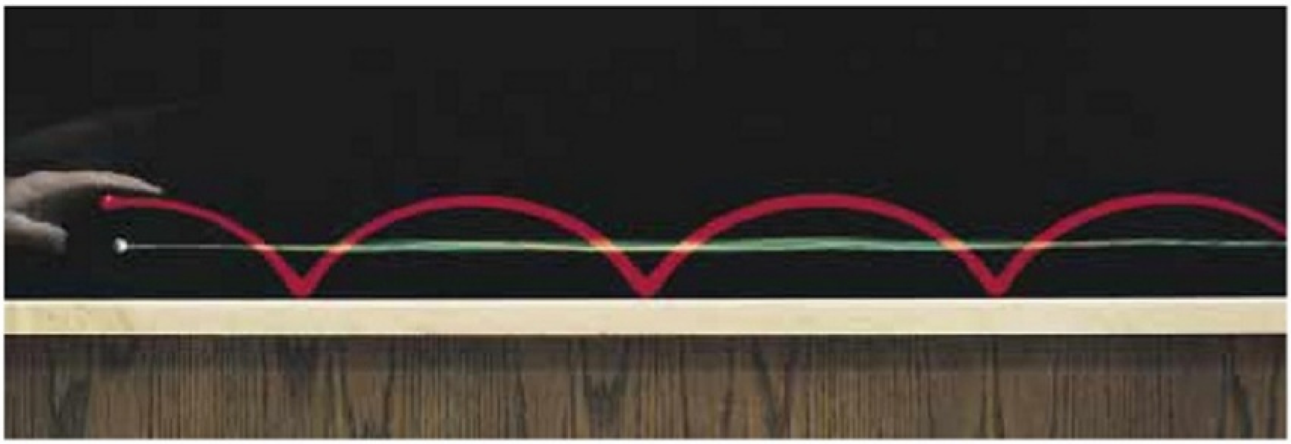
ROLLING MOTION OF A RIGID OBJECT

In this topic we treat the motion of a rigid object rotating about a moving axis. In general,such motion is very complex. However, we can simplify mat ers by restricting our discussionto a homogeneous rigid object having a high degree of symmetry, such as a cylinder, sphere,or hoop. Furthermore, we assume that the object undergoes rolling motion along a flat surface. We shal see that if an object such as a cylinder rolls without slipping on the surface(we cal this **pure rolling motion**), a simple relationship exists between its rotational and translational motions.

Suppose a cylinder is rolling on a straight path. As the following Figure shows, the center ofmass moves in a straight line, but a point on the rim moves in a more complex path cal eda cycloid. This means that the axis of rotation remains paral el to its initial orientation inspace. Consider a uniform cylinder of radius R rolling without slipping on a horizontalsurface (Fig. 11.2). As the cylinder rotates through an angle θ, its center of mass moves alinear distance s = Rθ. Therefore, the linear speed of the center of mass for pure rolling motion is given

$$v_{CM} = \frac{ds}{dt} = R\frac{d\theta}{dt} = R\omega$$

by where ω is the angular velocity of the cylinder. This equation holds whenever a cylinderor sphere rolls without slipping and is the condition for pure rolling motion. Themagnitude of the linear acceleration of the center of mass for pure rolling motion is



One light source at the center of a rolling cylinder and another at one point on the rimil ustrate the different paths these two points take. The center moves in a straight line (greenline), whereas the point on the rim moves in the path cal ed a cycloid (red curve).

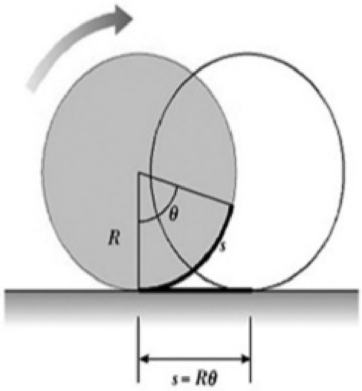


Figure In pure rolling motion, as the cylinder rotates through an angle θ, its center of mass moves a linear distance $s = R\theta$.

$$a_{CM} = \frac{dv_{CM}}{dt} = R\frac{d\omega}{dt} = R\alpha$$

where α is the angular acceleration of the cylinder.

The linear velocities of the center of mass and of various points on and within the cylinderare il ustrated in Figure below. A short time after the moment shown in the drawing, the rim point labeled P will have rotated from the six o'clock position to, say, the seven o'clock position, the point Q wil have rotated from the ten o'clock position to the eleven o'clock position, and so on. Note that the linear velocity of any point is in a direction perpendicular to the line from that point to the contact point P. At any instant, the part of the rim that is at point P is at rest relative to the surface because slipping does not occur.

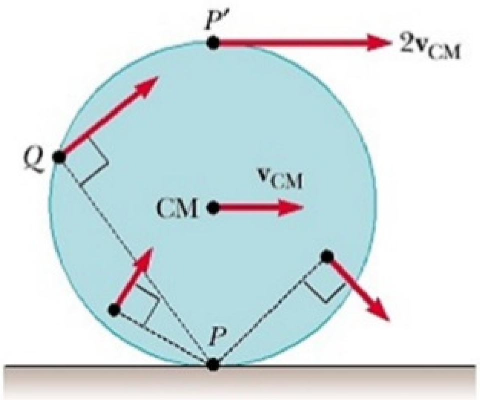


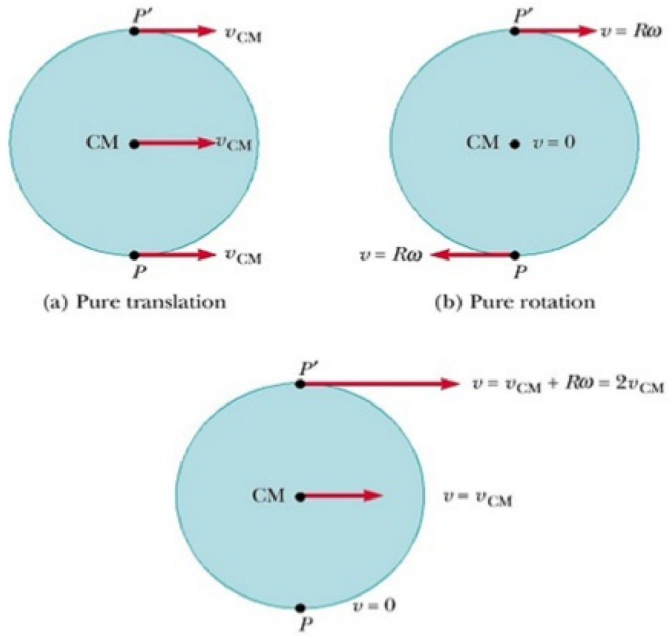
Figure: All points on a rolling object move in a direction perpendicular to an axis through theinstantaneous point of contact P. In other words, al points rotate about P. The center of massof the object moves with a velocity vCM, and the point P' moves with a velocity $2v_{CM}$.

All points on the cylinder have the same angular speed. Therefore, because the distance fromP' to P is twice the distance from P to the center of mass, P' has a speed 2vCM = 2Rω. One canalso model the rolling motion of the cylinder as a combination of translational (linear) motion and rotational motion. For the pure translational motion shown in imagine that the cylinder does not rotate, so that each point on it moves to the right with speed vCM. For thepure rotational motion imagine that a rotation axis through the center of mass is stationary, sothat each point on the cylinder has the same rotational speed ω. The combination of thesetwo motions represents the rolling motion.The top of the cylinder has linear speed vCM + Rω= vCM + vCM = 2vCM, which is greater than the linear speed of any other point on the cylinder.As noted earlier, the center of mass moves with linear speed vCM while the contact point between the surface and cylinder has a linear speed of zero. We can express the total kinetic energy of the rolling cylinder as

$$K = \frac{1}{2} I_P \omega^2$$

where IP is the moment of inertia about a rotation axis through P. Applying the paral el-axistheorem, we can substitute IP = ICM + MR2

Therefore, $$K = \frac{1}{2} I_{CM} \omega^2 + \frac{1}{2} M R^2 \omega^2$$

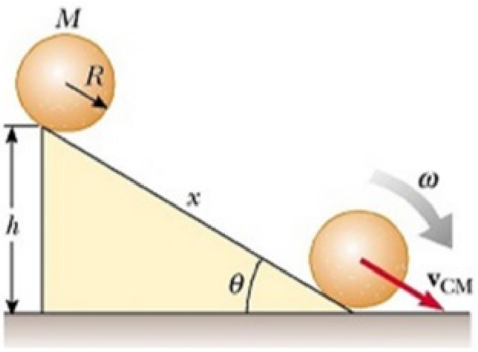


(c) Combination of translation and rotation

$$K = \frac{1}{2} I_{CM} \omega^2 + \frac{1}{2} M v_{cm}^2 \qquad \text{as } V_{cm} = RW$$

The term ½ ICMω2 represents the rotational kinetic energy of the cylinder about its center of mass, and the term ½ M2CM represents the kinetic energy the cylinder would have if it were just translating through space without rotating. Thus, we can say **that the total kinetic energy of a rolling object is the sum of the rotational kinetic energy about the center ofmass and the translational kinetic energy of the center of mass.**

We can use energy methods to treat a class of problems concerning the rolling motion of asphere down a rough incline. Assume that a sphere rolls without slipping and is released from rest at the top of the incline. Note that accelerated rolling motion is possible only if africtional force is present between the sphere and the incline to produce a net torque aboutthe center of mass. Despite the presence of friction, no loss of mechanical energy occurs because the contact point is at rest relative to the surface at any instant. On the other hand, ifthe sphere were to slip, mechanical energy would be lost as motion progressed.



A sphere rolling down an incline. Mechanical energy is conserved if no slipping occurs.Using the fact that vCM = Rω for pure rolling motion, we can express Kinetic energy as

$$K = \frac{1}{2} I_{CM} \left(\frac{v_{CM}}{R} \right)^2 + \frac{1}{2} M {v_{CM}}^2$$

$$K = \frac{1}{2} \left(\frac{I_{CM}}{R^2} + M \right) {v_{CM}}^2$$

By the time the sphere reaches the bottom of the incline, work equal to Mgh has been doneon it by the gravitational field, where h is the height of the incline. Because the sphere startsfrom rest at the top, its kinetic energy at the bottom, must equal this work done. Therefore,the speed of the center of mass at the bottom can be obtained by equating these two quantities:

$$\frac{1}{2} \left(\frac{I_{CM}}{R^2} + M \right) {v_{CM}}^2 = Mgh$$

$$v_{CM} = \left(\frac{2gh}{1 + I_{CM}/MR^2} \right)^{1/2}$$

Examples of Rolling Friction

The term rolling friction refers to the resistance created by an object rolling across a surface.Synonymous terms include rolling drag and rolling resistance. It is dramatical y less thanother types of friction, such as sliding friction.

There are various factors that can affect rolling friction such as: •

•Shape of wheel

• The type of surface on which the wheel is rolling

• Any movement of the surface or below the surface

• Original speed of the wheel

• Diameter of the wheel• Amount of pressure on the wheel

• Adhesion of the surface

• Any amount of sliding that occurs in addition to the rolling motion

• Deformation of object or of surface

• Over inflation of tires• Micro-sliding

• Thickness of tread on tires

• Shape of tread on tires

• Material that wheel or bal is made of

Any bal or wheel has rolling friction when rolled on a surface. Some examples of items that have rolling friction are:

• Truck tires

• Bal bearings

• Bike wheels

• Soccer bal , basketbal , or basebal

• Car tires

• Skateboard tires

• Railroad steel wheels

• Bowling ball

Everyday Examples of rolling Friction

• A car wil eventual y come to a stop if just al owed to roll as the friction between theroad surface and the wheels causes friction that causes the vehicle to stop.

• Bike wheels that are thicker wil lessen the potential speed of the bike because there is agreater wheel surface to create friction against the surface which wil slow the bike.

• Heavy duty trucks get greater gas mileage when tread begins to wear on the tires becausethere is less rolling friction, al owing the truck to move more quickly with lessresistance.

• A skateboard set on a slight decline will eventual y stop itself because of the resistancecaused by the friction between the wheels and the surface.

• A soccer bal kicked across a grassy field wil slow more quickly than one kicked acrossa smooth, hard surface because the rolling friction is far greater on the field.

• When a train goes around a curve there is greater rolling friction.

• Roller skates have greater rolling friction than Rol erblades because there is moresurface-to-wheel contact on roller skates.

• A duckpin bowling bal is likely to have less rolling friction than a full size bowling bal because of its size and weight which create less rolling friction.

• A dump truck wil have greater rolling friction than a smal car because the dump truckis a heavier load bearing down on the wheel and therefore causing greater rolling friction.

Practice Questions:

1. Derive an expression for the velocity of an object rolling down an inclined planestarting from rest. Also find the acceleration.

2. Does the time take by the body rolling down the plane vary with the moment ofinertia? How?

3. If a mass m and radius r is shaped as a sphere, shel , ring, disc, Hollow cylinder or asolid cylinder and al owed to rol down an inclined plane without slipping, with ofthem wil reach the lower-most point first.

Conclusive Remarks:

The learner is expected to appreciate the combination of motion in the rolling objects andas a result of the same feels good for the help it gives for the field of transportation. Theway the velocity is found for different position, picturises the change in the angle theradius vector makes about the given axis. It is for the learner to apply this idea for al structures with are capable of rolling.

CONCEPT OF COG AND COM

Introduction

Mass is an intrinsic property of every body which is unaffected by external factors(Newtonianmechanics). The weight of a body however is the force it exerts on its support keeping it upright against gravity.

Now the center of mass of a body is the point at which the whole mass of the body is taken to beconcentrated. That is if we assume the body to be a point mass at this place then it wil exhibit

Since weight is mass time acceleration due to gravity and the gravitational field due to mostobjects which exert significant gravitational force like the earth may be taken constant, thisacceleration factor cancels out and the center of gravity and center of mass coincide.However this is only true for uniform gravitational fields. If the field is non uniform the to pointsare different.

Learning Outcome:

The learner :-

-wil have a conceptual understanding of centre of mass and centre of gravity.

-wil understand the basic concept of centre of mass and centre of gravity.

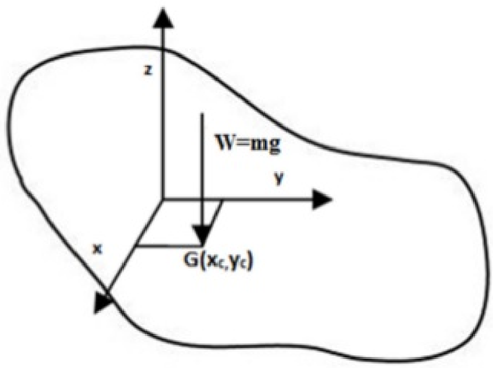
- wil understand the difference between concept of centre of mass and centre of gravity.

Conceptual Understanding:

Understand the meaning of the center of gravity (CG) and its effect on the stability of an object.Learn how to calculate the CG of different systems of objects with a series of examples.

Centre of Gravity (C.G)

Consider a body of mass m consisting of a number ofparticles of masses m1, m2,...., mn. Forces m1g, m2g.....mngact on different particles in a direction vertical ydownward. Thus, the resultant ‘W’ of these paral el forcesact at a single point ‘G’ which is called the center ofgravity (C.G) of the body.

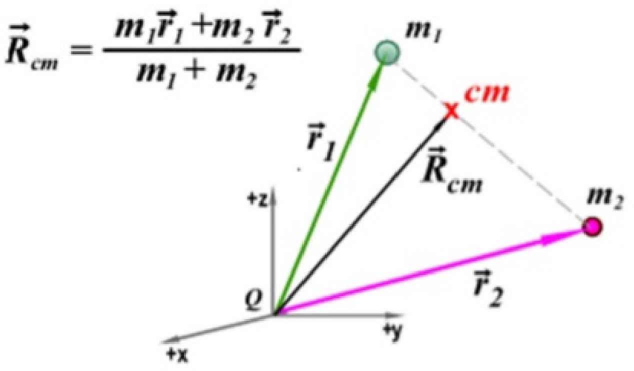


Center of gravity of a body is a point, through which theresultant of al the forces experienced the various particlesof the body, due to at raction of earth, passes irrespective of the orientation of the body.

For regular bodies the position of the center of gravity can be easily located. In case of a thin rodit lies at the center of rod while in case of a rectangular or a square lamina it lies on the point ofintersection of their diagonals.

A body when suspended freely by a string must have its center of gravity lying on a vertical linepassing through its point of suspension. It is only in that case the condition of equilibrium arefulfilled. So, to locate the C.G. of an irregular body, suspend it by any point and draw a verticalline passing through the point of suspension. Now suspend it form another point and again drawa vertical line passing through the point of suspension. The point of intersection of these twolines gives the center of gravity of the body.

Centre of Mass



Let $\vec{r_1}, \vec{r_2}, \ldots.. \vec{r_n}$ be the position vectors of the different particles of the body with respect toan arbitrary origin Q as shown in the figure.

The center of mass of the system is defined as the point in space, so that moment of the mass ofthe system about a reference point (origin), when whole of the system is supposed to beconcentrated at it (center of mass) is equal to the vector sum of the momenta of the masses, ofindividual particles around the reference point.

If $\vec{R}_{CM}$ is the position vector of the center of mass,

$$(m_1 + m_2 + m_3 + . + m_n)\vec{R}_{CM} = m_1\vec{r_1} + m_2\vec{r_2} + m_3\vec{r_3} + . + m_n\vec{r_n}$$

$$\vec{R}_{CM} = \frac{m_1\vec{r_1} + m_2\vec{r_2} + m_3\vec{r_3} + . + m_n\vec{r_n}}{(m_1 + m_2 + m_3 + . + m_n)}$$

Or, $$\vec{R}_{CM} = \frac{\sum_{i=1}^{n} m_i\vec{r_i}}{\sum_{i=1}^{n} m_i} = \frac{\sum_{i=1}^{n} m_i\vec{r_i}}{M}$$

Or,

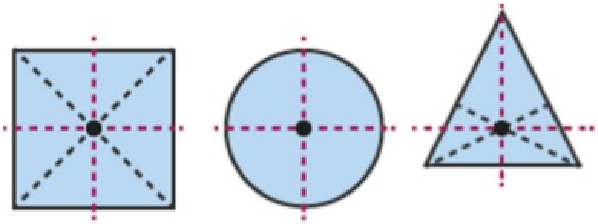
Here, M = mass of the body.

