MODULE - 6
for
PHYSICS LECTURERS
2016-17

PRACTICLE MOTION TO
WAVE MOTION

स्वाध्यायान्मा प्रमदः

State Council of Educational Research and Training

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Module- 6

Contents

ABOUT THE MODULES.......

The series of Six Modules of physics at the Higher Secondary Stage has been developed with a view that the school education is crucial and challenging as it is a transition from general science to discipline-based curriculum. The recommendations of National Curriculum Framework-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 will develop an interest in the learners to study Physics as a discipline and inculcate in learners the abilities, useful concepts of Physics in real-life situations for making learning of Physics relevant, meaningful and interesting. The learner is expected to realize and appreciate the interface 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 the Curriculum - to create interest in the learmer, to pursue their future careers in basic sciences- physics. This demands sufficient conceptual background of Physics which would eventually make 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 the feedback received from the teachers during earlier INSET programmes organised by SCERT time to time. The educational and curricular concerns and issues provided in the National Curriculum 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 Physics concepts/content, useful in real-life situations for making Physics learning more relevant, meaningful and interesting.
- Emphasis on Numerical analysis.
- Emphasis on Technical educational Movie – Analysis from Physics and scientific approach
- Emphasis on Physics-related technological/industrial aspects to cope up with changing demand of society committed to the use of Physics, technology and informatics.
- Providing logical sequencing of the concepts and their linkages for better learning and matching the concepts/content with comprehension level of the learners.
- Reducing the curriculum load by eliminating overlapping of concepts/content within the discipline of Physics or with other disciplines; reducing the descriptive portion and providing suitable formulation/depth of treatment appropriate to the comprehension level of learners, making room for contemporary core - topics and emerging curricular areas in Physics.
- The content are so sequenced as to provide different dimensions of Physics as a discipline. 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 and Comprehensive 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 work and foundation for further learning Physics at the tertiary level more effectively and learning the relationship with daily-life situations;
- Develop conceptual competence in the learners and make them realize and appreciate the interface of Physics with other disciplines;
- 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 to develop interest in the learners in the study of Physics as a discipline;
- Understand the relationship between nature and matter on scientific basis, develop positive scientific attitude, and appreciate the contribution of Physics towards the improvement of quality of life and human welfare;
- Physics teaching-learning at the higher secondary stage enables the learners to comprehend the contemporary knowledge and develop aesthetic sensibilities and process skills. The experimental skills and process-skills developed

together with conceptual Physics knowledge prepare the learners for more meaningful learning experiences and contribute to the significant improvement of quality of life. The learners would also appreciate the role and impact of Physics and technology, and their linkages with overall national development.

PGT-PHYSICS	
S.No.	**TITLE**
Module-1	**Micro Level Understanding of Physics in Macroscopic View** • Free Body Diagram and Resolution of Vector • Electrostatic Properties of Dielectrics/Conductors • 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 also say that Physics adds meaning to Mathematics. This module requires a greater mathematical strength to understand and impart in a classroom situation. It covers the free body diagram where many forces are involved, resolution of vectors-force, indication of electric field in dielectric and conductors. These topics demand utmost dedication and will to learn and apply in the situations that evolve in due course. Activity on potentiometer is taken for in depth study with hands-on-tools to overrule the practical problems faced in the laboratory. This segment will enhance your skills in the experimentation and thereby the theory also will get strengthened. Applications and computational skills for problem solving have been stressed in the question papers now-a-days. Rather than solving a single question with values if one can generalize the problem the student can in fact do a lot of numerical questions and will enhance his confidence in Physics. This will also encourage the student to take up Physics as a subject in higher classes. You also stand out to gain a greater insight into physics by learning 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 quantitative theoretical structures that constitute our contemporary understanding of the concept is aimed at 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 application are 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 Board Syllabus is followed. The activities of optics and optical benches are taken from the practical side as many students fail to make an image without Parallax. The methods that will be shown 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 because of the way it is introduced. So a lucid style and a comparative approach on the interaction of waves is done efficiently. Numerical questions are open ended and are to be solved with care such that a similar twisted questions are done with ease. The numerical session in groups will enhance the teaching ability as the teachers in the group may provide multiple approach to the same query or situation. In a way one may also understand the defect in our organs 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 Simple pendulum. This is dealt with in detail so that the many students can be given one aspect of the 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 teaching practices and the simplified ways and means to understand any topic. The topics of Heat and Thermodynamics, Communication systems and some experiments on Resonance are on the neglected list over a period of time. The student tries to do the minimum work on these areas and the absence of intent hinders the learning process. The fundamental aspects of the topics transfer of Heat and Thermodynamics is dealt with in a manner that will ease the difficulty in learning. The degrees of freedom in different molecular formation can be done with ease with idea incorporated here. The experiment on the Resonance tube apparatus is taken for a complete demonstration and this will ease the difficulty in performing them in the school. The content of the chapter – Communication Systems is available in plenty. But how to make the student to understand the same is a difficult task which was expressed by the teachers in the previous INSET programme. The content may look the same way as the rest but as you attend the session you may feel the way the content be used for the student to score 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 way technological tools can be used in the teacher training programme is done. The movie that is to be shown here partly is to bring certain changes in your classroom so that the good traits from the reel world is a reality and helps the student community. The attempt by SCERT in providing Freedom for the content developers in bringing necessary variations in the regular topics that has been provided will make this module a unique one.