If the force acting on the body are al in the downward direction center of mass coincides with the center of gravity.

Position vector of COG can be written as

$$R_{CG} = \frac{\sum_{i-1}^{N} W_i\vec{r_i}}{\sum_{i-1}^{N} W_i}$$

The Centre of Mass After Removal of a Part of a Body



Indicates centre of mass

If a portion of a body is taken out, the remaining portion may be considered as, original mass(M) -mass of the removed part (m)

= {Original mass (M)} + {- mass of the removed part (m)}

The formula changes to:

Xcm = (Mx-mx')/(M-m) and Ycm = (My-my')/(M-m)

where primed ones represent the coordinate of the C.M. of the removed part.

Centre of Mass for a Continuous Distribution

For a continuous distribution of mass, we can treat an element of mass dm at any position as apoint mass and replace the summation by integration as shown below:

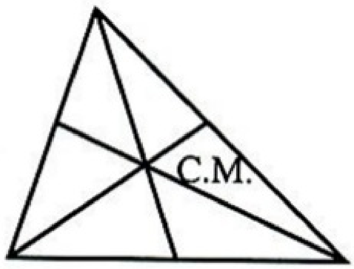
Rcm = 1/M ∫ x dm

So, we get Xcm = 1/M ∫ x dm

Ycm = 1/M ∫ y dm

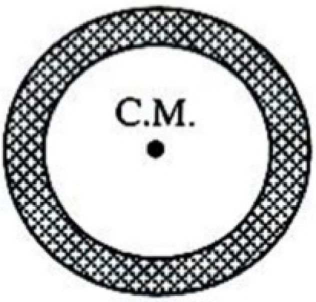
Zcm = 1/M ∫ z dm,

Note:For centre of mass the following are self-explanatory.



(1) There may or may not be any mass present at the centre of mass as can be seen in the figuresbelow. In the first body there is mass present at the centre of mass but in the second example of aring there is no mass at the centre of mass.

(2) Its position depends on the shape of the body. It is nearer to the region where more mass isconcentrated (because of vector r).



(3) For symmetrical bodies having homogeneous distribution of mass coincides with the centreof symmetry (again think in terms of vector r).

(4) Centre of mass and centre of gravity need not be at the same points (consider a very highmountain and apply the concept of variation of g with height).

Motion of Centre of Mass

Now that we have the position, we extend the concept of the center of mass to velocity and acceleration, and thus give ourselves the tools to describe the motion of a system of particles. Taking a simple time derivative of our expression for x cm we see that:

Vcm = m1v1+m2v2/m1+m2

Thus we have a very similar expression for the velocity of the center of mass. Differentiating

again, we can generate an expression for acceleration:

acm = m1a1+m2a2/m1+m2

With this set of three equations we have generated the necessary elements of the kinematics of as ystem of particles.

So, (m1+m2) acm = m1a1+m2a2

Fcm = F1+ F2 + ….

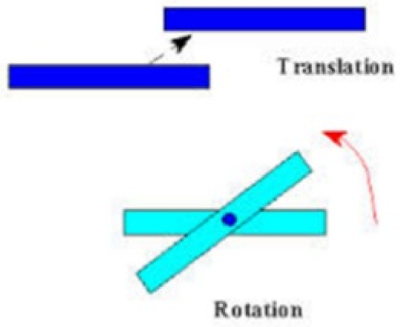
Here, Fcm = M (acm)

Here M is the total mass of the system.

Hence the total mass of the system times the acceleration of its centre of mass is equal to vector sum of al the forces acting on the group of particles.

Equilibrium

A rigid body is said to be in equilibrium if the forces actingon it do not change its state of rest or of uniform motion(linear or rotational).



This means if a body is at rest it should remain at rest. If thebody is in motion, it should keep on moving with uniformvelocity (may be linear or angular). Accordingly the equilibrium is classified into following two categories:

(a) Translatory equilibrium

A body is said to be in translatory equilibrium if its centre of mass possess no linear accelerationin an inertial frame of reference. For a body to be in translatory equilibrium the basic condition isthat the vector sum of al the external forces acting on the body should be zero. In such case abody at rest wil remain at rest. This equilibrium is static equilibrium. A body moving withuniform velocity, along a straight line, wil keep on doing so. This equilibrium is termed asdynamic translatory equilibrium.

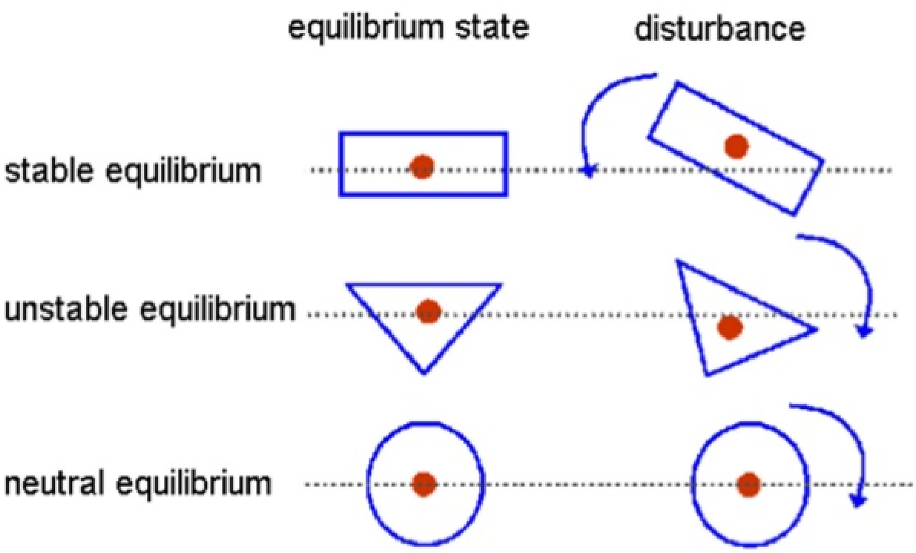
(b) Rotatory equilibrium

A body is said to be in rotatory equilibrium if it possesses no angular acceleration about any axisin an inertial frame.For the body to be in rotatory equilibrium the basic condition is that the vector sum of al theexternal torques acting on the body is zero.For a body to be in equilibrium is must satisfy both the conditions stated above simultaneously,i.e.,

(a) the vector sum of al the external forces acting on the body should vanish.

(b) the vector sum of al the external torque acting on the body should vanish.

State of Equilibrium



Equilibrium can be classified into three categories

(a) Stable equilibrium

The equilibrium of a body is said to stable if, on being slightly disturbed, it tends to come back toits original position.

(b) Unstable equilibrium

The body is said to be in unstable equilibrium if on being slightly disturbed, it shows no tendency to come back to its original position and moves away from it.

(c) Neutral equilibrium

A body is said to be in neutral equilibrium if on being slightly displaced, it remains in the new position.

Condition for Stable Equilibrium

The degree of stability of the depends upon the height of the centre of gravity of the body fromthe surface of support. Smal er the height of centre of gravity, greater is its stability.

(a) The vertical drawn from center of gravity should pass through the base.

(b) The center of gravity should be as low as possible.

(c) The base should be as wide as possible.

Example 1

Follow me through a quick experiment. You'l need the following:

• A #2 pencil

• A fine edge like a ruler or a credit card

• A permanent marker

• A ruler (if you don't have one, you may be able to eyebal it)

Step 1: Attempt to balance the pencil on the edge you have selected.

Balancing the pencil may take some trial and error. The point at which the pencil balances maynot be where you first thought. If it begins to tip in one direction, move the pencil back slowly inthe opposite direction until it wil stay there on its own.

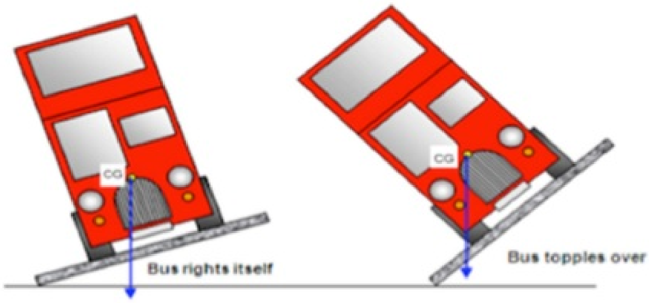
Step 2: Once the pencil is balanced, mark the location of the balancing point with apermanent marker.

Step 3: Measure the distance between the ends of the pencil and the balancing point youhave marked. Are the two lengths equal? On my pencil, the length from the eraser to thebalancing point was actual y 1.25 inches less than the length from the pencil tip to the balancingpoint. Why would this be the case?

In our experiment, the balancing point was another word for the center of gravity of this pencil. In other words, if we cut the pencil in two at the mark we made in the experiment, the two partswould be equal in weight. However, they are not equal in length. As you may have alreadyfigured out, the metal piece that houses the eraser contributes more to the weight of the pencil, sothe CG is closer to that side of the pencil.

Example 2

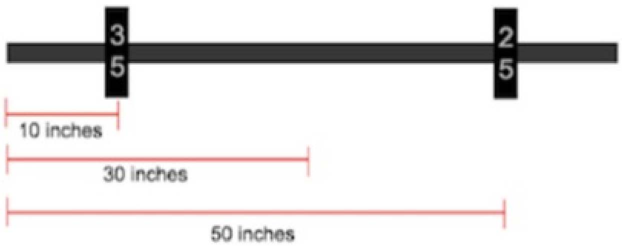
Keeping Up with that Center



The center of gravity is an important concept in determining the stability of a structure. It's thereason why a good homeowner wil keep the top branches of his trees trimmed. It's also thereason why a pick-up truck might not be the best vehicle choice for a first time driver. Stability ismaximized in objects with a lower center of gravity and a wide base. The tal er and more top-heavy an object, the more likely it is to tip over when it is tilted by a force. This figuredemonstrates a bus driving on two different grades; the second one is steep enough to cause thecenter of gravity to fal outside of the base of the vehicle, which wil cause it to topple over.

Example 3

One Dimensional Example



To make more sense of our CG equation, let's see it applied in a simple one-dimensional example that I like to cal the **Confused Weightlifter.**

Jack goes to the gym and loads a bar for his workout. The bar is 60 inches long, with a weight of45 pounds. He picks out a 35 pound weight to load onto the left side of the bar but accidental ygrabs a 25 pound weight for the right side of the bar. Before he realizes his mistake, he hasalready lifted the bar over his head with one hand. Where does Jack have to hold his hand toprevent the bar from tipping?

$$\frac{(35\ lb * 10\ in) + (45\ lb * 30\ in) + (25\ lb * 50\ in)}{105\ lb}$$
$$= 28\ inches$$

What is the center of mass and how is it calculated? Is it the same as the centroid or center ofgravity? Learn how to find the center of mass of objects in one, two, even three dimensional space!

Example 4 - Two Objects in a Line

Let's say you have a one-yard rod of negligible weight with one bal at each end. If one of theballs weighs 6 pounds and the other weighs 2 pounds, where along the rod would it be possibleto balance the system? This situation reduces the three-dimensional concept of center of massdown to a single dimension. Crazy, right?

Wait, how can we proceed with a center of mass calculations if we have weights instead ofmasses? Since the force of gravity is the same for both objects here, the center of mass and thecenter of gravity is the same. There are some systems where this is not the case, such as satel itesor planetary bodies with eccentric orbits, but it works perfectly fine in this instance.Using our equation and taking x=0 as the center of the heavier bal , we get:

x = (6 lb)(0 ft)+(2 lb)(3 ft)/(6 lb+2 lb) = (0 + 6)ft lb / 8 lb = 0.75 ft

Example 5 - Three Objects on a Plane

Let's try another. Determine the center of mass for 3 objects on a flat board with the followingmasses and locations on the coordinate plane, in meters:

A: 2 kg, (0, 10)

B: 3 kg, (10, 1)

C: 7 kg, (2, 2)

This example steps up the complexity one notch. We now have to consider two dimensions,(x, y).

x-coordinate center of mass =

2 kg(0 m) + 3 kg(10 m) + 7 kg(2 m) / (2 kg+3 kg+7 kg) = (0+30+14)kg m / 12 kg

= 3.67 m

y-coordinate center of mass =

2 kg(10 m) + 3 kg(1 m) + 7 kg(2 m) / (2 kg+3 kg+7 kg) = (20+3+14)kg m / 12 kg

= 3.08 m

The center of mass for this system is (3.67 m, 3.08 m). Starting to make more sense? Let's tryone more.

Example 6 - Four Objects in Three Dimensions

Last stop on our complexity tour! Four objects with different coordinates and weights in threedimensions, in feet. Remember that the center of mass and the center of gravity are the same forthis situation, but this is not always the case.

Center of Mass vs. Center of Gravity

Center of mass and center of gravity are two terms that are often used interchangeably, butthey're real y not the same.

Let's take an object, like, for example, a 5 kilogram bowling bal . If you drop a bowling bal , itwill fal to the ground because of the force of gravity. But did you know that the bowling bal will fal to the ground in the same way that a 5 kilogram point mass would if the point mass wasplaced at the very center of the bowling ball ?

The bowling ball is a uniform object with a **center of mass** at the very center of the bowling bal .The center of mass is the mean position of the mass in an object. If you have the same amount of mass to your right as you have to your left and the same amount above as you have below andthe same amount in front as you have behind, then you must be at the center of mass.

The bowling ball also has **a center of gravity**, which is the point where gravity appears to act. Orin other words, it's the sum total of al the forces of gravity on al the particles in the object. Itdoesn't take much understanding of physics to realize that for the bowling bal , this is also at thevery center of the object. For the bowling bal , the center of mass and center of gravity are pret ymuch in the same place.

But they're NOT the same thing. It turns out that they're only the same when the gravitationalfield is uniform across the object, or at least close enough to be uniform that it isn't worthdiscussing. With smal objects near the surface of the Earth, that's always the case. But once youstart put ing spaceships in space, suddenly things get weird.

Examples

Let's go through a couple of examples of when the center of mass and center of gravity are notthe same. We'l start off with a super abstract example.

One day, you buy a real y large aluminum bar. Because you have nothing bet er to do with yourmoney. This bar is HUGE. It's as tal as you are, just as deep, and it's 100 miles wide. I told youit was huge!

You position this bar on a stand, such that the longest side of the cuboid is at 90 degrees to theradius of the Earth. In this situation, the center of mass and center of gravity of the cuboid is notthe same. Here's why.

We like to think of the Earth's gravitational field strength as being a nice constant of 9.8 m/s/s.But that's not actual y true. That's the average value at the surface of the Earth. But as you getfurther and further away from the Earth, gravity gets gradual y weaker. Not a lot at first, just abit. But it does change. On Mount Everest, for example, the acceleration due to gravity is morelike 9.75 m/s/s.

So anyway, if you have a huge metal bar, the center of the bar wil be closer to the center of theEarth than the outside of the bar. Remember that the Earth is round (or an oblate spheroid to beexact). So the two edges wil be further away from the center of the earth and experience weakergravity. The center of mass of the bar is stil right in the center, but because of this variation ingravitational field strength, the center of gravity, the place where gravity appears to act, ends upbeing a lit le higher - a lit le further from the center of the Earth.

Did You Know ?

• The center of mass is the unique point at the center of a distribution of mass in space that has the propertythat the weighted position vectors relative to this point sum to zero.

• The center of mass is the location where all of the mass of the system could be considered to be located.

• For a solid body it is often possible to replace the entire mass of the body with a point mass equal to that ofthe body's mass. This point mass is located at the center of mass.

• For homogenous solid bodies that have a symmetrical shape, the center of mass is at the center of body'ssymmetry, its geometrical center.

• The center of mass is the point about which a solid will freely rotate if it is not constrained.

• For a solid body the center of mass is also the balance point. The body could be suspended from its centerof mass and it would not rotate, i.e. not be out of balance.

• The center of mass of a solid body does not have to lie within the body. The center of mass of a hula-hoop isat its center where there is no hoop, just hula.

• The center of mass for a system of independently moving particles still has meaning and is useful in analyzing the interactions between the particles in the system.

• if the object is symmetric and the mass is distributed uniformly throughout the object's volume, then the center of mass lies on an axis of symmetry

• If an object is pivoted on its center of gravity it balances in any orientation (no rotation).

• If the acceleration of gravity is the same throughout the object, then the center of gravity coincides with the center of mass.

• The center of mass (COM) is the unique point at the center of a distribution of mass in space that has theproperty that the weighted position vectors relative to this point sum to zero.

• An object thrown through the air may spin and rotate, but its center of gravity will fol ow a smooth parabolicpath, just like a ball.

• If you tilt an object, it will fall over only when the center of gravity lies outside the supporting base of the object.

• If you suspend an object so that its center of gravity lies below the point of suspension, it wil be stable. It may oscillate, but it won't fall over.

• The center of mass of an object of uniform density is the body’s geometric center. Note that the center ofmass does not need to be located within the object itself.

Practice questions

Problem 1

A particle of mass 1 kg is projected upwards with velocity 60 m/s. Another particle of mass 2 kgis just dropped from a certain height. After 2s when neither of the particles have collided withground. Find out acceleration and velocity of COM.

Solution:

We know that, aCOM = [m1a1 + m2a2]/[m1+m2] and uCOM = [m1u1 + m2u2]/[m1+m2]

So, aCOM = [m1a1 + m2a2]/[m1+m2]

= [(1) (-10) + 2 (-10)] / 3

= -10 m/s2

uCOM = m1u1 + m2u2/m1+m2

= [(1) (60) + (2) (0)]/3 = + 20 m/s

From the above observation we conclude that, acceleration of the centre of mass wil be-10m/s2 nad velocity of the centre of mass will be 20 m/s.

Problem 2 :

A system consisting of two objects has a total momentum of (18 kgm/sec)i and its center of masshas the velocity of (3 m/s)i. One of the object has the mass 4 kg and velocity (1.5 m/s)i. The massand velocity of the other

objects are

(a) 2 kg, (6 m/s)i

(b) 2 kg, (-6 m/s)i

(c)2 kg, (3 m/s)i

(d) 2 kg, (-3 m/s)i

Solution:

Given, Total momentum=(18 kgm/sec)i, velocity of Center of mass=(3 m/s)i, Mass of oneobject=4 kg, Velocity of this object=(1.5 m/s)iLet m be the mass of other object and v be the velocity.Now we know total momentum =Total massX velocity of center of mass

(18 kgm/sec)i=(m+4)(3 m/s)i.

or m=2 kg

Now Vcm=(m1v1+m2v2)/(m1+m2)

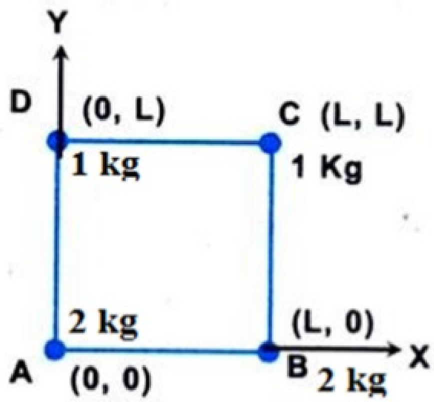
Or, 3i=(4 1.5i + 2v)/6

So, 18i=6i+2v

Or, v=6i m/sec

From the above observation, we conclude that option (a) is correct.

Problem 3:



Particle of masses 2 kg, 2 kg, 1 kg and 1 kg are placed at the corners A, B, C, D of a square ofside L as shown in the figure. Find the centre of mass of the system.

Solution:

If A is taken as origin, then,

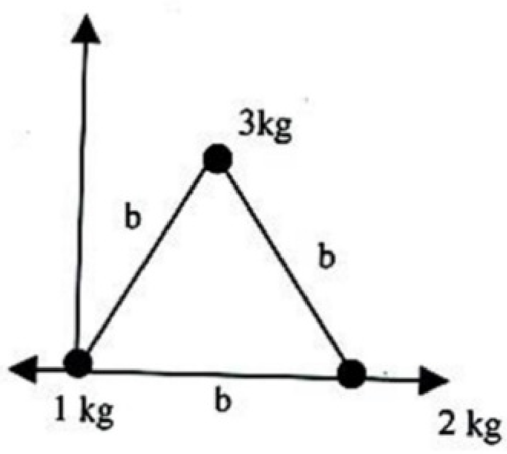
xcm = (m1 x1 + m2 x2 + m3 x3 + m4 x4) / (m1 + m2 + m3 + m4)

= (2.0+2.L+1.L+1.0)/6 = 1/2

ycm = (m1 x1 + m2 x2 + m3 x3 + m4 x4) / (m1 + m2 + m3 + m4)

= (2.0+2.0+1.L+1.L)/6=L/3

Problem 4:



Locate the centre of mass of the given system of three particles located at the vertices of anequilateral triangle.

Solution:

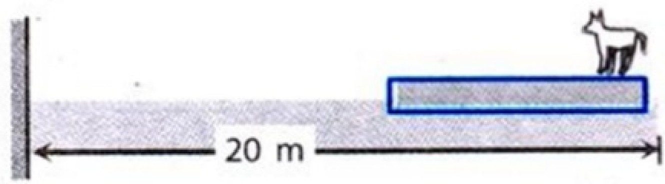
xcm = (1×0+2×0+3(b/2))/(1+2+3) = 7/12

ycm = (1×0+2×0+3√3(b/2))/(1+2+3) = (3b√3)/12.

Problem 5:

A dog of mass 10 kg is standing on a flat 10 m long boat so that is 20 meters from the shore. Itwalks 8 m on the boat towards the shore and then stops. The mass of the boat is 40 kg andfriction between the boat and th

water surface is negligible. How far is the dog from the shore now?



Solution:

Take boat and dog as a system. Initial y, centre of mass of the system is at rest. Since no externalforce is acting on the system, hence centre of mass

of the system wil remain stationary. Let initial y distance of the centre of mass of the boat fromthe shore be x m.

Then, x1.c.m. = (40 × x × 10 × 20)/(40 + 10) m …… (i)

Here, x1.c.m. = distance of the C.M. of the system from the shore.

Since dog moves towards the shore, for the centre of mass of the system to be at rest, the boathas to move away from the shore. Let distance moved by the boat be ‘x’. Then,

x2.c.m. = (40 (x+x') + 10(20 - 8 + x'))/(40 + 10)

As x1.c.m. = x2.c.m

.=> (40x + 200)/50 + (40(x + x') + 10(12 + x'))/50

=> 50x’ = 80 => x’ = 1.6 m.

Hence, distance of the dog from the shore is (20 – 8 + 1.6)m = 13.6 cm\

#Test Your knowlwdge

Question 1

A cricket bat is cut at the location of its centre of mass as shown. Then,

(a) the two pieces wil have the same mass

(b) the bottom piece wil have larger mass

(c) the handle piece wil have larger mass

(d) mass of handle piece is double the mass of bottom piece

Question 2

The center of mass of a rigid body :

(a) coincides with geometric center.

(b) is a geometric point.

(c) lies always inside the rigid body.

(d) lies always outside the rigid body.

Question 3

The density of a rod is not constant. In which of the following situation COM cannot lie at thegeometric center ?

(a) Density increases from left to right for the first half and decreases from right to left for thesecond half

(b) Density increases from left to right

(c) Density decreases from left to right

(d) Density decreases from left to right for the first half and increases from right to left for the second half

Question 4

The center of gravity is usual y located where

(a) more weight is concentrated

(b) less weight is concentrated(c) less mass is concentrated(d) more mass is concentrated

Question 5

The stationary sail boat air is blown at the sails from a fan attached to the boat. The boat wil :(a) move in the direction opposite to that in which air is blown

(b) move in the direction in which air blown

(c) spin around

(d) remain at rest.

AMPERES CIRCUITAL LAW AND SOLENOID

Introduction:

The estimate of the magnetic field at a point is done by using Biot-Savart Law. But for thees timation in a region we have to consider a loop and the same is done using Amperes Circuital Law. So there is a transition from a point to a regional view in this law. For estimating the magnetic field due to a wire of thin or thick wire using the circular loop thatcan be made one can use this law. This highlights a fact that there will be non-zero magneticfield at some portions of a thick wire and differentiates a magnetic field from an electricfield.

Learning outcome:

1. Understands the need for Amperes Circuital law

2. Differentiates this from the estimate of field at a point.

3. Understands to apply this law.

4. Appreciates the angle between the elementary portion and the magnetic field at that place. Conceptual Learning Ampere's Circuital Law:

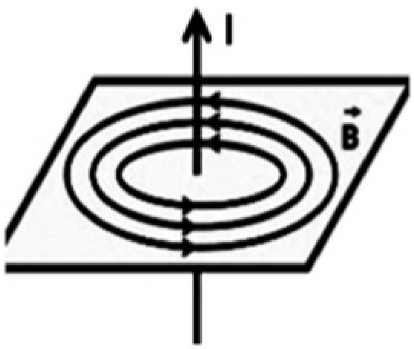
Conceptual Learning

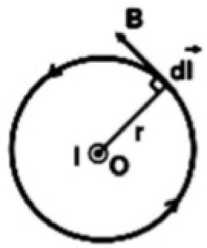
Ampere's Circuital Law:

The line integral $\oint \vec{B} \cdot \vec{dl}$ for a closed curve is equal to μ_0 times the net current I threading through the area bounded by the curve.

$$\oint \vec{B} \cdot \vec{dl} = \mu_0 I$$

Proof:





Current is emerging out and the magnetic field is anticlockwise.

Proof:

$$\oint \vec{B} \cdot \vec{dl} = \oint B \cdot dl \cos 0°$$

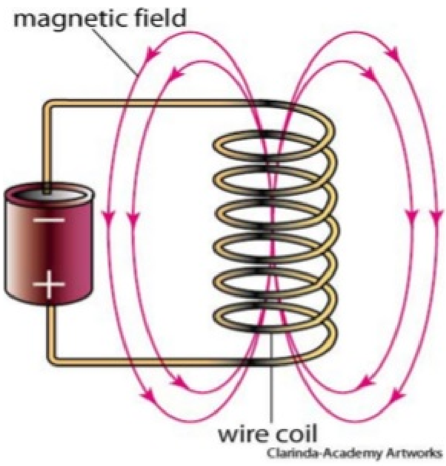
$$= \oint B \cdot dl = B \oint dl$$

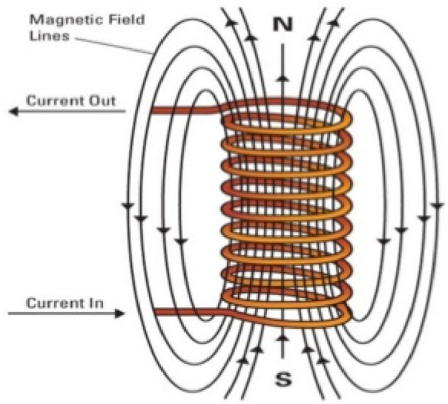
$$= B (2\pi r) = (\mu_0 I / 2\pi r) \times 2\pi r$$

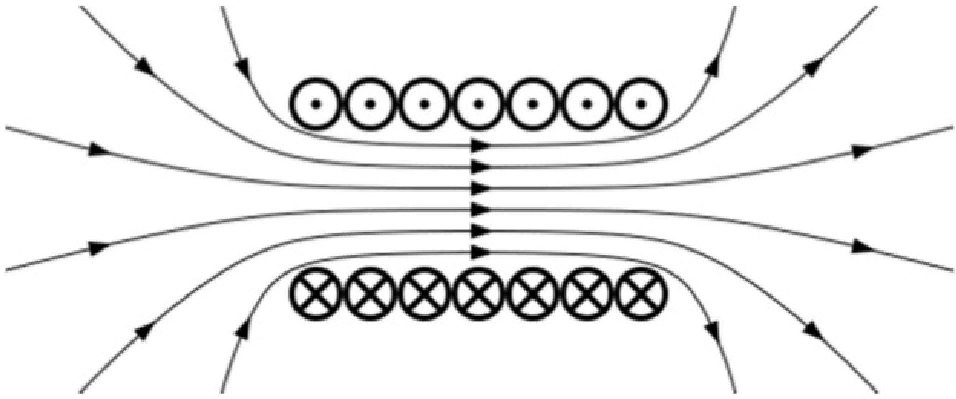
Therefore $\oint \vec{B} \cdot \vec{dl} = \mu_0 I$

Solenoid

A solenoid is a coil wound into a tightly packed helix. It is often a coil wrapped arounda metal ic core, which produces a uniform magnetic field in a volume of space whenan electric current is passed through it. A solenoid is a type of electromagnet when thepurpose is to generate a controlled magnetic field. If the purpose of the solenoid is instead toimpede changes in the electric current, a solenoid can be more specifical y classified asan inductor rather than an electromagnet. The magnetic field in the solenoid is shownbelow.K = 1 2 N m v 2 ¯ {\displaystyle K={\frac {1}{2}}Nm{\overline {v^{2}}}}K = 1 2 N m v 2 ¯ {\displaystyle K={\frac {1}{2}}Nm{\overline {v^{2}}}} .







Magnetic field in a Solenoid

We can consider the line integral of B (the magnetic flux density vector) around the loop oflength l. The horizontal components vanish, and the field outside is ideal y zero. So Ampère'sLaw gives us

$$Bl = \mu_0 N I,$$

where is the magnetic constant or Magnetic permeability, the number of turns, andthe current. From this we get

$$B = \mu_0 \frac{NI}{l}.$$

This equation is valid for a solenoid in free space, which means the permeability of themagnetic path is the same as permeability of free space, μ_0.If the solenoid is immersed in a material with relative permeability μ_r, then the field isincreased by that amount to be

$$B = \mu_0 \mu_{\rm r} \frac{NI}{l}.$$

In most solenoids, the solenoid is not immersed in a higher permeability material, but rathersome portion of the space around the solenoid has the higher permeability material and someis just air (which behaves much like free space). In that scenario, the full effect of the highpermeability material is not seen, but there wil be an effective (or apparent)permeability μ_{eff} such that $1 \le \mu_{eff} \le \mu_r$.The inclusion of a ferromagnetic core, such as iron, increases the magnitude of the magneticflux density in the solenoid and raises the effective permeability of the magnetic path. This isexpressed by the formula

$$B = \mu_0 \mu_{\rm eff} \frac{NI}{l} = \mu \frac{NI}{l},$$

where μ_{eff} is the effective or apparent permeability of the core. The effective permeability is afunction of the geometric properties of the core and its relative permeability.

Activity 1

Take a coil of specific number of turns and connect it to a source of energy. As the current isal owed to flow, keep a magnetic needle in the neighbourhood and observe the deflection.Observe and Record the deflection in the needle with variation in

i)The number of turns

ii)Increase/decrease in currenti

iii) The material in the core of the solenoid

Activity II

Any metal slinky mimics the magnetic field of a solenoid, which forms the basis for themagnet of machines of MRI. Students run current through the slinky and explore themagnetic field created by the slinky.While sending current through the solenoid, i)Determine the relationship between magnetic field and the number of turns permeter in a solenoid.

ii)Explain how the field varies inside and outside a solenoid.

Record your Observations and discuss with the fel ow classmates to have a bet erunderstanding of the Solenoid and the magnetic field.

Practice Questions:

1. Estimate the magnetic field at any point due to a thick wire of radius R carrying acurrent i.

2. Sketch the change in magnetic field caused due to a current carrying wire at any pointform the centre of a wire to infinity.

3. Is the presence of magnetic field in contrast to that of a conductor having an electricfield? What are the probable reasons?

Conclusive Remarks:

The learner appreciates the presence of magnetic field in loops and tries to identify and relatewith a dipole. The ideal nature of coils is understood with the fact that there wil be magneticfield only in the axis of the solenoid and absent outside. The linear nature of the field insidethe wire and non-linear nature outside is graphical y understood and gives a clearer picture ofthe presence of the magnetic field.

EXPERIMENT TO FIND FOCAL LENGTH OF MIRROR

AIM

To find the focal length of a convex mirror using a convex lens.

APPARATUS AND MATERIAL REQUIRED

An optical bench with uprights for holding lens, mirror and two needles, two needles (pins), a thin convex lens, a convex mirror, index needle (may be a knitting needle or a pencil sharply pointed at both ends), a metre scale and a spirit level.

PRINCIPLE

Fig. illustrates the formation of image of an object AB by a convex mirror MM′ (having a small aperture) in two different situations. The image formed by a convex mirror is virtual and erect. Therefore, its focal length cannot be determined directly. However, it can be determined by introducing a convex lens in between the object and the convex mirror.

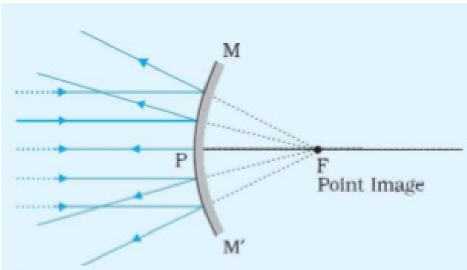


Fig. *Object is at infinity. A highly diminished and point image is located at the focus behind the convex mirror*

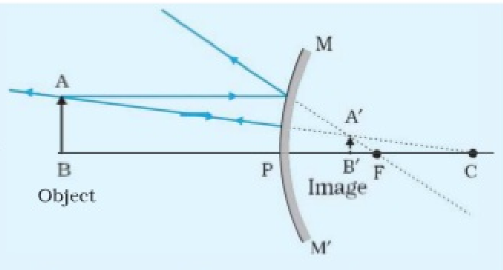


Fig. *Object is in front of the mirror. A diminished virtual image is produced between the pole and focus behind the mirror*

An object AB is placed at point P′ in front of a thin convex lens such that its real, inverted and magnified image A′B′ is formed at position

C on the other side of the lens [Fig. (b)]. Now a convex mirror is introduced between the convex lens and point C and so adjusted that the real and inverted image A′B′ coincides with the object AB at point P′ [Fig. (a)]. This is possible if the light rays starting from the tip of the object, after passing through the lens, fall normally on the reflecting surface of the convex mirror and retrace their path. Any normal ray (perpendicular) to a spherical surface has to be along the radius of that sphere so that point C must be the centre of curvature of the convex mirror. Therefore, the distance P C is the radius of curvature R and half of it would be the focal length of the convex mirror. That is,

$$f = \frac{\text{P C}}{2} = \frac{R}{2}$$

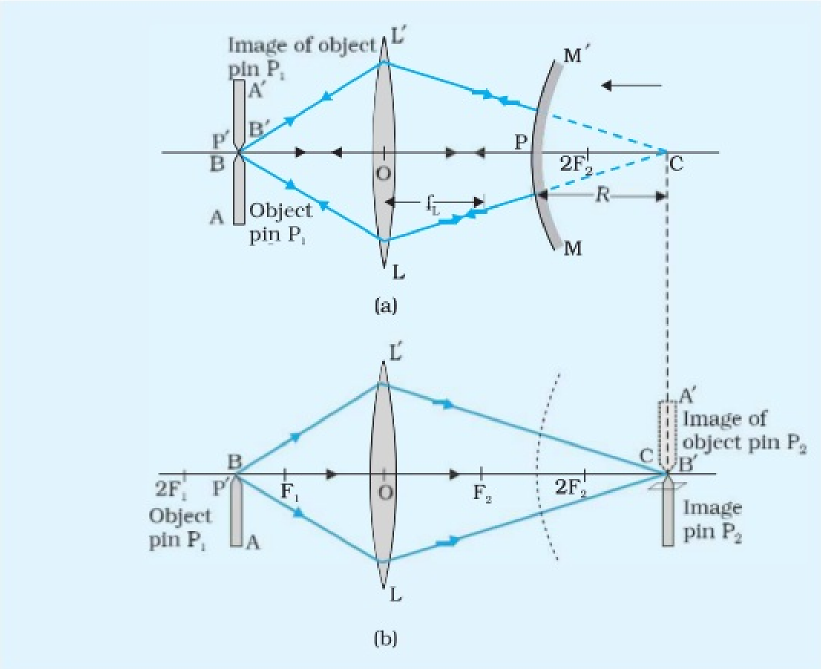


Fig. *Image formed by (a) convex mirror and convex lens-image A′ B′ coincides with the object A B at P′ (b) convex lens- image is inverted and magnified*

PROCEDURE

1. In case, if the focal length of the given thin convex lens is not known then approximate value of its focal length should be estimated first.