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Module 5 – Study and Application of Matter and Electricity

Time and again there has been a difficulty felt in the classroom in dealing with some interesting but felt hard topics in the class XI and XII Physics syllabus. Some of these areas include Bernoulli’s theorem and Capacitance. They play a great role in the scoring pattern of the student and to a greater extent induce interest in our subject. An attempt is made here to simplify and apply to a greater extent in the classroom. Why a ball spinned around rises up in the sky when the student is playing cricket is an unanswered question in his mind. The module here with you is an answer to bring the spinning ball into the classroom. Various other examples like the quantifying the volume of water that is being received from a canal outside Delhi will bring reality to classrooms. The capacitors as a energy storage device and their combinations in various circuits have revolutionised the field of communication. Unless and until the student is informed of the daily use of capacitors while doing the topic of Electrostatics - Capacitance it is difficult to make them mentally prepared for conceptualisation. The numerical questions given as practice questions are to prepare the student through the teachers for the board examination. In the practical part there is apprehension in the handling of Sonometer. This induced us to build a session on Sonometer. The session will be hands-on on the stage with the recording of results highlighting the intricacies of the practical handling of Sonometer. One may understand that simple recording is not doing experiment but to understand the nuances of the topic is of prime focus. Following a regular pattern in the teaching –learning process 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 way technological tools can be used in the teacher training programme is done. The movie that is to be shown here partly is to bring certain changes in your classroom so that the good traits from the reel world is a reality and helps the student community. The attempt by SCERT in providing Freedom for the content developers in bringing necessary variations in the 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 explanations and reasons is the real fun of Science. Bringing down the observations to find theoretical justification 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 of qualitative 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 most people know, the purpose is to create fascination and curiosity of the level that the child feels to interrogate every specification that the child observes and seeks for a theory that supports the same. The projectile motion faces lack of connect of how the various parameters like horizontal range , maximum height serves to make student's life easy.The topic aims to extend and connect the theoretical findings with its applications in the real world to enable students to appreciate the value of the various derivations ,their findings and understanding from the same. To make someone realize the existence of something for which first hand experience is difficult to attain is a task,which if accomplished is a real achievement.Wave optics being one of the most mind opening experience to realize the possibilities of what you observe in nature, the qualitative description of the same has been taken up in the module.The purpose stays as basic as to widen the vision and possibilities that a student can incorporate to extract understanding and knowledge from nature.For the things there in books and theories are hard to experience and trust in real life , experiencing that perception being existing for real people gives a better idea of authentic existence of the same . Movies based on Scientific ideology to avail critical thinking to the learners , so as to go down the the line to the thought process of the person who had thought about this edge of the Scientific development and progress is another concern of the module.

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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 disciplinaw 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 N0. O42)

COURSE STRUCTURE

Class XI (Theory) (2016-17)

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

		No. of Periods	Marks
Unit-I	**Physical World and Measurement**	10	
	Chapter-1: Physical World		
	Chapter-2: Units and Measurements		

Unit-II	**Kinematics**	24	23
	Chapter-3: Motion in a Straight Line		
	Chapter-4: Motion in a Plane		
Unit-III	**Law of Motion**	14	
	Chapter-5: Law 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 Solids		
	Chapter-11: Mechanical Properties of Solids		
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	20
	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 9 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.Zcm, 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-T2 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 hrs. **Max Marks: 70**

S.No	Typology of Questions	Very Short Answer (VSA) (1 mark)	Short Answer-I (SA) (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 Er 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.

1. 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**		
	Chapter-1: Electric Charges and Fields	22	
	Chapter-2: Electrostatic Potential and Capacitance		15
Unit-II	**Current Electricity**	20	
	Chapter-3: Current Electricity		
Unit-III	**Magnetic Effects of Current and Magnetism**	22	
	Chapter-4: Moving Charges and Magnetism		
	Chapter-5: Magnetism and Matter		
Unit-IV	**Electromagnetic Induction and Alternating Currents**	20	16
	Chapter-6: Electromagnetic Induction		
	Chapter-7: Alternating Current		
Unit-V	**Electromagnetic Waves**	04	
	Chapter-8: Electromagnetic Waves		
Unit-VI	**Optics**	25	17
	Chapter-9: Ray Optics and Optical Instruments		

	Chapter-10: Wave Optics		
Unit-VII	**Dual Nature of Radiation and Matter**	08	
	Chapter-11: Mechanical Properties of Solids		
Unit-VIII	**Atoms and Nuclei**	14	10
	Chapter-12: Atoms		
	Chapter-13: Nuclei		
Unit-IX	**Electronic Devices**		
	Chapter—14: Semiconductor Electronics: Materials,Devices and Simple Circuits	15	12
Unit-X	Communication Systems		
	Chapter-15: Communication Systems	10	
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 **22 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. Magnetic Effects of Current and

Unit III: 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 appearance 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. xxm

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 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,(m) 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 obsewe 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**

Identificationl 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-a-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 (m)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 ll, 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 (2016-11)

Time 3 hours **Max. Marks: 30**

S.No	Typology of Questions	Very Short Answer (VSA) (1 mark)	Short Answer-I (SA) (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 Er 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	1	-	2	1	-	11	16%

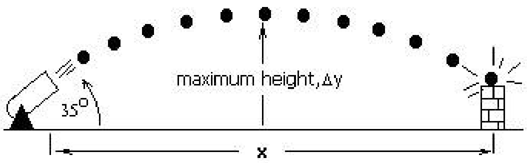
	outcome, or to predict outcomes based on values)							
	Total	**5x1=5**	**5x2=10**	**12x3=36**	**1x4=4**	**3x5=15**	**70(26)**	**100%**

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.