2. Place the optical bench on a rigid table or on a platform. Using the spirit level, make it horizontal with the help of levelling screws provided at the base of the bench.

3. Place the uprights mounted with pin P_1 (object pin), convex lens LL′, and convex mirror MM′ on the horizontal optical bench [Fig. (a)].

4. Check that the lens, mirror, and pin P_1 are vertically placed on the optical bench. Also verify that the tip of the pin, optical centre O of the convex lens LL′, and pole P′ of the convex miror MM′ lie on the same horizontal straight line, parallel to the optical bench.

5. Determine the index correction between upright holding of the convex mirror and image pin respectively, using an index needle.

6. Place the object pin P_1 from the convex lens LL′ at a distance slightly greater than the focal length of the lens.

7. Adjust the position of the convex mirror MM′ till the light rays reflected back from the mirror pass through the lens and form a real and inverted image coinciding with the object pin P_1, as shown in Fig.E (a). This occurs when the rays starting from the tip of pin P_1, after passing through the lens strike the mirror normally and are reflected back along their original paths. Remove the parallax between the image and object pins.

8. Read the position of uprights holding the object pin P_1, convex lens LL′, and convex mirror MM′ and record the observations in the observation table.

9. Remove the convex mirror from its upright and fix image pin P_2 on it. Adjust the height of pin such that the tip of it also lies on the principal axis of the lens. That is, the tips of the pins P_1 and P_2 and the optical centre O of the convex lens, all lie on a straight horizontal line parallel to the length of the optical bench.

10. You may put a small piece of paper on image pin P_2 to differentiate it from the object pin P_1.

11. Using the method of parallax and without changing the position of lens LL′ and object pin P_1, adjust the position of image pin P_2 on the other side of the lens so that it coincides with the real and inverted image of the object pin P_1 formed by the convex lens [Fig. E 11.2(b)]. Note the position of the image pin.

12. Repeat the experiment by changing the separation between the pin P_1 and lens L L′ and the mirror MM′. In this manner, take five sets of observations.

OBSERVATIONS

1. Focal length of the convex lens, f (estimated/given) = ... cm
2. Actual length of the index needle, l = ... cm
3. Observed length of the index needle l'

   = Position of mirror upright – position of pin upright on the scale = ... cm
4. Index correction, e = Actual length – observed length $(l - l')$ = ... cm

Table E 1: Determination of radius of curvature of convex mirror, *R*

Sl. No.	Upright position of				Observed $R' = c - d$ (cm)	Corrected R Observed $R' + e$ (cm)	Focal length f (cm)	Δf (cm)
	Object pin P_1 a (cm)	Convex lens LL′ b (cm)	Convex mirror MM′ c (cm)	Image pin P_2 d (cm)				
1								
2								
--								
5								
					Mean			

CALCULATIONS

Calculate the mean value of radius of curvature of the convex mirror, R, and determine its focal length using the following relation

$$f = \frac{R}{2} = \text{... cm}$$

Error

$$f = \frac{R' + l}{2} = \frac{(c - d) + (l - l')}{2}$$

$$\frac{\Delta f}{f} = \frac{\Delta c}{c} + \frac{\Delta d}{d} + \frac{\Delta l}{l} + \frac{\Delta l}{l'}$$

when Δc, Δd, Δl and $\Delta l'$ are the least counts of the measuring instruments. Maximum of the five values of Δf is to be reported with the result as the experimental error.

RESULT

The focal length of the given convex mirror is ($f \pm \Delta f$) ... ± ... cm. Here f is mean value of the focal length.

PRECAUTIONS

1. The uprights supporting the pins, lens and mirror must be rigid and mounted vertically.
2. The apertures of the given convex lens and convex mirror should be small, otherwise the image formed will be distorted.
3. Eye should be placed at a distance of about 25 cm or more from the image pin.
4. Optical bench should be horizontal. The tips of pins, centre of convex lens and pole of the mirror should be at the same horizontal level.

SOURCES OF ERROR

1. The tip of the inverted image of the object pin should just touch the tip of the image pin and must not overlap. This should be ensured while removing the parallax.
2. Personal eye defects may make removal of parallax tedious.
3. The convex mirror should preferably be front-coated. Otherwise multiple reflections may take place.

DISCUSSION

It may not be possible to perform this experiment with just any convex lens. The focal length of the lens used in this experiment should neither be too small nor too large. Why?

SELF ASSESSMENT

1. If focal length of the concave mirror is determined, by using convex lenses of different focal lengths, do you expect any change in the result? If yes, what type of change? If not, why not?
2. How will the result change if a convex lens of different refractive indices were used?
3. If the convex lens selected for the experiment has focal length less than that of the convex mirror, how would this selection limit the experiment?

EXPERIMENT TO FIND FOCAL LENGTH OF A CONVEX LENS

AIM

To find the focal length of a concave lens with the help of a convex lens.

APPARATUS AND MATERIAL REQUIRED

An optical bench with uprights for holding the lenses and two needles, a thin concave lens, a convex lens of focal length (~15 cm) smaller than that of the concave lens, index needle (may be a knitting needle), a metre scale and a spirit level.

PRINCIPLE

Figs. E 12.1 (a),(b),(c) and (d) illustrate the formation of image A′ B′ of an object AB by a concave lens. It is clear that the image formed by a

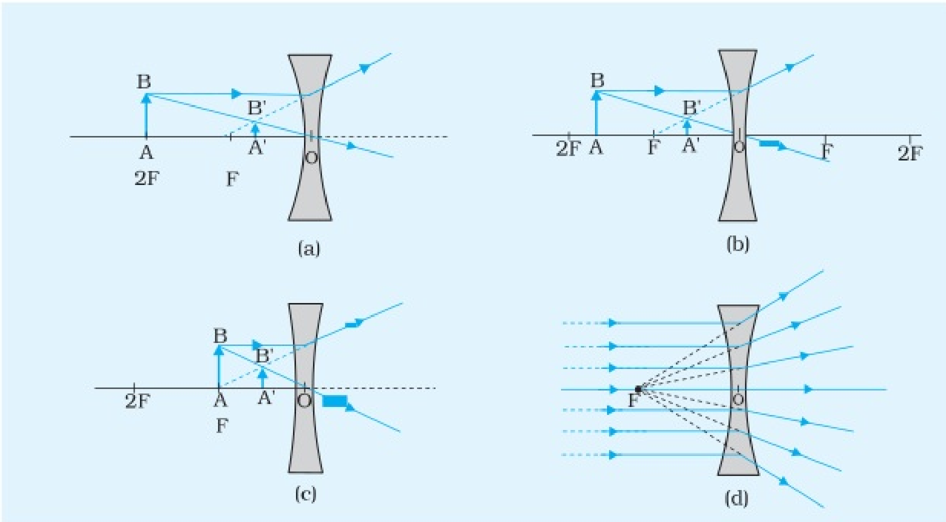


Fig. E 12.1 (a),(b),(c), (d) *The images formed by a concave lens for different object positions*

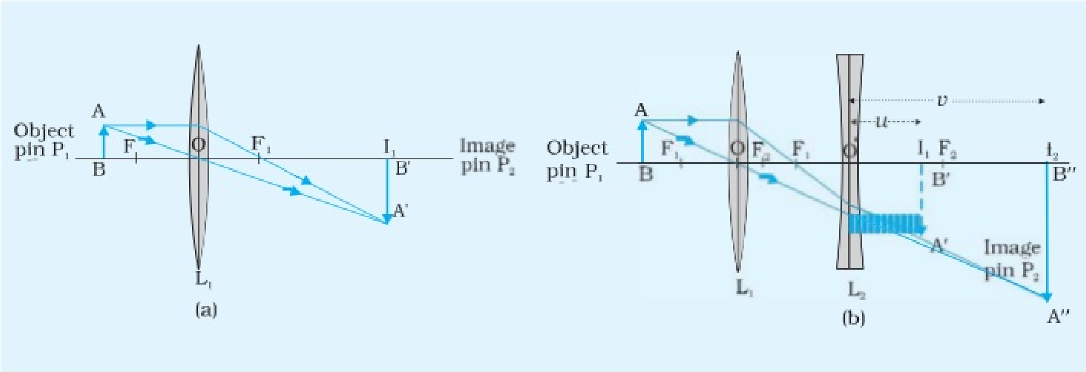


***Fig. 2** Formation of image (a) by a convex lens; and (b) by a combination of convex lens and concave lens*

concave lens is always virtual and erect in these cases. Therefore, its focal length cannot be determined directly. However, it can be determined indirectly by introducing a convex lens in between the object and the concave lens and producing a real image as illustrated in Fig.

A convex lens L_1 converges the light rays starting from the object AB to form a real and inverted image A′B′ at position I_1 [Fig. E (a)]. If a concave diverging lens L_2 is inserted between the lens L_1 and point I_1 as shown in Fig. 2 (b), for concave lens L_2 image A′ B′ behaves as virtual object. A real and inverted image A″ B″ is formed at point I_2 by the diverging lens L_2. Thus, for the concave lens L_2 the distances O′ I_1 and O′ I_2 would be the distances u and v, respectively. It is important to note that the focal length of convex lens L_1 must be smaller than the focal length of the concave lens L_2. The second image A″ B″ is formed only when the distance between lens L_2 and first image A′B′ is less than the focal length of L_2.

The focal length of the concave lens L_2 can be calculated from the relation

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u} \text{ or } f = \frac{uv}{u - v} \qquad \text{(E 12.1)}$$

Here for the concave lens both distances u and v are positive and since u will be found to be less than v, f will always be negative.

PROCEDURE

1. In case, if the focal length of the given thin convex lens is not known then rough value of its focal length (f_L) should be estimated first to ensure that its focal length is less than that of the concave lens.

2. Place the optical bench on a rigid platform and using the spirit level, make it horizontal with the help of levelling screws provided at the base of the bench.

3. Place the uprights mounted with pin P_1 (object pin), convex lens L_1, and another pin P_2 (image pin) on the optical bench. You may put a small piece of paper on image pin P_2 to differentiate it from the image of object pin P_1 [Fig. 2(a)].

4. Check the collinearity of the tip of pin P_1, optical centre O of convex lens L_1, and the tip of image pin P_2 along a horizontal straight line which is parallel to the length of the optical bench. In this condition the planes of lens and both the pins would be perpendicular to the axis of the lens.

5. For the determination of the index correction, bring a mounted pin close to the concave lens L_2. Adjust the index needle (a sharp-edged knitting needle would also serve the purpose) horizontally such that its one end touches one of the curved surfaces of the lens and the other end touches the tip of the pin. Note the positions of the two uprights on the scale provided on the optical bench. The difference of the two would give the *observed length* of the index needle. The *actual length* between the tip of the pin and optical centre O′ of the lens L_2 would be length of the index needle (as measured by a scale) plus half of the thickness of the lens at its optical centre. The difference of the two lengths is the index correction.

   (If the concave lens is thin at the centre, its thickness at the centre can be ignored).

6. Separate the object pin P_1 from the convex lens by a distance slightly greater than the focal length f_L of the lens.

7. Locate its real and inverted image at point I_1 on the other side of the lens by removing the parallax between the image pin P_2 and image of the object pin P_1 [Fig. 3(a)].

8. Read the positions of the uprights holding the object pin P_1, convex lens L_1, and image pin P_2 (i.e. point I_1). Record these observations in Table E 12.1.

9. From now on, do not change the position of the convex lens L_1 and the position of the object pin P_1. Insert the concave lens L_2 in between the convex lens L_1 and image pin P_2. Now the image of object pin will shift further from the convex lens L_1 to a point I_2 (say). Adjust the position of the concave lens so that the point I_2 is sufficiently away from the point I_1.

10. In case the image formed by the combination of convex and concave lenses is not distinctly visible, try to see it on moving the concave lens nearer to the point I_1 and to locate the image by using a pencil

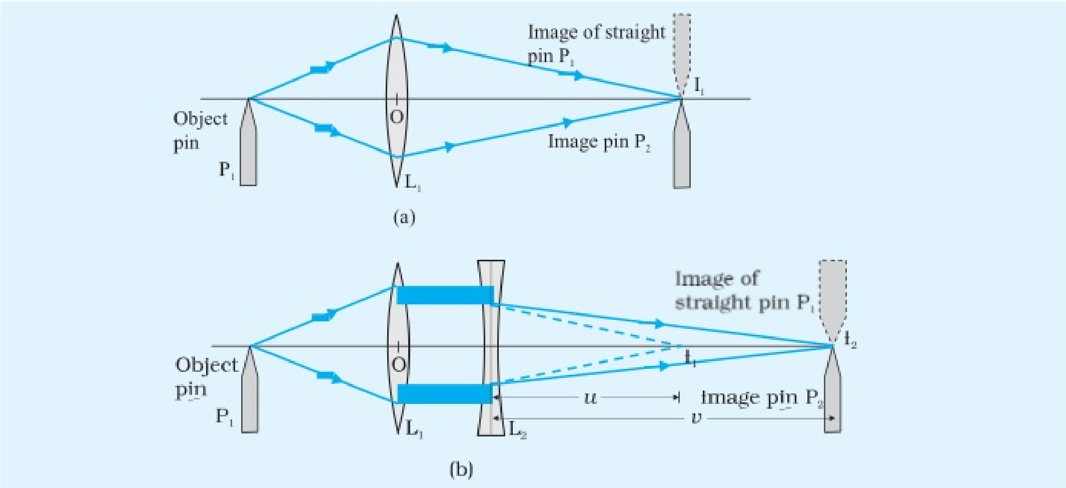


Fig. 3 *Focal length of concave lens with the help of convex lens*

held in hand, and keeping the image pin P_2 at point I_1 as a guide to decide which way to shift the concave lens L_2. After having seen the clear image at point I_2 and ensured that it lies within the range of the optical bench, move image pin P_2 to locate the image (or point I_2) more accurately using the method of parallax [Fig. 3(b)]. Since the image forming at I_2 is quite enlarged, it can be blurred.

11. Note the position of uprights holding the concave lens and image pin P_2, *i.e.*, point I_2. Note the readings in the Observation Table.

12. Change the position of upright holding the object pin P_1 and repeat the steps 6 to 10. Take five sets of observations.

OBSERVATIONS

1. Focal length of the convex lens, f_L = ... cm
2. Length of the index needle as measured by the scale, s = ... cm
3. Thickness of the thin concave lens (given) at its optical centre, t = ... cm
4. Actual length between the optical centre O of the lens and tip of the pin, $l = s + t/2$ = ... cm
5. Observed length of the index needle, l'

   = Distance between the pole of the lens and tip of the pin

   = Position of lens upright - position of pin upright on the scale

   = ... cm

Table E 12.1: Determination of *u*, *v*, and *f* of concave lens

Sl. No.	Position of										
	Object pin upright P_1, *a* (cm)	Convex lens L_1 upright, *b* (cm)	Image formed by L_1, point I_1, *c* (cm)	Concave lens L_2 upright, *d* (cm)	Image formed by L_1 and L_2, point I_2, *g* (cm)	Observed *u* = *c* – *d* (cm)	Observed *v* = *g* – *d* (cm)	Corrected *u* = Observed *u* + *e* (cm)	Corrected *v* = Observed *v* + *e* (cm)	$f = uv/(u-v)$ (cm)	Δf (cm)
1											
2											
--											
5											
									Mean		

6. Index correction, $e = l - l' = ...$ cm

CALCULATIONS

Find the focal length of the concave lens using the formula $f = \frac{uv}{u-v}$

Error $\frac{1}{f} = \frac{1}{\upsilon} - \frac{1}{u}$

$$\frac{\Delta f}{f^2} = \frac{\Delta u}{\upsilon^2} + \frac{\Delta u}{u^2}$$

$$\Delta f = f^2 \left[\frac{\Delta \upsilon}{\upsilon^2} + \frac{\Delta u}{u^2}\right]$$

where Δu, Δv represent least counts of the measuring scale. Values of *u*, *v*, *f* are to be taken from the Observation Table. Maximum of the five values of the error Δf is to be reported with the result as error.

RESULT

The focal length of the given concave lens is $(f \pm \Delta f) = ... \pm ...$cm. Here *f* is mean value of the focal length.

PRECAUTIONS

1. The concave lens must be placed near the convex lens. In fact, the second image I_2 is formed only when the distance between concave lens L_2 and first image I_1 (which acts as virtual object for the concave lens) is less than the focal length of the concave lens.

2. Since the image formed at I_2 is quite enlarged, it can be blurred. Therefore, it would be preferable to use a thin and sharp object pin and shine it with light using a lighted electric bulb.

3. The convex lens and the pin P_1 must not be disturbed during the second part of the experiment.

4. A diminished, real and inverted image of the image pin P_2 might also be formed by the light rays reflecting from the concave surface of the lens L_2. It should not be confused with the bold and bright image formed by the combination of convex and concave lenses.

5. Index correction/ bench correction for u and v should be made.

SOURCES OF ERROR

1. If tip of object pin and optical centre of the lens are not aligned properly (if not brought at the same horizontal level), image tip and image of object pin tip will not touch each other. There may be some gap between the two or there could be overlap between the two. In such situations, there can be error in removing parallax and it will lead to errors in the result.

2. For greater accuracy we should use sharply pointed object pin.

DISCUSSION

1. As concave lens diverges the rays, the image formed by a concave lens alone will not be real and cannot be taken on a screen. To converge these diverging rays to form a real image, convex lens is used.

2. Diverging rays from concave lens can be made to fall normally on a concave mirror to get the real image formed at the point where object is placed. Hence, the focal length of the concave lens can be found by using a concave mirror also.

3. Since the image I_2 is quite enlarged, it can get blurred by chromatic aberration of the two lenses. Thus it is better to put a screen behind object pin P_1 and thus do the entire experiment with one colour of light instead of with white light. For the same reason, pin P_1 should be quite thin and sharp compared to pin P_2.