PROJECTILE MOTION

Introduction:

Motion of a bal as thrown up by a student is a common example of projectile motion.

A “projectile” is defined as an object subject only to the force of gravity and no othersp;forces. So this eliminates anything self-propel ed like rockets and airplanes. Goodexamples are a thrown or bat ed baseball, a thrown or kicked football, an arrow, a bulletp;etc.

The shape we find when we throw or fire at an angle is a ‘projectile’

<u>What two motions can you break this up into?</u>

it goes up-down, or vertical, motion

it goes forward, or horizontal motion

The motions are independent of each other: horizontal velocity has no effect on vertical velocity, and vice-versa.

So we need to determine how fast an object is moving upward versus how fast it is *moving* outward, or horizontally.

<u>**LEARNING OUTCOME:-**</u>

Learner is expected to

1. Resolve vectors

2. Understand the value of velocity at various points

3. Apply equation of motions for two one dimensional considerations.

4. Draw path of the projectile in various angles of projections.

<u>ASSUMPTIONS TO STUDY PROJECTILE MOTION:</u>

-No effect on motion of the projectile due to :

1.Air resistance

2.Earth’s curvature.

3.Earth’s rotation.

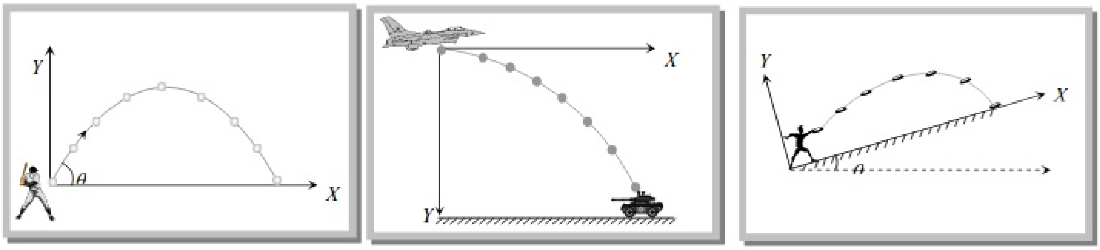
- The magnitude and direction of acceleration due to gravity remains constant at all points of the motion of projectile.

(NOTE:-These assumptions are taken to have better understanding of the topic ofprojectile. The teacher may try to bring these factors one by one and discuss theconsequence in the class.)

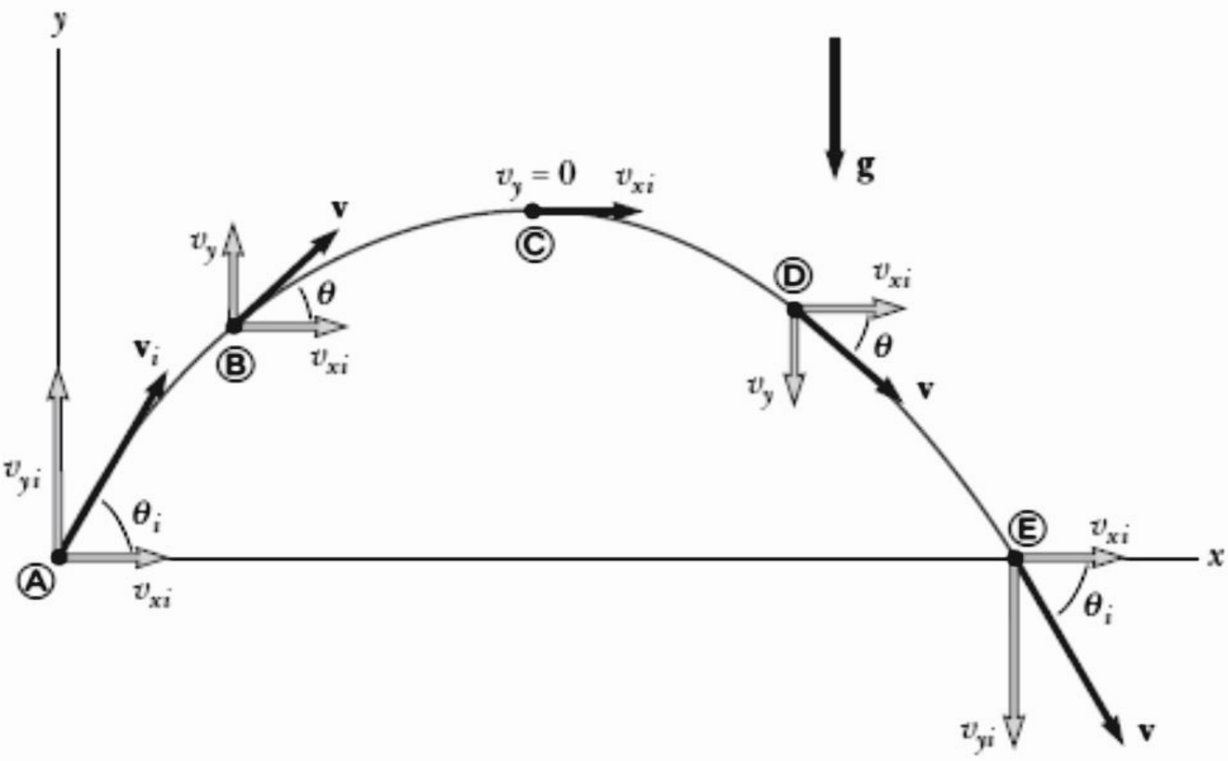
3.5 Types of Projectile Motion.

(1) Oblique projectile motion (2) Horizontal projectile motion

(3) Projectile motion on an inclined plane



<u>(1) PROJECTILE GIVEN ANGULAR OR OBLIQUE OR PROJECTION</u>



The parabolic path of a projectile that leaves the origin with a velocity Vi- The velocity vector v changes with time in both magnitude and direction. This change is the result of acceleration in the negative y direction. The x component of vlocity remains constant in time because there is no acceleration along the horizontal direction. The y component of velocity is zero at the peak of the path.

In projectile motion, horizontal component of velocity (u cos θ), acceleration (g) andmechanical energy remains constant while, speed, velocity, vertical component of velocity(u sin θ), momentum, kinetic energy and potential energy al changes. Velocity, and KE are maximum at the point of projection while minimum (but not zero) at highest point.

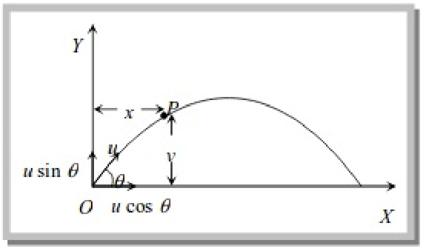
(1)**Equation of trajectory :** A projectile thrown with velocity u at an angle θ with the horizontal. The velocity u can be resolved into two rectangular components.

μ cos θ component along X –axis and u sin θ component along Y–axis. For an interval t seconds, In horizontal motion $x = u\cos\theta \times t \Rightarrow t = \dfrac{x}{u\cos\theta}$ .... (i)

For vertical motion $y = (u\sin\theta)t - \dfrac{1}{2}gt^2$ .... (ii)

From equation (i) and (ii) $y = u\sin\theta\left(\dfrac{x}{u\cos\theta}\right) - \dfrac{1}{2}g\left(\dfrac{x^2}{u^2\cos^2\theta}\right)$

$$y = x\tan\theta - \frac{1}{2}\frac{gx^2}{u^2\cos^2\theta}$$



This equation shows that the trajectory of projectile is parabolic because it is similar to equation of parabola

$$y = ax - bx^2$$

Note : ❑ Equation of oblique projectile also can be written as

$$y = x\tan\theta\left[1 - \frac{x}{R}\right] \qquad \text{(where } R = \text{horizontal range} = \frac{u^2\sin 2\theta}{g}\text{)}$$

(1) Equation of trajectory : A projectile thrown with velocity u at an angle θ withthe h

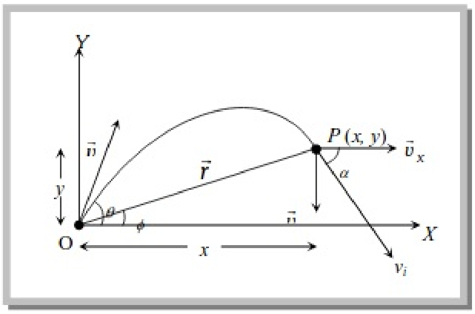
Sample problem:

Problem 1. The trajectory of a projectile is represented by projection is

(a) 30^o (b)45^o (c) 60^o (d) None of these

Solution : (c) By comparing the coefficient of x in given equation with standard equation

(2) **Displacement of projectile** $(\vec{r})$ **:** Let the particle acquires a position P having the coordinates (x, y) just after time t from the instant of projection. The corresponding position vector of the particle at time t is $\vec{r}$ as shown in the figure.



$$\vec{r} = x\hat{i} + y\hat{j} \qquad \text{....(i)}$$

The horizontal distance covered during time t is given as

$x = v_x t \Rightarrow x\ u\cos\theta\ t$ ....(ii)

The vertical velocity of the particle at time t is given as

$v_y = (v_0)_y - gt$, ...(iii)

Now the vertical displacement y is given as

$y = u\sin\theta t - 1/2gt^2$ ....(iv)

Putting the values of x and y from equation (i) and equation (iv) in equation (i) weobtain the position vector at any time *t* as