OPEN ENDED QUESTIONS

Introduction:

This open ended questions are framed such that the teacher can bring in the changes invarious parameters (as asked) involved and study how the changes affect the outcome of theother related parameters. The intrinsic parameters are to be understood to solve thesequestions. With change in value of these parameters multiple conclusions can be drawn. Thiswil reflect up on the conceptual understanding of the learner which is expected to enhancethe Teaching – Learning process in the Classroom Situation.

Learning outcome:

1. Tries to understand the given situation at micro-level.

2. Picturises the situation for al the objects involved.

3. Tries to relate with Physics in the given situation.

4. Recal s the mathematical tools

5. Applies the mathematical tools to the given situation.

6. Critically analyses the steps involved to simplify the steps wherever possible.

7. Understands the Physics through the thought that evolves in the group.

8. Appreciates the quick processing ability of the learner in the group and tries to imbibesuch abilities.

9. Tries to develop the thought process that can be built up on in his/her lectuire tobenefit the learner.

10. Learns to appreciate the grasp, scientific approach, logical thinking and feedback ofthe Learner.

Mode of Activity:

Teachers wil be grouped in 6 or 7 members and wil be assigned to do atleast 3 questions outof the six in a time of One hour. The same wil be presented by the Team leader and thequeries that evolve wil be answered. The teacher facilitator wil move among the groups tojust give a helping hand without opening the complete answer. The facilitator is to final ymake the teacher learner to grasp, think, execute, perform the task and enhance his skil s fordelivery in the classroom.

Problem 1: Doppler Effect in different cases – With Light and Sound

A source emits sound of frequency f and an observer at a distance receives them. Wil therebe any change in frequency in the fol owing cases:

i)Both are at Rest

ii)Both move with the same speed v in the same direction

iii) Both are at Rest and the medium is moving with a speedv1

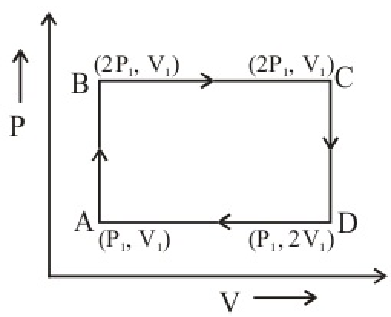
iv)Source follows the observer approaching

v)Source follows the observer receding

If the source is a light source instead of Sound source wil your answer vary in each case?What wil be the difference in the observation? Based on this study, differentiate theDoppler’s effect in Sound and Light.

Problem 2 : P-V and P-T Graph – Work Done and internal energy

Using the given P-V graph find the Heat energy change in the process.



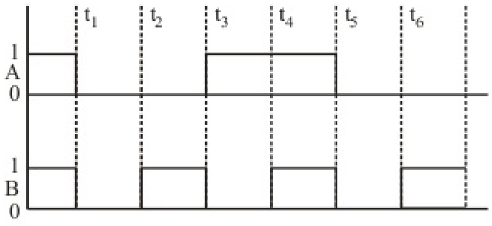
If the x co-ordinate is replaced by Absolute Temperature wil your answer change? Givereason for your answer. Derive the relation for the same.

Problem 3 : Vertical Circle

A mass m is at ached to a string of length l is whirled in a vertical circle. What wil be i) thevelocity and i) Tension in the string at any point P such that the string makes an angle ¬ withthe vertical (in terms of the velocity at the lower-most point).

Find a relation for the minimum velocity at the lower-most point. Using the same, find theposition where the mass wil return back if the velocity at the lower-most point is half thatrequired to complete a vertical circle. If the string makes an angle 90 < ¬ < 180 (in degrees)when the mass stops what is the velocity at the lower-most point.

Problem 4 : Establish that “NOR and NAND” Gates are Universal Gates.If the inputs A and B to a OR Gate made using only “NOR” Gates is as below.t1



Show the output pattern.

Problem 5 : Energy Released in a Decay

We are given the fol owing atomic masses:= 238.05079441

= 4.002604= 234.0436342He = 4.00260 u

23490 Th = 234.04363 u= 1.007834

= 237.051214

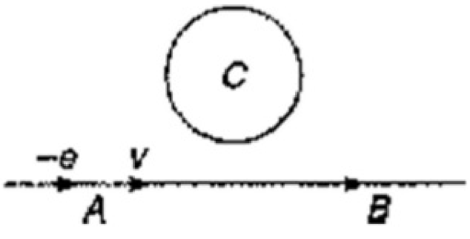
Here the symbol Pa is for the element protactinium (Z = 91).

(a) Calculate the energy released during the alpha decay of U238.

(b) Show that U238 cannot spontaneously emit a proton.

Problem 6 : Wire and a rind in neighbourhood – Emf induced

An electron moves along the line AB which lies in the same plane as a circular loop ofconducting wire as shown in figure. What wil be the direction of the current induced (if any)in the loop?



If series of electrons are moving in the same line will your answer vary? How?If the line is replaced with a wire and a current is sent along what wil be the direction ofinduced e.m.f, if any, when the current is i) Constant, i) increasing and i i) decreasing.

Hint/Steps to solve the Problems

Teachers are requested to try solving the questions with al variables possible before seeingthe steps in the group to share their experiences in solving a Question.

1. Recal the relation for apparent frequency when both the source and the sink are inmotion towards each other with the fact that the sign with the velocities exist due tothe relative motion on the line joining them in which Doppler effect. Change the signfor different directions and apply Binomial theorem for velocities comparable to thevelocity of light in free space.

2. Check whether the process is Cyclic or not. Recal the way work can be found in aprocess. Apply proper sign convention.

3. Draw a free body diagram for the mass suspended from the point using a thread oflength (say l) oriented at angle [illegible] with the vertical. A relation for tension wil evolve.Use the conservation energy to express the velocity at this point in terms of thevelocity at the lower-most point.

4. Use the truth tables to identify the unique combination of output. Identify the timeinterval in which this combination of input exist and mark the output. The rest of theinputs are the same as for as OR and AND gates are concerned.

5. Find the mass defect and the Binding energy. Remember negative energy means thatthe action is not possible.

6. Recal that

the motion of charge constitutes a current

Only varying current can bring Induction.

Right hand Flemings rule wil give you the direction of the induced current

Induced current opposes the cause of change in Flux.

Conclusive Remarks

The at empt through these questions is to enhance the teaching process. The teacher isexpected to incorporate the methods learned in solving the numerical questions duringroutine lecture and thereby make learning an enjoyable and a complete process. The joy ofget ing a correct answer to the questions by any student is unquestionable good.

SET-1

Series SSO

कोड नं.
Code No. **55/1/RU**

रोल नं.
Roll No. | | | | | | | |

परीक्षार्थी कोड को उत्तर-पुस्तिका के मुख-पृष्ठ पर अवश्य लिखें ।
Candidates must write the Code on the title page of the answer-book.

- कृपया जाँच कर लें कि इस प्रश्न-पत्र में मुद्रित पृष्ठ **16** हैं ।
- प्रश्न-पत्र में दाहिने हाथ की ओर दिए गए कोड नम्बर को छात्र उत्तर-पुस्तिका के मुख-पृष्ठ पर लिखें ।
- कृपया जाँच कर लें कि इस प्रश्न-पत्र में **26** प्रश्न हैं ।
- **कृपया प्रश्न का उत्तर लिखना शुरू करने से पहले, प्रश्न का क्रमांक अवश्य लिखें ।**
- इस प्रश्न-पत्र को पढ़ने के लिए 15 मिनट का समय दिया गया है । प्रश्न-पत्र का वितरण पूर्वाह्न में 10.15 बजे किया जाएगा । 10.15 बजे से 10.30 बजे तक छात्र केवल प्रश्न-पत्र को पढ़ेंगे और इस अवधि के दौरान वे उत्तर-पुस्तिका पर कोई उत्तर नहीं लिखेंगे ।
- Please check that this question paper contains **16** printed pages.
- Code number given on the right hand side of the question paper should be written on the title page of the answer-book by the candidate.
- Please check that this question paper contains **26** questions.
- **Please write down the Serial Number of the question before attempting it.**
- 15 minute time has been allotted to read this question paper. The question paper will be distributed at 10.15 a.m. From 10.15 a.m. to 10.30 a.m., the students will read the question paper only and will not write any answer on the answer-book during this period.

भौतिक विज्ञान (सैद्धान्तिक)

PHYSICS (Theory)

निर्धारित समय : 3 घण्टे | *अधिकतम अंक : 70*

Time allowed : 3 hours | *Maximum Marks : 70*

सामान्य निर्देश :

(i) ***सभी** प्रश्न अनिवार्य हैं । इस प्रश्न-पत्र में कुल **26** प्रश्न हैं ।*

(ii) *इस प्रश्न-पत्र के **5** भाग हैं : खण्ड अ, खण्ड ब, खण्ड स, खण्ड द और खण्ड य ।*

(iii) *खण्ड अ में **5** प्रश्न हैं, प्रत्येक का **1** अंक है । खण्ड ब में **5** प्रश्न हैं, प्रत्येक के **2** अंक हैं । खण्ड स में **12** प्रश्न हैं, प्रत्येक के **3** अंक हैं । खण्ड द में **4** अंक का एक मूल्याधारित प्रश्न है और खण्ड य में **3** प्रश्न हैं, प्रत्येक के **5** अंक हैं ।*

(iv) *प्रश्न-पत्र में समग्र पर कोई विकल्प नहीं है । तथापि, दो अंकों वाले एक प्रश्न में, तीन अंकों वाले एक प्रश्न में और पाँच अंकों वाले तीनों प्रश्नों में आन्तरिक चयन प्रदान किया गया है । ऐसे प्रश्नों में आपको दिए गए चयन में से केवल एक प्रश्न ही करना है ।*

(v) *जहाँ आवश्यक हो आप निम्नलिखित भौतिक नियतांकों के मानों का उपयोग कर सकते हैं :*

$c = 3 \times 10^{8}$ m/s

$h = 6{\cdot}63 \times 10^{-34}$ Js

$e = 1{\cdot}6 \times 10^{-19}$ C

$\mu_o = 4\pi \times 10^{-7}$ T m A^{-1}

$\varepsilon_o = 8{\cdot}854 \times 10^{-12}$ $C^2 N^{-1} m^{-2}$

$\frac{1}{4\pi\varepsilon_o} = 9 \times 10^{9}$ N m^2 C^{-2}

$m_e = 9{\cdot}1 \times 10^{-31}$ kg

न्यूट्रॉन का द्रव्यमान = $1{\cdot}675 \times 10^{-27}$ kg

प्रोटॉन का द्रव्यमान = $1{\cdot}673 \times 10^{-27}$ kg

आवोगाद्रो संख्या = $6{\cdot}023 \times 10^{23}$ प्रति ग्राम मोल

बोल्ट्ज़मान नियतांक = $1{\cdot}38 \times 10^{-23}$ JK^{-1}

General Instructions :

(i) ***All*** *questions are compulsory. There are* ***26*** *questions in all.*

(ii) *This question paper has* ***five*** *sections : Section A, Section B, Section C, Section D and Section E.*

(iii) *Section A contains* ***five*** *questions of* ***one*** *mark each, Section B contains* ***five*** *questions of* ***two*** *marks each, Section C contains* ***twelve*** *questions of* ***three*** *marks each, Section D contains one value based question of* ***four*** *marks and Section E contains* ***three*** *questions of* ***five*** *marks each.*

(iv) *There is no overall choice. However, an internal choice has been provided in one question of two marks, one question of three marks and all the three questions of five marks weightage. You have to attempt only one of the choices in such questions.*

(v) *You may use the following values of physical constants wherever necessary :*

$c = 3 \times 10^8$ m/s

$h = 6{\cdot}63 \times 10^{-34}$ Js

$e = 1{\cdot}6 \times 10^{-19}$ C

$\mu_o = 4\pi \times 10^{-7}$ T m A^{-1}

$\varepsilon_o = 8{\cdot}854 \times 10^{-12}$ C^2 N^{-1} m^{-2}

$\frac{1}{4\pi\varepsilon_o} = 9 \times 10^9$ N m^2 C^{-2}

$m_e = 9{\cdot}1 \times 10^{-31}$ kg

Mass of neutron = $1{\cdot}675 \times 10^{-27}$ kg

Mass of proton = $1{\cdot}673 \times 10^{-27}$ kg

Avogadro's number = $6{\cdot}023 \times 10^{23}$ per gram mole

Boltzmann constant = $1{\cdot}38 \times 10^{-23}$ JK^{-1}

खण्ड अ

SECTION A

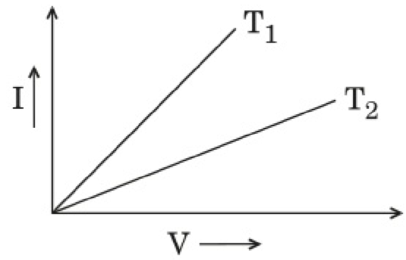
1. किसी कुंडली के 'स्वप्रेरकत्व' पद की परिभाषा दीजिए । इसका एस.आई. (S.I.) मात्रक लिखिए । *1*

Define the term 'self-inductance' of a coil. Write its S.I. unit.

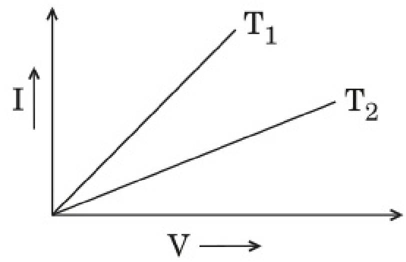
2. स्वच्छ आकाश में नीले रंग की प्रधानता क्यों होती है ? *1*

Why does bluish colour predominate in a clear sky ?

3. धातु के किसी तार के लिए दो विभिन्न तापों T_1 तथा T_2 पर I – V आलेख (ग्राफ़) चित्र में दर्शाए गए हैं । इन दोनों तापों में से कौन-सा ताप दूसरे से कम है और क्यों ? *1*



I – V graph for a metallic wire at two different temperatures, T_1 and T_2 is as shown in the figure. Which of the two temperatures is lower and why ?



4. टेलीफ़ोन संचार में किस मूल संचार विधि का उपयोग होता है ? *1*

Which basic mode of communication is used for telephonic communication ?

5. स्थिर-वैद्युत क्षेत्र रेखाएँ संवृत (बंद) पाश क्यों नहीं बनाती हैं ? *1*

Why do the electrostatic field lines not form closed loops ?

खण्ड ब

SECTION B

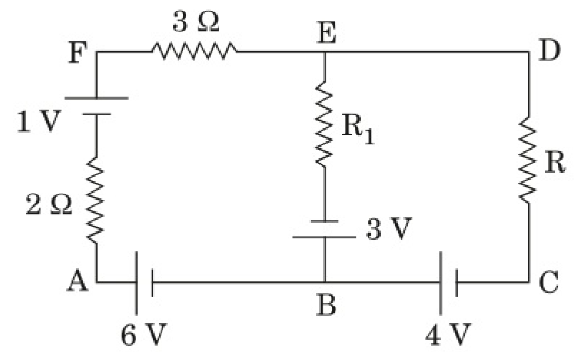
6. हाइड्रोजन परमाणु में जब कोई इलेक्ट्रॉन तृतीय उत्तेजित अवस्था से न्यूनतम ऊर्जा अवस्था में संक्रमण करता है, तो उस इलेक्ट्रॉन से सम्बद्ध दे ब्रॉग्ली तरंगदैर्ध्य में क्या परिवर्तन होगा ? अपने उत्तर की पुष्टि के लिए कारण लिखिए । *2*

When an electron in hydrogen atom jumps from the third excited state to the ground state, how would the de Broglie wavelength associated with the electron change ? Justify your answer.

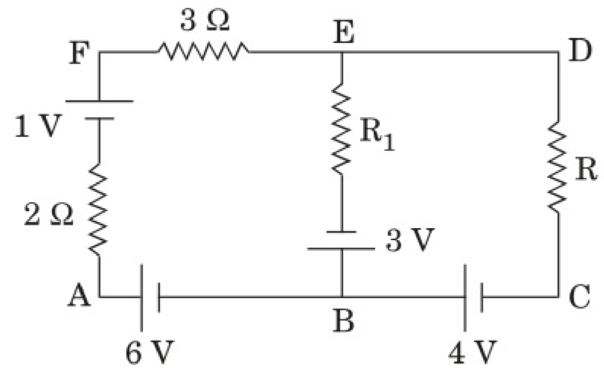
7. प्रसारण से पहले निम्न आवृत्ति संकेतों को उच्च आवृत्ति संकेतों में माडुलन की आवश्यकता के औचित्य के लिए, दो कारकों का उल्लेख कीजिए । *2*

Write two factors which justify the need of modulating a low frequency signal into high frequencies before transmission.

8. आरेख में दर्शाए गए विद्युत् परिपथ जाल में, भुजा BE से विद्युत् प्रवाह न होने की स्थिति में, बिन्दुओं A तथा D के बीच विभवान्तर का मान, किरखोफ के नियमों के उपयोग से ज्ञात कीजिए । *2*



Use Kirchhoff's rules to determine the potential difference between the points A and D when no current flows in the arm BE of the electric network shown in the figure.



9. एक संयुक्त सूक्ष्मदर्शी बनाने के लिए आपको 1·25 cm तथा 5 cm फोकस दूरियों के दो अभिसारी लेंस दिए गए हैं । यदि इस सूक्ष्मदर्शी से 30 आवर्धन क्षमता प्राप्त करनी हो, तो अभिदृश्यक तथा नेत्रिका के बीच की दूरी ज्ञात कीजिए । *2*

अथवा

किसी छोटे दूरदर्शी के अभिदृश्यक लेंस तथा नेत्रिका की फोकस दूरियाँ क्रमश: 150 cm तथा 5 cm हैं । सामान्य संयोजन में दूर स्थित वस्तुओं को देखने के लिए दूरदर्शी की आवर्धन क्षमता कितनी होगी ?