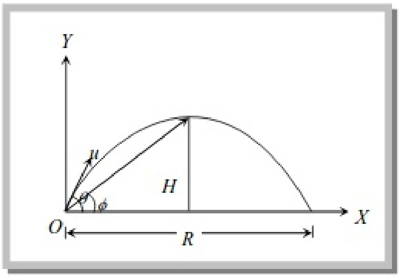
$$\vec{r} = (u\cos\theta)t\,\hat{i} + \left((u\sin\theta)t - \frac{1}{2}gt^2\right)\hat{j} \quad \Rightarrow \quad r = \sqrt{(ut\cos\theta)^2 + \left((ut\sin\theta) - \frac{1}{2}gt^2\right)^2}$$

$$r = ut\sqrt{1 + \left(\frac{gt}{2u}\right)^2 - \frac{gt\sin\theta}{u}} \quad \text{and} \quad \phi = \tan^{-1}(y/x) \quad = \tan^{-1}\left(\frac{ut\sin\theta - 1/2gt^2}{(ut\cos\theta)}\right) \quad \text{or}$$

$$\phi = \tan^{-1}\left(\frac{2u\sin\theta - gt}{2u\cos\theta}\right)$$

Note : The angle of elevation ø of the highestpoint of the projectile and the angle of projection θ are related to each other as

$$\tan\phi = \frac{1}{2}\tan\theta$$



Sample problem:

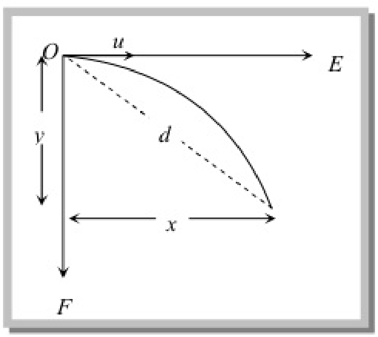
Problem 2. A body of mass 2 kg has an initial velocity of 3 m/s along OE and it issubjected to a force of 4 Newton's in OF direction perpendicular to OE.

The distance of the body from O after 4 seconds wil be

(a) 12 m (b) 28 m (c) 20 m (d) 48 m

Solution : (c) Body moves horizontal y with constant initial velocity 3 m/s upto 4 seconds

$\therefore$ x = ut = 3 ×x 4 = 12m



and in perpendicular direction it moves under ythe effect of constant force with zero initialvelocity upto 4 seconds.

$$\therefore \quad y = ut + \frac{1}{2}(a)t^2 \quad = 0 + \frac{1}{2}\left(\frac{F}{m}\right)t^2 \quad = \frac{1}{2}\left(\frac{4}{2}\right)4^2 = 16\,m$$

So its distance from O is given by d= $\sqrt{x^2 + y^2} = \sqrt{(12)^2 + (16)^2}$

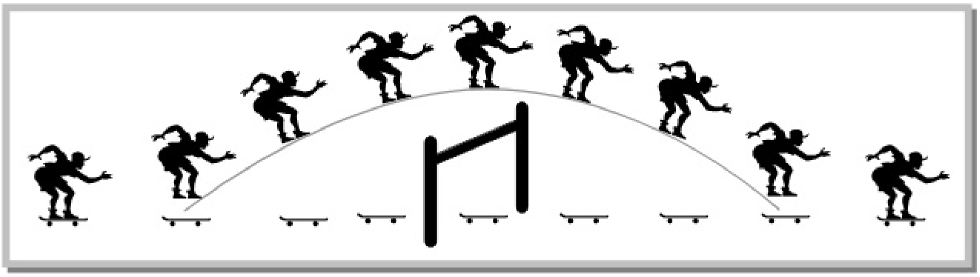
$\therefore$ d=20m

---

(3) Instantaneous velocity v : In projectile motion, vertical component of velocity changes but horizontal component of velocity remains always constant.

Example : When a man jumps over the hurdle leaving behind its skateboard then vertical component of his velocity is changing, but not the horizontal component, which matches with the skateboard velocity.

As a result, the skateboard stays underneath him, al owing him to land on it.



Let v_i be the instantaneous velocity of projectile at time t direction of this velocity is along the tangent to the trajectory at point P.

$$\vec{v}_i = v_x i + v_y \hat{j} \Rightarrow v_i = \sqrt{v_x^2 + v_y^2} = \sqrt{u^2 \cos^2\theta + (u\sin\theta - gt)^2}$$

$$v_i = \sqrt{u^2 + g^2t^2 - 2ugt\sin\theta}$$

Direction of instantaneous velocity $\tan\alpha = \frac{v_y}{v_x} = \frac{u\sin\theta - gt}{u\cos\theta}$ or

$$\alpha = \tan^{-1}\left[\tan\theta - \frac{gt}{u}\sec\theta\right]$$

(4) Change in velocity : Initial velocity (at projection point) $\vec{u}_i = u\cos\theta\,\hat{i} + u\sin\theta\,\hat{j}$

Final velocity (at highest point) $\vec{u}_f = u\cos\theta\,\hat{i} + 0\,\hat{j}$

(i) Change in velocity (Between projection point and highest point) $\Delta u = \vec{u}_f - \vec{u}_i = -u\sin\theta\,\hat{j}$

When body reaches the ground after completing its motion then final velocity $\vec{u}_f = u\cos\theta\,\hat{i} - u\sin\theta\,\hat{j}$

(ii) Change in velocity (Between complete projectile motion) $\Delta u = u_f - u_i = -2u\sin\theta\,\hat{i}$

Sample problem:

Problem 3. A projectile is fired at 30^{o} to the horizontal. The vertical component of its velocity is 80 ms^{-1}. Its time of flight is T. What will be the velocity of the projectile at t = T/2

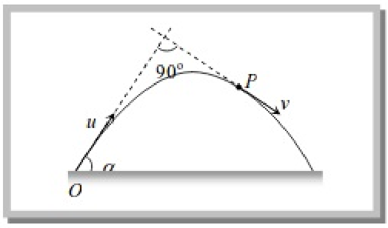
(a) 80 ms^{-1} (b) $80\sqrt{3}$ ms^{-1} (c) $(80/\sqrt{3})$ ms^{-1} (d) 40 ms^{-1}

Solution : (b) At half of the time of flight, the position of the projectile will be at the highest point of the parabola and at that position particle possess horizontal component of velocity only.

Given $u_{vertical} = u \sin\theta = 80 \Rightarrow u = \frac{80}{\sin 30^\circ} = 160\, m/s$

$\therefore \quad u_{horizontal} = u\cos\theta = 160 \cos 30^\circ = 80\sqrt{3}\, m/s.$

<u>Problem 4</u>. A particle is projected from point O with velocity u in a direction making an angle α with the horizontal. At any instant its position is at point P at right angles to the initial direction of projection. Its velocity at point P is



(a) u tanα

(b) u cotα

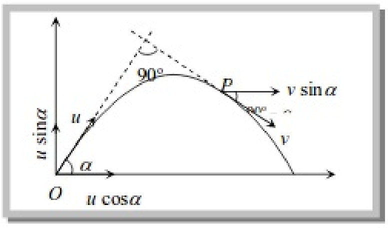
(c) u cosecα

(d) u secα

Solution : (b) Horizontal velocity at point 'O' = ucosα

Horizontal velocity at point ' P'= vsinα

In projectile motion horizontal component of velocity remains constant throughout the motion



$\therefore \quad v\sin\alpha = u\cos\alpha \Rightarrow v = u\cot\alpha$

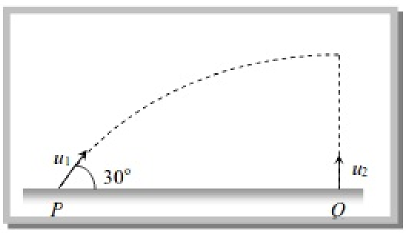
<u>Problem 5</u>. A particle P is projected with velocity u1 at an angle of 30^o with the horizontal. Another particle Q is thrown vertically upwards with velocity u_2 from a point vertically below the highest point of path of P. The necessary condition for the two particles to collide at the highest point is

(a) $u_1 = u_2$

(b) $u_1 = 2u_2$

(c) $u_1 = \frac{u_2}{2}$

(d) $u_1 = 4u_2$



Solution : (b) Both particle collide at the highest point it means the vertical distance travelled by both the particle will be equal, i.e. the vertical component of velocity of both particle will be equal

$u_1 \sin 30^\circ = u_2 \Rightarrow \frac{u_1}{2} = u_2 \qquad \therefore \quad u_1 = 2u_2$

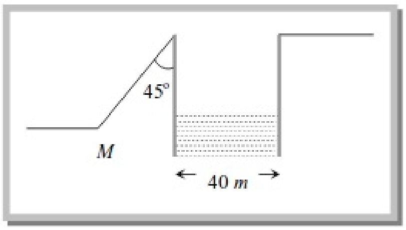
Problem 6. A body is projected up a smooth inclined plane (length = 20 √2m) with velocity u from the point M as shown in the figure. The angle of inclination is 45^O and the top is connected to a well of diameter 40 m. If the body just manages to cross the well, what is the value of v

(a) $40 ms^{-1}$

(b) $40\sqrt{2} ms^{-1}$

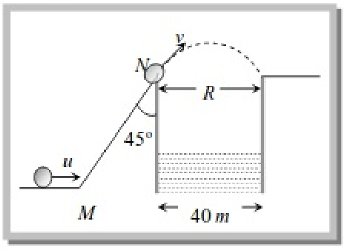
(c) $20 ms^{-1}$

(d) $20\sqrt{2} ms^{-1}$



Solution : (d) At point N angle of projection of the body will be 45°. Let velocity of projection at this point is v.

If the body just manages to cross the well then Range = Diameter of well



$\frac{v^2 \sin 2\theta}{g} = 40$ [As $\theta = 45°$]

$v^2 = 400 \Rightarrow v = 20 m/s$

But we have to calculate the velocity (u) of the body at point M.

For motion along the inclined plane (from M to N)

Final velocity (v) = 20 m/s,

acceleration (a) = $-g \sin\alpha = -g \sin 45°$, distance of inclined plane (s) = $20\sqrt{2}\ m$

$(20)^2 = u^2 - 2\frac{g}{\sqrt{2}}.20\sqrt{2}$ [Using $v^2 = u^2 + 2as$]

$u^2 = 20^2 + 400 \Rightarrow u = 20\sqrt{2} m/s.$

(5) **Time of flight :** The total time taken by the projectile to go up and come down to the same level from which it was projected is called time of flight.