यदि इस दूरदर्शी से 3 किलोमीटर दूर स्थित 100 m ऊँचे टावर (मीनार) को देखा जाए, तो अभिदृश्यक लेंस द्वारा बनाए गए टावर के प्रतिबिम्ब की ऊँचाई कितनी होगी ? *2*

You are given two converging lenses of focal lengths 1·25 cm and 5 cm to design a compound microscope. If it is desired to have a magnification of 30, find out the separation between the objective and the eyepiece.

OR

A small telescope has an objective lens of focal length 150 cm and eyepiece of focal length 5 cm. What is the magnifying power of the telescope for viewing distant objects in normal adjustment ?

If this telescope is used to view a 100 m tall tower 3 km away, what is the height of the image of the tower formed by the objective lens ?

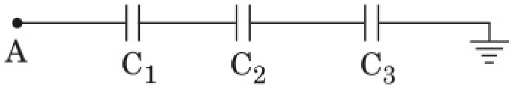
10. हाइड्रोजन परमाणु के स्पेक्ट्रम में बामर श्रेणी की सबसे कम (न्यूनतम) तरंगदैर्घ्य का मान परिकलित कीजिए । यह तरंगदैर्घ्य हाइड्रोजन परमाणु के स्पेक्ट्रम के किस भाग (अवरक्त, दृश्य, पराबैंगनी) में होगी ? *2*

Calculate the shortest wavelength in the Balmer series of hydrogen atom. In which region (infra-red, visible, ultraviolet) of hydrogen spectrum does this wavelength lie ?

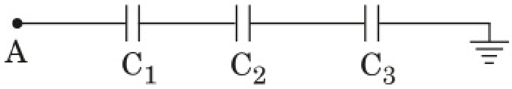
खण्ड स

SECTION C

11. आरेख में दर्शाए गए परिपथ में, संधारित्र C_2 का विभवान्तर तथा इसमें संचित ऊर्जा का मान परिकलित कीजिए । दिया गया है, A पर विभव 90 V, C_1 = 20 μF, C_2 = 30 μF तथा C_3 = 15 μF. *3*



Calculate the potential difference and the energy stored in the capacitor C_2 in the circuit shown in the figure. Given potential at A is 90 V, C_1 = 20 μF, C_2 = 30 μF and C_3 = 15 μF.



12. किसी चालक में आवेश वाहकों के अपवाह वेग तथा विश्रांति काल के बीच सम्बन्ध ज्ञात कीजिए ।

L लम्बाई का एक चालक, 'E' विद्युत्-वाहक बल (इ.एम.एफ.) के एक डी.सी. (d.c.) स्रोत से जुड़ा है । यदि 'E' को स्थिर रखते हुए, चालक (तार) को खींचकर उसकी लम्बाई तीन गुना कर दी जाए, तो स्पष्ट कीजिए कि अपवाह वेग पर क्या प्रभाव होगा । *3*

Find the relation between drift velocity and relaxation time of charge carriers in a conductor.

A conductor of length L is connected to a d.c. source of emf 'E'. If the length of the conductor is tripled by stretching it, keeping 'E' constant, explain how its drift velocity would be affected.

13. स्पष्ट कीजिए कि अध्रुवित प्रकाश किसी पोलेरॉइड से होकर गुज़रने के पश्चात् रैखिकत: ध्रुवित कैसे हो जाता है ।

(i) I_0 तीव्रता का अध्रुवित प्रकाश किसी पोलेरॉइड P_1 पर आपतित होता है जिसको एक अन्य पोलेरॉइड P_2 के पास रखा जाता है जिसका पारित-अक्ष P_1 के पारित-अक्ष के समान्तर है । P_2 को इसी अवस्था में स्थिर रखते हुए, यदि P_1 को घुमाया जाए, तो पोलेरॉइडों P_1 तथा P_2 से पारगमित प्रकाश की तीव्रताओं, क्रमश: I_1 तथा I_2 में क्या परिवर्तन होगा ?

(ii) I_1 तथा I_2 तीव्रताओं के बीच सम्बन्ध लिखिए । *3*

State clearly how an unpolarised light gets linearly polarised when passed through a polaroid.

(i) Unpolarised light of intensity I_0 is incident on a polaroid P_1 which is kept near another polaroid P_2 whose pass axis is parallel to that of P_1. How will the intensities of light, I_1 and I_2, transmitted by the polaroids P_1 and P_2 respectively, change on rotating P_1 without disturbing P_2 ?

(ii) Write the relation between the intensities I_1 and I_2.

14. माडुलन सूचकांक को परिभाषित कीजिए । व्यवहार में इसका मान एक (1) से कम क्यों रखा जाता है ?

1·5 MHz आवृत्ति तथा 50 V आयाम की एक वाहक तरंग को 10 kHz आवृत्ति की किसी ज्यावक्रीय तरंग द्वारा माडुलित किया जाता है जिससे 50% आयाम माडुलन उत्पन्न होता है । आयाम माडुलित (A.M.) तरंग के आयाम तथा उत्पन्न पार्श्व बैंडों की आवृत्तियों का परिकलन कीजिए । *3*

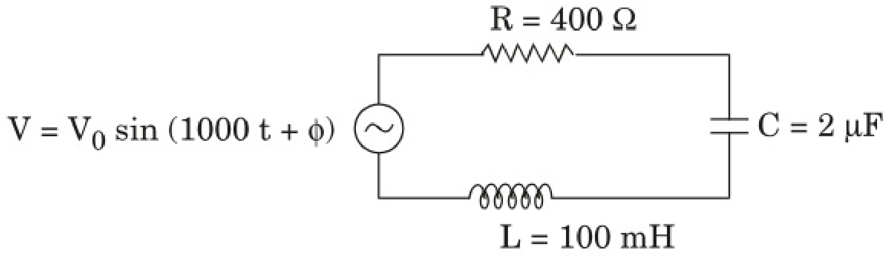
Define modulation index. Why is its value kept, in practice, less than one ?

A carrier wave of frequency 1·5 MHz and amplitude 50 V is modulated by a sinusoidal wave of frequency 10 kHz producing 50% amplitude modulation. Calculate the amplitude of the AM wave and frequencies of the side bands produced.

15. x-अक्ष के अनुदिश, धनात्मक दिशा में एक एकसमान चुम्बकीय क्षेत्र $\vec{B}$ स्थापित किया जाता है । 'q' आवेश तथा 'm' द्रव्यमान का एक कण, $\vec{v}$ वेग से इस क्षेत्र में मूल-बिन्दु पर X-Y तल में इस प्रकार प्रवेश करता है कि इसके वेग-अवयव, चुम्बकीय क्षेत्र $\vec{B}$ के अनुदिश तथा उसके लम्बवत्, दोनों ही दिशाओं में हैं । कारण देते हुए इस कण के प्रक्षेप-पथ का अनुरेखण कीजिए । इस कण द्वारा चुम्बकीय क्षेत्र के अनुदिश, एक चक्कर में तय की गई दूरी के लिए व्यंजक ज्ञात कीजिए । *3*

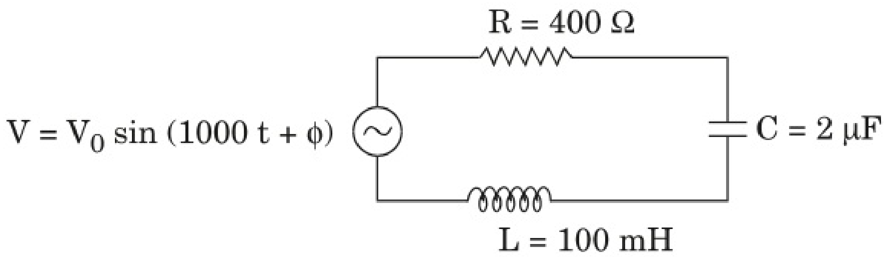
A uniform magnetic field $\vec{B}$ is set up along the positive x-axis. A particle of charge 'q' and mass 'm' moving with a velocity $\vec{v}$ enters the field at the origin in X-Y plane such that it has velocity components both along and perpendicular to the magnetic field $\vec{B}$. Trace, giving reason, the trajectory followed by the particle. Find out the expression for the distance moved by the particle along the magnetic field in one rotation.

16. (a) दिए गए श्रेणी एल.सी.आर. (LCR) परिपथ में विद्युत् धारा तथा वोल्टता में कलान्तर का मान निर्धारित कीजिए ।



(b) परिकलित कीजिए कि इस परिपथ में संधारित्र C के साथ कितनी धारिता का एक अतिरिक्त संधारित्र जोड़ा जाए कि परिपथ का शक्ति गुणांक एक (1) हो जाए । *3*

(a) Determine the value of phase difference between the current and the voltage in the given series LCR circuit.



(b) Calculate the value of the additional capacitor which may be joined suitably to the capacitor C that would make the power factor of the circuit unity.

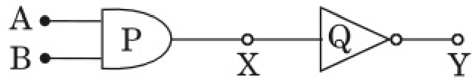
17. ऐम्पियर के परिपथीय नियम के व्यापकीकृत रूप के लिए व्यंजक लिखिए । इसके महत्त्व पर चर्चा कीजिए और संक्षेप में वर्णन कीजिए कि विस्थापन धारा की अभिधारणा को, किसी विद्युत् परिपथ में किसी संधारित्र के आवेशित व अनावेशित होने की घटना द्वारा कैसे समझाया जा सकता है । *3*

Write the expression for the generalized form of Ampere's circuital law. Discuss its significance and describe briefly how the concept of displacement current is explained through charging/discharging of a capacitor in an electric circuit.

18. हाइगेन्स के सिद्धान्त के उपयोग से यह दर्शाइए कि कोई समतल तरंगाग्र सघन माध्यम से विरल माध्यम में कैसे संचरित होता है । इससे स्नैल के अपवर्तन नियम का सत्यापन कीजिए । *3*

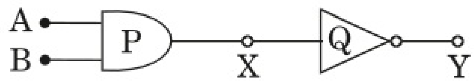
Use Huygens' principle to show how a plane wavefront propagates from a denser to rarer medium. Hence verify Snell's law of refraction.

19. यहाँ दर्शाए गए आरेख में P तथा Q गेटों (द्वारों) को पहचानिए । इनके दर्शाए गए गेटों (द्वारों) के संयोजन के लिए सत्यमान सारणी बनाइए ।



इस परिपथ को निरूपित करने के लिए तुल्य गेट (द्वार) का नाम लिखिए तथा उसका तर्क प्रतीक लिखिए । *3*

Identify the gates P and Q shown in the figure. Write the truth table for the combination of the gates shown.



Name the equivalent gate representing this circuit and write its logic symbol.

20. किसी सी.ई. (C.E.) ट्रांज़िस्टर प्रवर्धक का परिपथ आरेख बनाइए । इसकी कार्यविधि को संक्षेप में स्पष्ट कीजिए तथा इस प्रवर्धक की (i) धारा लब्धि, (ii) वोल्टता लब्धि के लिए व्यंजक लिखिए । *3*

Draw a circuit diagram of a C.E. transistor amplifier. Briefly explain its working and write the expression for (i) current gain, (ii) voltage gain of the amplifier.

21. (a) नाभिकीय बल के तीन अभिलक्षणिक गुण लिखिए ।

(b) एक न्यूक्लिऑन युग्म के पृथक्करण के फलन के रूप में स्थितिज ऊर्जा का एक आलेख बनाइए । उन दो महत्त्वपूर्ण निष्कर्षों को लिखिए जो इस आलेख (ग्राफ़) से निकाले जा सकते हैं । *3*

(a) Write three characteristic properties of nuclear force.

(b) Draw a plot of potential energy of a pair of nucleons as a function of their separation. Write two important conclusions that can be drawn from the graph.

22. (a) प्रकाश-विद्युत् प्रभाव की परिघटना में तीन प्रायोगिक अध्ययन से प्रेक्षित लक्षणों का संक्षेप में वर्णन कीजिए ।

(b) संक्षेप में चर्चा कीजिए कि इन लक्षणों की व्याख्या, प्रकाश के तरंग सिद्धान्त द्वारा क्यों नहीं हो सकती । *3*

अथवा

(a) फ़ोटॉनों के उन मुख्य गुणधर्मों का उल्लेख कीजिए जिनका उपयोग आइन्स्टाइन के प्रकाश-विद्युत् समीकरण को स्थापित करने में किया जाता है ।

(b) इस समीकरण से (i) देहली आवृत्ति तथा (ii) निरोधी विभव की धारणाओं की व्याख्या कीजिए । *3*

(a) Describe briefly three experimentally observed features in the phenomenon of photoelectric effect.

(b) Discuss briefly how wave theory of light cannot explain these features.

OR

(a) Write the important properties of photons which are used to establish Einstein's photoelectric equation.

(b) Use this equation to explain the concept of (i) threshold frequency and (ii) stopping potential.

खण्ड द

SECTION D

23. एक दिन प्रात:काल में एक वृद्ध व्यक्ति नंगे पाँव अपने घर में पावर सप्लाई के मेन-स्विच के विद्युत्-फ्यूज़ को बदलने का प्रयत्न कर रहा था । एकाएक वह चीखकर फ़र्श पर गिर पड़ा । चीख सुनकर उसकी पत्नी सहायता के लिए चिल्लाई । उसे सुनकर उनके पड़ोसी का बेटा अनिल जूते पहनकर वहाँ पहुँचा और लकड़ी की छड़ी से उसने मेन सप्लाई के स्विच को बन्द कर दिया ।

निम्नलिखित प्रश्नों के उत्तर दीजिए : *4*

(i) भारत में घरों में विद्युत् मेन सप्लाई की वोल्टता तथा आवृत्ति कितनी है ?

(ii) आजकल जिन विद्युत् युक्तियों का हम उपयोग करते हैं, उनमें से अधिकांश को ए.सी. (प्रत्यावर्ती धारा) वोल्टता की आवश्यकता होती है । क्यों ?

(iii) क्या डी.सी. (d.c.) वोल्टता के मान के उच्चयन (बढ़ाने) के लिए ट्रांसफॉर्मर का उपयोग हो सकता है ?

(iv) अपने कार्य से अनिल द्वारा प्रदर्शित दो गुणों का उल्लेख कीजिए ।

One morning an old man walked bare-foot to replace the fuse wire in kit kat fitted with the power supply mains for his house. Suddenly he screamed and collapsed on the floor. His wife cried loudly for help. His neighbour's son Anil heard the cries and rushed to the place with shoes on. He took a wooden baton and used it to switch off the main supply.

Answer the following questions :

(i) What is the voltage and frequency of mains supply in India ?

(ii) These days most of the electrical devices we use require a.c. voltage. Why ?

(iii) Can a transformer be used to step up d.c. voltage ?

(iv) Write two qualities displayed by Anil by his action.

खण्ड य
SECTION E

24. (a) विद्युत् फ्लक्स को परिभाषित कीजिए । इसका एस.आई. (S.I.) मात्रक लिखिए । "स्थिर-वैद्युतिकी में गाउस का नियम किसी भी आकार या साइज़ (आमाप) के संवृत पृष्ठों के लिए सत्य है ।" एक उपयुक्त उदाहरण की सहायता से इस कथन की पुष्टि कीजिए ।

(b) गाउस के नियम के उपयोग द्वारा सिद्ध कीजिए कि एकसमान आवेशित गोलीय कोश (खोल) के भीतर विद्युत्-क्षेत्र का मान शून्य होता है । 5

अथवा

(a) किसी समान्तर पट्टिका (प्लेट) संधारित्र में संचित ऊर्जा के लिए व्यंजक व्युत्पन्न कीजिए । इससे किसी विद्युत्-क्षेत्र के ऊर्जा घनत्व के लिए व्यंजक प्राप्त कीजिए ।

(b) पूर्ण रूप से आवेशित एक समान्तर पट्टिका (प्लेट) संधारित्र को एक अन्य सर्वसम (ठीक इसी प्रकार के) अनावेशित संधारित्र के दो सिरों से जोड़ा गया है । यह दर्शाइए कि इस संयोजन में संचित ऊर्जा का मान प्रारम्भ में आवेशित (एकल) संधारित्र में संचित ऊर्जा के मान से कम होगा । 5

(a) Define electric flux. Write its S.I. unit.

"Gauss's law in electrostatics is true for any closed surface, no matter what its shape or size is." Justify this statement with the help of a suitable example.

(b) Use Gauss's law to prove that the electric field inside a uniformly charged spherical shell is zero.

OR

(a) Derive the expression for the energy stored in a parallel plate capacitor. Hence obtain the expression for the energy density of the electric field.

(b) A fully charged parallel plate capacitor is connected across an uncharged identical capacitor. Show that the energy stored in the combination is less than that stored initially in the single capacitor.

25. नामांकित आरेख की सहायता से किसी चल कुंडली धारामापी (गैल्वेनोमीटर) के कार्यकारी सिद्धान्त तथा कार्यविधि को स्पष्ट कीजिए । इसमें (i) एकसमान अरीय (त्रिज्य) चुम्बकीय क्षेत्र, (ii) नर्म लौह क्रोड का क्या प्रकार्य है ?

किसी धारामापी (गैल्वेनोमीटर) के लिए उसकी (i) धारा सुग्राहिता तथा (ii) वोल्टता सुग्राहिता पदों की परिभाषा दीजिए । धारा सुग्राहिता में वृद्धि से वोल्टता सुग्राहिता का बढ़ना आवश्यक क्यों नहीं है ? *5*

अथवा

(a) किसी $\vec{dl}$ लम्बाई के अवयव से I धारा प्रवाहित हो रही है । इससे $\vec{r}$ दूरी पर चुम्बकीय क्षेत्र $\vec{B}$ के लिए एक व्यंजक सदिश रूप में, बायो – सावर्ट नियम के उपयोग से लिखिए ।

इससे R त्रिज्या के किसी पाश (लूप) के केन्द्र से उसकी अक्ष के अनुदिश, x दूरी पर स्थित, किसी बिन्दु P पर चुम्बकीय क्षेत्र के लिए व्यंजक व्युत्पन्न कीजिए, यदि इस पाश से विद्युत् धारा प्रवाहित हो रही है ।

(b) स्पष्ट कीजिए कि बायो – सावर्ट नियम से, ऐम्पियर के परिपथीय नियम को समाकलन (इंट्रीग्रल) रूप में यथा,

$$\oint \vec{B} \cdot \vec{dl} = \mu_0 I$$

के रूप में कैसे व्यक्त किया जा सकता है, जहाँ I उस पृष्ठ से होकर गुज़रने वाली कुल धारा है । *5*

Explain, using a labelled diagram, the principle and working of a moving coil galvanometer. What is the function of (i) uniform radial magnetic field, (ii) soft iron core ?

Define the terms (i) current sensitivity and (ii) voltage sensitivity of a galvanometer. Why does increasing the current sensitivity not necessarily increase voltage sensitivity ?

OR

(a) Write, using Biot – Savart law, the expression for the magnetic field $\vec{B}$ due to an element $\vec{dl}$ carrying current I at a distance $\vec{r}$ from it in a vector form.

Hence derive the expression for the magnetic field due to a current carrying loop of radius R at a point P distant x from its centre along the axis of the loop.

(b) Explain how Biot – Savart law enables one to express the Ampere's circuital law in the integral form, viz.,

$$\oint \vec{B} \cdot \vec{dl} = \mu_0 I$$

where I is the total current passing through the surface.

26. (a) दो कलासम्बद्ध स्रोतों S_1 तथा S_2 की एकवर्णी तरंगें उत्पन्न करने से व्यतिकरण पैटर्न बनता है । मान लीजिए S_1 द्वारा उत्पन्न तरंग का विस्थापन,

$Y_1 = a \cos \omega t$ तथा S_2 द्वारा उत्पन्न विस्थापन,

$Y_2 = a \cos (\omega t + \phi)$ है ।

किसी बिन्दु पर परिणामी विस्थापन के आयाम के लिए व्यंजक प्राप्त कीजिए और दर्शाइए कि उस बिन्दु पर तीव्रता,

$I = 4a^2 \cos^2 \phi/2$, होगी ।

इससे संपोषी तथा विनाशी व्यतिकरण के लिए प्रतिबन्ध (शर्तें) स्थापित कीजिए ।

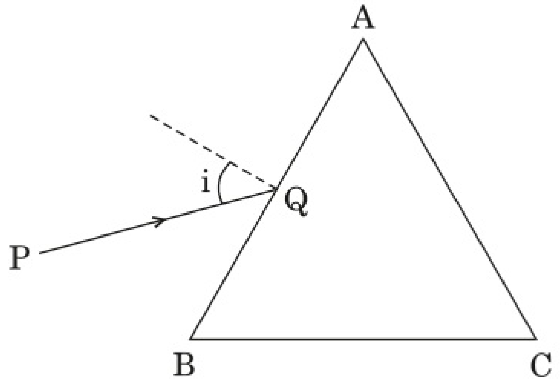
(b) यंग के द्वि-झिरी प्रयोग में व्यतिकरण फ्रिंजों पर क्या प्रभाव होता है, जब (i) स्रोत झिरी की चौड़ाई बढ़ा दी जाए; (ii) एकवर्णी स्रोत के स्थान पर श्वेत प्रकाश का स्रोत लिया जाए ? 5

अथवा

(a) यहाँ दर्शाए गए आरेख में, प्रकाश की एक किरण 'PQ', काँच के प्रिज़्म ABC के फलक AB पर आपतित होकर फलक AC से निर्गत होती है । इस किरण के मार्ग का अनुरेखण कीजिए । दर्शाइए कि

$$\angle i + \angle e = \angle A + \angle \delta$$

जहाँ δ तथा e क्रमशः विचलन कोण व निर्गत कोण को निरूपित करते हैं ।



आपतन कोण के साथ विचलन कोण के परिवर्तन को दर्शाने के लिए एक ग्राफ़ (आलेख) बनाइए । $\angle \delta$ का मान न्यूनतम होने के लिए शर्त (प्रतिबन्ध) का उल्लेख कीजिए ।

(b) प्रिज़्म के कोण (A) का मान न्यूनतम विचलन कोण (δ_m) के बराबर होने की अवस्था में काँच के प्रिज़्म के अपवर्तनांक (μ) तथा $\angle A$ के बीच सम्बन्ध प्राप्त कीजिए । इससे प्रिज़्म कोण A का मान 60° होने के लिए अपवर्तनांक का मान प्राप्त कीजिए । *5*

(a) Consider two coherent sources S_1 and S_2 producing monochromatic waves to produce interference pattern. Let the displacement of the wave produced by S_1 be given by

$$Y_1 = a \cos \omega t$$

and the displacement by S_2 be

$$Y_2 = a \cos (\omega t + \phi).$$

Find out the expression for the amplitude of the resultant displacement at a point and show that the intensity at that point will be

$$I = 4a^2 \cos^2 \phi/2.$$

Hence establish the conditions for constructive and destructive interference.

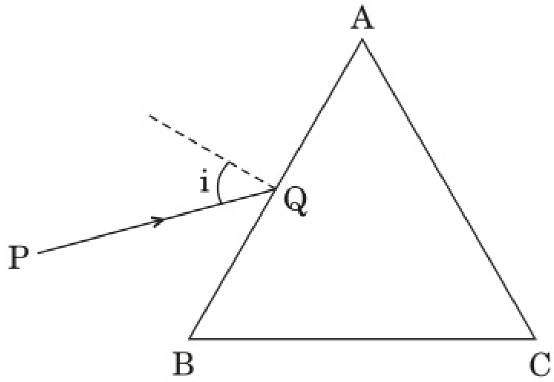
(b) What is the effect on the interference fringes in Young's double slit experiment when (i) the width of the source slit is increased; (ii) the monochromatic source is replaced by a source of white light ?

OR

(a) A ray 'PQ' of light is incident on the face AB of a glass prism ABC (as shown in the figure) and emerges out of the face AC. Trace the path of the ray. Show that

$$\angle i + \angle e = \angle A + \angle \delta$$

where δ and e denote the angle of deviation and angle of emergence respectively.



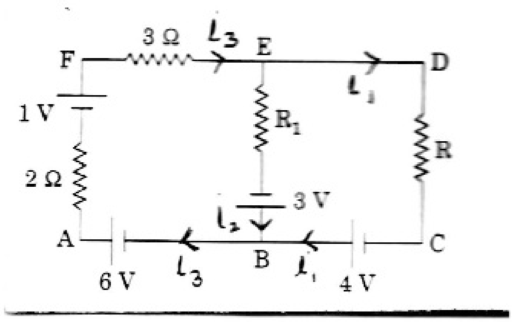
Plot a graph showing the variation of the angle of deviation as a function of angle of incidence. State the condition under which $\angle \delta$ is minimum.

(b) Find out the relation between the refractive index (μ) of the glass prism and $\angle$ A for the case when the angle of prism (A) is equal to the angle of minimum deviation (δ_m). Hence obtain the value of the refractive index for angle of prism A = 60°.

MARKING SCHEME
SET 55/1/RU

Q. No.	**Expected Answer / Value Points**	**Marks**	**Total Marks**
	Section A		
Set1, Q1 Set2,Q5 Set3,Q4	Self inductance of the coil is numerically equal to magnetic flux linked with it when unit current flows through it. / Self inductance is numerically equal to induced emf in the coil when rate of change of current is unity. Unit- Henry or / volt−second/ ampere / weber ampere^{-1}	½ ½	1
Set1, Q2 Set 2,Q3 Set 3,Q1	Scattering of the blue colour is maximum due to its shorter wavelength / As per Rayleigh scattering law, the amount of scattering varies inversely with the fourth power of wavelength.	1	1
Set1, Q3 Set 2,Q4 Set 3,Q5	T_1 Since slope($=\frac{1}{Resistance}$) of T_1 is greater / Resistance of the wire at T_1 is lower.	½ ½	1
Set1, Q4 Set 2,Q2 Set 3,Q3	Point to Point communication mode	1	1
Set1, Q5 Set 2,Q1 Set 3,Q2	Due to conservative nature of electric field / These lines start from the positive charges and terminate at the negative charges. **<u>Alternatively,</u>** There are two kinds of electric charges (positive and negative) (which acts as the „source' and „sink' for the electric field lines.)	1	1

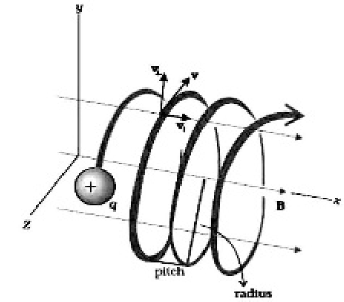
	Section B		
Set1, Q6 Set 2,Q8 Set 3,Q10	Formula for Energy ½ Formula for de-Broglieg wavelength ½ Calculation ½ Effect on wavelength ½ $\lambda = \frac{h}{p} = \frac{h}{\sqrt{2mK}}$ $\frac{\lambda_1}{\lambda_4} = \sqrt{\frac{K_4}{K_1}}$ But $K_n(= -E_n) \propto \frac{1}{n^2}$ Hence , $\frac{\lambda_1}{\lambda_4} = \sqrt{\frac{1}{16}}$ $\therefore \frac{\lambda_1}{\lambda_4} = \frac{1}{4}$ $\lambda_4 = 4\lambda_1$ i.e. $\lambda_4 > \lambda_1$	 ½ ½ ½ ½	

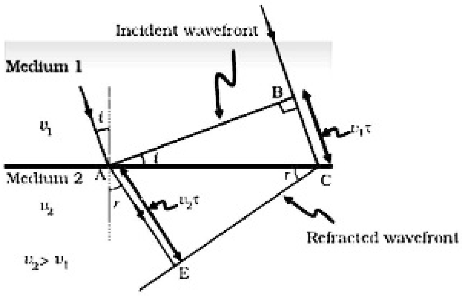
	Alternatively $$\lambda_n = \frac{h}{p_n} = \frac{\lambda}{mv_n}$$ Velocity of electron in n[th] state $v_n \propto \frac{1}{n}$ $$\lambda_n \propto \frac{1}{v_n} \;\therefore \lambda \propto n$$ $$\therefore \frac{\lambda_4}{\lambda_1} = \frac{n_4}{n_1} = \frac{4}{1}$$	½ ½ ½ ½	2 2
Set1, Q7 Set 2,Q6 Set 3,Q9	Any two Factors 1 + 1 1. Size of the antenna or aerial or $(L \sim \frac{\lambda}{4})$ 2. Increase in effective power radiated by an Antenna (OR Power radiated $\alpha \left(\frac{1}{\lambda}\right)^2$) 3. To minimize mixing of signals from different transmitters (Any two)	1 + 1	2
Set1, Q8 Set 2,Q9 Set 3,Q7	Labeling of current in different branches of the circuit ½ Calculation 1 Result ½  According to Kirchoff's Junction law at B $i_3 = i_1 + i_2 \quad \therefore i_3 = i_1$ (As I_2=0 (given)) Applying second law to loop AFEB $i_3 \times 2 + i_3 \times 3 + i_2 R_1 = 1 + 3 + 6$ $\therefore i_3 = i_1 = 2\,A$ From A to D along AFD $\therefore V_{AD} = 2i_3 - 1 + 3 \times i_3$ $= (4 - 1 + 6)V$ $= 9\,V$ [**Alternatively**, if the student determine value of V_{AD} by finding the value of R, award full marks.] [**Note:** If the student just writes Kirchoff's rules, award ½ mark]	½ ½ ½ ½	2

Set1, Q9 Set 2,Q10 Set 3,Q8	Formula for magnification ½ Substitution and Calculation 1 Result ½ $M = m_0 \times m_e$ $= \frac{L}{f_0}\left(1+\frac{D}{f_e}\right)$ $\therefore 30 = \frac{L}{1.25}\left(1+\frac{25}{5}\right)$ $30 \times 1.25 = L \times 6$ $L = 5 \times 1.25$ $= 6.25\ cm$	½ ½ ½ ½	2
	OR Formula for magnification ½ Calculation & Result ½ Angular magnification ½ Height of image ½ $M = \frac{f_o}{f_e}$ $\therefore M = \frac{150}{5} = 30$ For objective lens, $\frac{1}{v_o} - \frac{1}{u_o} = \frac{1}{f_o}$ $\frac{1}{v_o} = \frac{1}{1.5} - \frac{1}{3000}$ $\therefore\ v_o = \frac{3000}{1999} \approx 1.5$ $\frac{h_i}{h_o} = \frac{v_o}{u_o}$ $h_i = 100 \times \frac{1.5}{3\times10^3} = .05\ m$ **<u>Alternatively,</u>** Angular size of the object= $\frac{100}{3\times1000}$ radian $= \frac{1}{30}$ radian ∴ Angular size of image= $(\frac{1}{30} \times 30)$ radian $= 1$ radian ∴ Height of image= $1 \times \left(\frac{5}{100}\right)$ m $= 0.05$ m	½ ½ ½ ½ ½ ½ 1	2
Set1, Q10 Set 2,Q7 Set 3,Q6	Formula ½ Substitution of correct value in formula ½ Value of λ ½ Region of wavelength ½ $\frac{1}{\lambda} = R\left(\frac{1}{{n_1}^2} - \frac{1}{{n_2}^2}\right)$ For shortest wavelength in Balmer series $n_1 = 2 \quad n_2 = \infty$	½	

	$\therefore \frac{1}{\lambda} = R\left(\frac{1}{4} - \frac{1}{\infty}\right)$ $= \frac{R}{4}$ $\lambda = 3640A^o$ $\because R = 1.09 \times 10^7 m^{-1}$ [**Note**: Since the value of R is not given, award full marks to the candidate if he writes $\lambda = \frac{4}{R}$] It will lie in Ultra Violet region (Give ½ mark if the student just writes, visible region)	½ ½ ½	2
	Section C		
Set1, Q11 Set 2,Q18 Set 3,Q15	Formula for net capacitance and its calculation ½ + ½ Calculation for net charge ½ Formula and calculation for P.d ½ Formula and calculation for energy stored ½ + ½ Net Capacitance , $\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$ $\frac{1}{C} = \frac{1}{20} + \frac{1}{30} + \frac{1}{15}$ $\therefore C = \frac{20}{3} \mu F$ Net Charge on Capacitors q = CV $= \frac{20}{3} \times 10^{-6} \times 90$ C $= 600 \times 10^{-6}$ C $= 600\ \mu C$ (0.6 mC) $\therefore P.d\ across\ C_2 = \frac{q}{C_2}$ $= \frac{600 \times 10^{-6}}{30 \times 10^{-6}}\ V$ = 20 V Energy stored in capacitoracross $C_2 = \frac{1}{2} C_2 {V_2}^2$ $= \frac{1}{2} \times 30 \times 10^{-6} \times 400$ $= 6 \times 10^{-3} J\ (= 6mJ)$	½ ½ ½ ½ ½ ½	3
Set1, Q12 Set 2,Q19 Set 3,Q16	Derivation of the Relation 2 Effect on drift velocity 1 There being a random distribution, in the velocities of the charge carriers, their average velocity can be taken to be zero. We have, F = ma = e F_E (F_E =electric field) $\therefore a = \frac{eF_E}{m}$ If τ is the average time between collisions (called „relaxation time')	½ ½ ½	

	$v_d = \frac{eF_E\tau}{m}$ Now , $F_E = \frac{P.D}{distance}$ ∴ For given E, the field becomes $\frac{1}{3}rd$ when the length is made 3 times. Hence, $v_d'(New) = \frac{1}{3}v_d$ $\therefore v_{d'} = \frac{v_d}{3}$ [**Note**: If explained by any other appropriate method **award 1 mark** for the explanation]	½ ½ ½	3
Set1, Q13 Set 2,Q20 Set 3,Q17	Explanation of Polarization through polarizer — 1 Variation in I_1 and I_2 — 1 Relation between I_1 and I_2 — 1 Let unpolarized light be incident on a polaroid; its electric vectors, oscillating in a direction perpendicular to that of the alignment of the molecules in the polaroid, are able to pass through it while the component of light along the aligned molecules gets blocked. Hence the light gets linearly polarised. [**Note** : If student gives labelled diagram, award full marks.] I_1 will remain unaffected whereas I_2 will decrease from maximum ($=I_o/2$) to zero of the incident light. $\left(I_1 = \frac{I_o}{2}\right)$ $I_2 = I_1 \cos^2\theta$ / $I_2 = (I_o / 2) \cos^2\theta$	1 1 1	3
Set1, Q14 Set 2,Q21 Set 3,Q18	Definition of Modulation index — 1 Reason — ½ Calculation of USB and LSB — ½ +½ Amplitude of AM — ½ The ratio of amplitude of modulating signal (E_m) and amplitude of carrier wave (E_C) is called modulating index. [**Note**: Also accept if only the formula ($\mu = \frac{E_m}{E_c}$) is given] To avoid /minimize distortion: Given: f_c=1.5 M Hz f_m=10 kHz =0.01 MHz $\because \mu = \frac{E_m}{E_c}$ $\frac{50}{100} = \frac{E_m}{50}$ $E_m = 25\ V$ USB frequency $=f_c+ f_m$ =(1.5+0.01)MHz =1.51 MHz LSB frequency= f_c-f_m =(1.5-0.01)MHz =1.49 MHz	1 ½ ½ ½ ½	3

Set1, Q15 Set 2,Q22 Set 3,Q11	Trajectory of particle 1 Reason /explanation 1 Expression for distance travelled 1 Trajectory will be a helix  **Explanation/Reason** The particle will describe a circle in the y-z plane, due to the component, v_y, of its velocity. It also moves along the x-axis (parallel to the field), due to the component v_x of its velocity. Hence its trajectory would be helical. Distance moved along the magnetic field in one rotation $x = \upsilon_x \times T$ $\because T = \dfrac{2\pi m}{Bq}$ $\therefore x = \dfrac{2\pi m \nu_p}{Bq}$	1 1 ½ ½	3
Set1, Q16 Set 2,Q14 Set 3,Q12	(a) Value of phase difference 2 (b) Value of additional Capacitance 1 (a) In LCR circuit $\tan\varphi = \dfrac{X_L - X_C}{R} = \dfrac{wL - \frac{1}{wC}}{R}$ Now $X_L = wL = (1000 \times 100 \times 10^{-3})\Omega$ $= 100\ \Omega$ and $X_C = \frac{1}{wC} = \left(\frac{1}{1000 \times 2 \times 10^{-6}}\right)\Omega$ $\therefore X_C = 500\ \Omega$ $\therefore \tan\varphi = \frac{500-100}{400} = 1$ $\tan\varphi = 1$ $\varphi = 45^o$	½ ½ ½ ½	