For vertical upward motion 0 = u sin θ – gt ⇒ t = (u sin θ/g)

Now as time taken to go up is equal to the time taken to come down so

Time of flight $T = 2t = \frac{2u\sin\theta}{g}$

(i) Time of flight can also be expressed as : $T = \frac{2.u_y}{g}$ (where u_y is the vertical component of initial velocity).

(ii) For complementary angles of projection θ and $90^\circ - \theta$

(a) Ratio of time of flight $= \frac{T_1}{T_2} = \frac{2u\sin\theta/g}{2u\sin(90-\theta)/g} = \tan\theta \Rightarrow \frac{T_1}{T_2} = \tan\theta$

(b) Multiplication of time of flight $= T_1T_2 = \frac{2u\sin\theta}{g}\frac{2u\cos\theta}{g} \Rightarrow T_1T_2 = \frac{2R}{g}$

(iii) If t_1 is the time taken by projectile to rise upto point p and t_2 is the time taken in falling from point p to ground level then $t_1 + t_2 = \frac{2u\sin\theta}{g} =$ time of flight

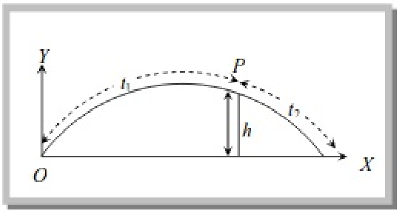
or $u\sin\theta = \frac{g(t_1+t_2)}{2}$

and height of the point p is given by

$h = u\sin\theta\, t_1 - \frac{1}{2}gt_1^2$

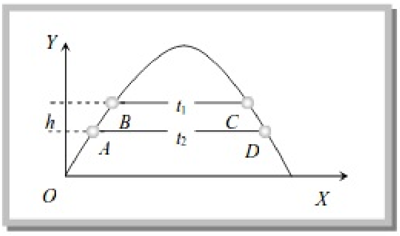
$h = g\frac{(t_1+t_2)}{2}t_1 - \frac{1}{2}gt_1^2$

by solving $h = \frac{gt_1t_2}{2}$



(iv) If B and C are at the same level on trajectory and the time difference between these two points is t_1, similarly A and D are also at the same level and the time difference between these two positions is t_2 then

$t_2^2 - t_1^2 = \frac{8h}{g}$



Sample problem:

<u>**Problem 10.**</u> For a given velocity, a projectile has the same range R for two angles ofprojection if t1 and t2 are the times of flight in the two cases then

(a) $t_1t_2 \propto R^2$ (b) $t_1t_2 \propto R$ (c) $t_1t_2 \propto \frac{1}{R}$ (d) $t_1t_2 \propto \frac{1}{R^2}$

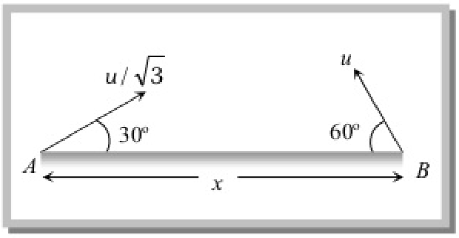
Solution : (b) As we know for complementary angles $t_1t_2 = \frac{2R}{g} \quad \therefore \quad t_1t_2 \propto R$.

<u>**Problem 11.**</u> A body is thrown with a velocity of 9.8 m/s making an angle of 30o with thehorizontal. It will hit the ground after a time

(a) 1.5 s (b) 1 s (c) 3 s (d) 2 s

Solution : (b) $T = \frac{2u\sin\theta}{g} = \frac{2 \times 9.8 \times \sin 30^o}{9.8} = 1 sec$

Problem 12. Two particles are separated at a horizontal distance x as shown in figure.They are projected at the same time as shown in figure with different initialspeed. The time after which the horizontal distance between the particlesbecome zero is



(a) u/2x (b) x/u (c) 2u/x (d) u/x

Solution : (b) Let x1and x2 are the horizontal distances travelled by particle A and Brespectively in time t.

$x_1 = \frac{u}{\sqrt{3}}.\cos 30^\circ \times t$ .....(i) and

$x_2 = u\cos 60^o \times t$ ......(ii)

$x_1 + x_2 = \frac{u}{\sqrt{3}}.\cos 30^o \times t + u\cos 60^o \times t = ut \Rightarrow x = ut \quad \therefore t = x/u$

Problem 13. A particle is projected from a point O with a velocity u in a directionmaking an angleαupward with the horizontal. After some time at point P itis moving at right angle with its initial direction of projection. The time offlight from O to P is

(a) $\frac{u\sin\alpha}{g}$ (b) $\frac{u\,\text{cosec}\alpha}{g}$ (c) $\frac{u\tan\alpha}{g}$ (d) $\frac{u\sec\alpha}{g}$

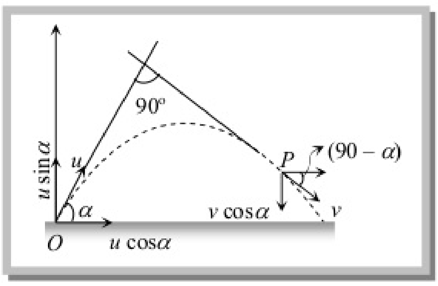
Solution : (b)When body projected with initial velocity $\vec{u}$ by making angle α with thehorizontal. Then after time t, (at point P) it's direction is perpendicular to $\vec{u}$.