	(b) Power Factor When power factor=1, we have X_L=X_C $\therefore\ X'_C = \frac{1}{\omega C'} = 100\Omega$ This gives $C' = \frac{1}{100\omega} = 10\mu F$ We , therefore, need to add a capacitor of capacitance (10-2)μF=8μF in parallel with the given capacitor. **Alternatively**, Let addition capacitance C_1 be connected $X'_C = \frac{1}{1000(2+C_1)\times 10^{-6}}$ $\therefore 100 = \frac{1}{1000(2+C_1)\times 10^{-6}}$ $\therefore 2 + C_1 = 10$ $C_1 = 8\ \mu F$	½ ½ ½ ½	3
Set1, Q17 Set 2,Q15 Set 3,Q13	Generalized form of Ampere's Circuital law 1 Significance 1 Explanation 1 Generalized form of Ampere Circuital law: $\oint \vec{B}.\vec{dl} = \mu_o\left(I_C + \varepsilon_o\frac{d\varphi}{dt}\right)$ It signifies that the source of magnetic field is not just due to the conduction electric current(ic) due to flow of charge but also due to the time rate of change of electric field called displacement current . During charging and discharging of a capacitor the electric field between the plates will change so there will be a change of electric flux (displacement current) between the plates.	1 1 1	3
Set1, Q18 Set 2,Q16 Set 3,Q14	Labelled Diagram 1 Verification of Snell's law 2  In Δ ABC $\sin i = \frac{BC}{AC} = \frac{v_1 t}{AC}$	1 ½	

In Δ CEA

$$\sin r = \frac{AE}{AC} = \frac{v_2 t}{AC}$$ ½

$$\therefore \frac{\sin i}{\sin r} = \frac{BC}{AE} = \frac{v_1 t}{v_2 t} = \frac{v_1}{v_2}$$

$$\because \mu_1 = \frac{c}{v_1}$$

$$\mu_2 = \frac{c}{v_2}$$ ½

$$\therefore \frac{\mu_2}{\mu_1} = \frac{v_1}{v_2}$$

$$\therefore \frac{\sin i}{\sin r} = \frac{\mu_2}{\mu_1}$$

or $\mu_2 \sin r = \mu_1 \sin i$ ------- It is Snell's law. ½

3

Set1, Q19
Set 2,Q17
Set 3,Q21

Name of Gates P and Q	½ + ½
Truth Table	1
Equivalent Gate	½
Logic symbol of equivalent Gate	½

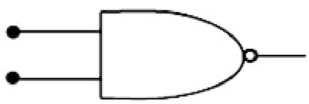
Gate P : **AND** ½

Gate Q: **NOT** ½

Truth table			
Input			
A	B	X	Y
0	0	0	1
0	1	0	1
1	0	0	1
1	1	1	0

1

Equivalent Gate: NAND ½



½

3

Set1, Q20
Set 2,Q11
Set 3,Q22

Labeled Circuit diagram	1
Working of Amplifier	1
Expression for voltage gain	½
Expression for current gain	½

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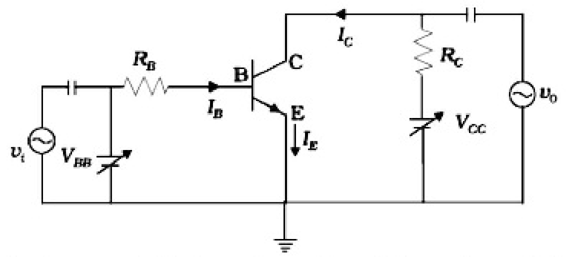
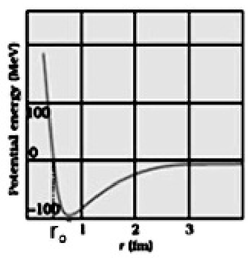


The input signal, connected between the emitter and base, along with the forward bias, causes corresponding large changes in output voltage across R.

Current gain
$$\beta_{ac} = \left|\frac{\Delta I_C}{\Delta I_B}\right|$$
Voltage gain
$$V_{Gain} = \frac{\Delta V_o}{\Delta V_I}$$
</td><td>1

1

½

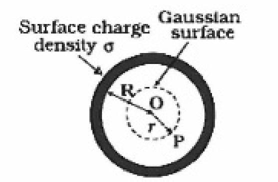
½</td><td>3</td></tr>
<tr><td>Set1, Q21
Set 2,Q12
Set 3,Q19</td><td>
<table>
<tr><td>Three characteristic properties</td><td>½ + ½ + ½</td></tr>
<tr><td>Graph for potential energy</td><td>½</td></tr>
<tr><td>Two conclusions</td><td>½ + ½</td></tr>
</table>
(a) Characteristic properties of Nuclear force
i) Short range force
ii) Saturation forces
iii) Very Strong force
iv) Charge independent
(Any Three)
(b)


Conclusions
i) Nuclear force is attractive for distance larger than r_o
ii) Nuclear force is repulsive if two nucleons are separated by distance less than r_o
iii) Nuclear force decreases very rapidly for $r > r_o$
iv) Potential energy is minimum at r_0/ Equilibrium position
(any two)
</td><td>½
+½+½

½

½ + ½</td><td>3</td></tr>
</table>

Set1, Q22 Set 2,Q13 Set 3,Q20	(a) Three experimental observations ½ +½+½ (b) Failure of wave theory 1 ½ (a) 1. There is no emission of photoelectrons i.e. no current if the frequency of the incident radiation is below a certain minimum value however large may be the intensity of the light. 2 The current varies directly with the intensity of the incident radiation. 3.The current becomes zero at a certain value of negative potential, applied at the anode , this is known as stopping potential. 4. The value of stopping potential increases with the increase in the frequency of the incident radiation. 5.Maximum kinetic energy of the photo electrons does not depend upon intensity of light.. 6.Maximum kinetic energy of photoelectron increases with the frequency of the incident radiation. 7.The process of photoelectric emission is instantaneous. **(Any three)**	½ + ½ + ½	
	(b) It fails to explain why 1.The photo electric emmission is instantaneous. 2.There exists a threshold frequency for a given metal. 3.The maximim KE of photoelectrons is independent of the intensity of incident radiation.	1 ½	3
	OR (a) Two properties of photon ½ + ½ (b) Eienstein equation 1 Explanation of threshold frequency ½ Stopping potential ½		
	(a) i) The energy of a photon is $h\nu$ ii)Each photon is completely absorbed by a single electron.	½ + ½	
	(b) $E_K = h\nu - W$ **Alternatively,** $h\nu = h\nu_0 + \frac{1}{2}m{v_{max}}^2$ **or** $h\nu = h\nu_0 + eV_o$ **or** $E_k = h(\nu - \nu_o)$ **(Any one)**	1	
	i. When Incident frequency < Threshold frequency, there will be no emission of electrons. Hence , frequency of incident radiation should be greater than threshold frequency. $\left(\nu_o = \frac{W}{h}\right)$ $E_K = eV_0 = h\nu - W$ $\therefore V_0 = \frac{h}{e}\nu - \frac{W}{e}$	½	
	ii. At $\nu = \nu_0, E_k = eV_o = 0$ V_o is called stopping potential.	½	3

	Section D		
Set1, Q23 Set 2,Q23 Set 3,Q23	Value of voltage and frequency in India ½ +½ Reason of A.C being used more ½ Use of transformer with D.C ½ Two qualities of Anil 1+ 1 (i) voltage = 220 V frequency = 50 Hz (ii) a) It can be stepped up / stepped down b)It can be converted into d.c c)Line losses can be minimised **(any one)** (iii) No (iv) Helping / Brave / Kind / Knowledge about AC or DC / Knowledge about insulator & conductors/ Awareness about safety precautions. (any two)	 ½ ½ ½ ½ 1+1	3
	Section E		
Set1, Q24 Set 2,Q25 Set 3,Q26	(a) Definition of electric flux and unit 1 + ½ Justification 1½ (b) Proof 1+1 a) Total number of electric lines of force passing perpendicular through a given surface. Unit – newton m^2 / coulomb (or V-m) According to Gauss theorem, the electric flux through a closed surface depends only on the net charge enclosed by the surface and not upon the shape or size of the surface. For any closed arbitrary slope of the surface enclosing a charge the outward flux is the same as that due to a spherical Gaussian surface enclosing the same charge. **Justification**: This is due to the fact (i) electric field is radial and (ii) the electric field $E \propto \frac{1}{R^2}$ b)  ∴According to Gauss theorem , $\phi \oint \vec{E}.\vec{dS} = \frac{q}{E_0} = 0$ (∵charge inside the shell is zero.) $\therefore E.dS = 0$, But $dS \neq 0$ $\therefore E = 0$	 1 ½ ½ 1 1 + 1	5

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OR

(a) Derivation for energy stored	2
Derivation for energy density	1
(b) Required Proof	2

(a)

$$dU = dW = \int_0^q V dq$$

$$U = \int_0^q \frac{q}{C} dq$$

$$= \frac{1}{C}\left|\frac{q^2}{2}\right|_0^q$$

$$U = \frac{1}{C}\frac{q^2}{2} \text{ or } \frac{1}{2}CV^2$$

Energy Density $U = \frac{Energy}{Volume} = \frac{1}{2}\frac{CV^2}{A.d}$

$U = \frac{\frac{1}{2}CV^2}{A.d}$

But $C = \frac{\varepsilon_0 A}{d}$ and $V = Ed$

$\therefore U = \frac{1}{2}\varepsilon_0 E^2$

(b) Energy before connecting

$U = \frac{1}{2}C_1 V_1^2$

After connecting

Common potential $= \frac{q_1+q_2}{c_1+c_2}$

$= \frac{c_1 v_1}{c_1+c_2}$

Energy Stored $U' = \frac{1}{2}(c_1+c_2)\frac{c_1^2 v_1^2}{(c_1+c_2)^2}$

$$U' = \frac{1}{2}\frac{c_1^2 v_1^2}{(c_1+c_2)}$$

$$= \frac{1}{2}\frac{C_1}{(c_1+c_2)} \text{U}$$

$$\therefore U' < U$$

</td><td>½
½
½
½
½
½
½
½
½
½</td><td>5</td></tr>
<tr><td>Set1, Q25
Set 2,Q26
Set 3,Q24</td><td>

Labelled diagram	1
Principle and working	½ + 1
Function of radial magnetic field and soft iron core	½ + ½
Current sensitivity	½
Voltage sensitivity	½
Explanation	½

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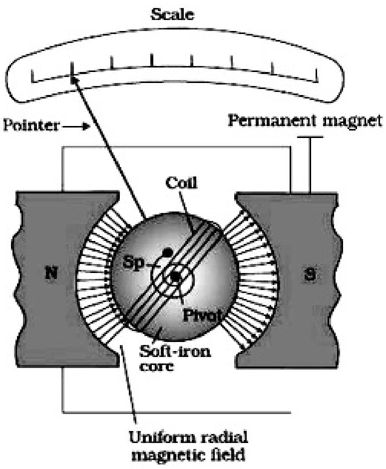
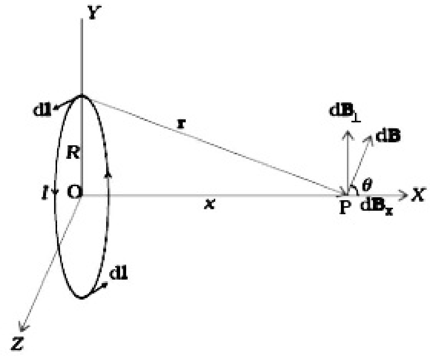
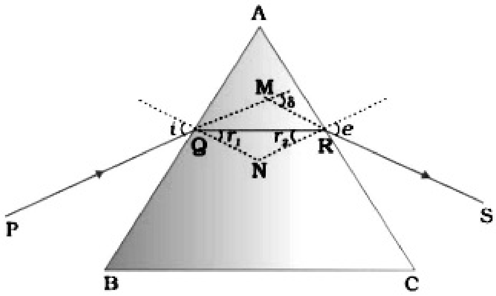
		1	
	Principle : "Whenever a current carrying coil is placed in magnetic field, it experiences a deflecting torque."	½	
	Working: When current is passed through a coil , free to rotate in a magnetic field , a deflecting torque (=NiABsinθ) act on it. The coil starts to rotate . The rotation of coil is opposed, by spring S_p by providing a restoring torque (=Kϕ). When the two torque becomes equal , coil comes to rest.	½	
	$\therefore N\iota AB = K\phi$ $i = \frac{C\phi}{NAB}$, Hence $i \propto \phi$	½	
	Functions of (1) **Radial field** ; It keeps magnetic field lines normal to the area vector of the coil	½	
	(2) **Soft iron core**; It increases the strength of magnetic field.	½	
	Current sensitivity = deflection per unit current / $\left(\frac{\phi}{\iota} = \frac{NAB}{K}\right)$	½	
	Voltage sensitivity : deflection per unit voltage / $\left(\frac{\phi}{V} = \frac{NAB}{KR}\right)$	½	
	If N⟶ 2N , then by increasing number of turns, current sensitivity increases but voltage sensitivity remains same because resistance increases proportionally.	½	5
	OR		
	(a) Expression for vector form of Biot-Savart law — 1 Expression for magnetic field due to loop — 3 (b) Biot-Savart law and Ampere's Circuital law — 1		

	(a) Biot-Savart law in vector form $\overrightarrow{dB} = \frac{\mu_0}{4\pi} I \left(\frac{\overrightarrow{dl} \times \vec{r}}{r^3}\right)$ Magnetic field on the axis of a circular current loop  The net magnetic field is along the x-axis only. Net contribution along X-axis $$B = \int dB cos\theta$$ $$\because dB = \frac{\mu_0}{4\pi} \frac{I\|dl \times r\|}{r^3}$$ $$\because r^2 = x^2 + R^2$$ $$\therefore dB = \frac{\mu_0}{4\pi} \frac{I\, dl}{(x^2 + R^2)}$$ $$\therefore B = \int \frac{\mu_0}{4\pi} \frac{I\, dl}{(x^2 + R^2)} . cos\theta$$ $$\because cos\theta = \frac{R}{(x^2 + R^2)^{1/2}}$$ $$\therefore B = \int \frac{\mu_0}{4\pi} \frac{R\, I\, dl}{(x^2 + R^2)^{3/2}}$$ $$B = \frac{\mu_0}{4\pi} \frac{IR}{(x^2 + R^2)^{3/2}} \int dl$$ $$\because \int dl = 2\, \pi R$$ $$\therefore B = \frac{\mu_0}{2} \frac{I\, R^2}{(x^2 + R^2)^{3/2}}$$	1 ½ ½ ½ ½ ½ ½	

	(b) Biot-Savart law can be expressed as Ampere's circuital law by considering the surface to be made up a large number of loops. The sum of the tangential components of the magnetic field multiplied by the length of all such elements, gives the result $$\oint \vec{B}.\vec{dl} = \mu_0 I$$ **Alternatively** , Ampere Circuital law and Biot-Savart law , both relate the magnetic field and the current , and both express the same physical consequences of a steady current.	1	5
Set1, Q26 Set 2,Q24 Set 3,Q25	(a) Expression for the Amplitude and the conditions — 3 (b) Effect on Interference fringes — 1 +1 (a) The resultant displacement will be $\vec{y} = \vec{y_1} + \vec{y_2}$ $= a[\cos \omega t + cos(\omega t + \phi)]$ $= 2a\, cos\frac{\phi}{2} \cos\left(\omega t + \frac{\phi}{2}\right)$ The amplitude of the resultant displacement is $A = 2a\, cos\frac{\phi}{2}$ $\therefore$ Intensity $A^2 = 4a^2 cos^2\frac{\phi}{2}$ If $\phi = 0, \pm 2\pi, \pm 4\pi$, ….. the intensity will be maximum. i.e $\phi = 2n\pi$ $= n\lambda$ where n = 1, 2, 3 .. Hence interference will be constructive. If $\phi = \pm\pi, \pm 3\pi, \pm 5\pi$, ….., the intensity will be zero, i.e $\phi = (2n + 1)\pi$ $= (2n + 1)\frac{\lambda}{2}$ where n=1, 2, 3 .. Hence interference will be destructive. (b)(i)Pattern will become less and less sharp. (ii) At the centre there will be white fringe followed by red colour fringes on either side. **OR** (a) Diagram — 1 Mathematical Proof — 1 ½ Graph for δ — 1 Conditions — ½ (b) Relation to μ — ½ Value of μ — ½ R	½ ½ ½ ½ ½ ½ 1 1	5

(a)



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In the quadrilateral AQNR at Q and R , two of the angles are right angles.
Therefore , the sum of the other angles of the quadrilateral is 180^0

$$\angle A + \angle QNR = 180^0$$ ½

From the triangle QNR ,
$r_1 + r_2 + \angle QNR = 180^0$
Comparing these two equations

$$r_1 + r_2 = A$$

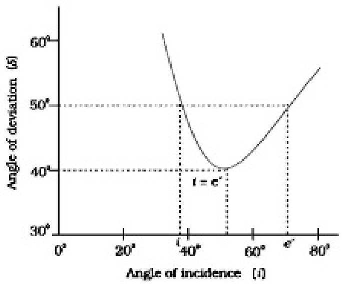
The total deviation δ is the sum of the deviations at the two faces

$$\delta = (\iota - r_1) + (e - r_2)$$ ½

i.e. $\delta = \iota + e - (r_1 + r_2)$

$$\delta = \iota + e - A$$

$$\delta + A = \iota + e$$ ½



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δ will be minimum for ι = e ½

(b)

$$\mu = \frac{\sin\left(\frac{A+\delta_m}{2}\right)}{sin\frac{A}{2}} = \frac{sin\ A}{\sin\frac{A}{2}} = 2\cos\frac{A}{2}$$ ½

If A = 60^0

$$\mu = 2\cos 30 = \sqrt{3}$$ ½ 5

Document Outline