Magnitude of velocity at point P is given by v = ucotα. (from sample problem no. 9)

For vertical motion : Initial velocity (at point O) = usinα

Final velocity (at point P) = -vcosα = -ucotα cosα

Time of flight (from point O to P) = t



Applying first equation of motion v=u-gt

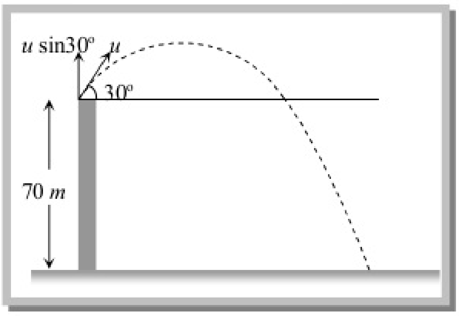
-ucotα cosα =usinα -gt

$$\therefore \quad t = \frac{u\sin\alpha + u\cot\alpha\cos\alpha}{g} = \frac{u}{g\sin\alpha}\left[\sin^2\alpha + \cos^2\alpha\right] = \frac{u\ \mathrm{cosec}\,\alpha}{g}$$

Problem 14. A ball is projected upwards from the top of tower with a velocity 50 ms^{-1}making angle 30o with the horizontal. The height of the tower is 70 m. Afterhow many seconds from the instant of throwing will the ball reach theground

(a) 2.33 sec (b) 5.33 sec (c) 6.33 sec (d) 9.33 sec

Solution : (c) Formula for calculation of time to reach the body on the ground from thetower of height 'h' (If it is thrownvertically up with velocity u) is given by $t = \frac{u}{g}\left[1 + \sqrt{1 + \frac{2gh}{u^2}}\right]$



So we can resolve the given velocity in

vertical direction and can apply the

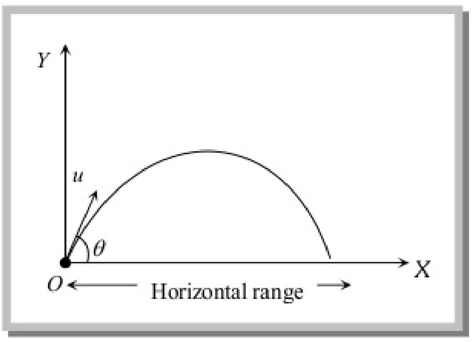
above formula.

Initial vertical component of velocity usinθ = 50sin30 = 25m/ .s

$$\therefore \quad t = \frac{25}{9.8}\left[1 + \sqrt{1 + \frac{2\times 9.8\times 70}{(25)^2}}\right] = 6.33\ sec.$$

(6) Horizontal range : It is the horizontal distance travelled by a body during thetime of flight.

So by using second equation of motion



$$R = u\cos\theta \times T = u\cos\theta \times (2u\sin\theta / g) = \frac{u^2\sin 2\theta}{g}$$

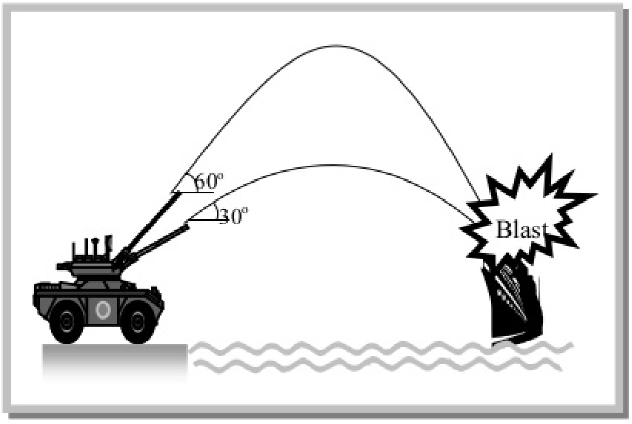
$$R = \frac{u^2\sin 2\theta}{g}$$

(i) Range of projectile can also be expressed as :

$$R = u\cos\theta \times T = u\cos\theta \frac{2u\sin\theta}{g} = \frac{2u\cos\theta \; u\sin\theta}{g} = \frac{2u_x u_y}{g}$$

$$\therefore \quad R = \frac{2u_x u_y}{g}$$

(where u_x and u_y are the horizontaland vertical component of initialvelocity)



(ii) If angle of projection is changedfrom θ to θ' = (90 – θ) then rangeremains unchanged.

$$R' = \frac{u^2 \sin 2\theta'}{g} = \frac{u^2 \sin[2(90^\circ - \theta)]}{g} = \frac{u^2 \sin 2\theta}{g} = R$$

So a projectile has same range at angles of projection θ and (90 – θ), though time offlight, maximum height and trajectories are different.

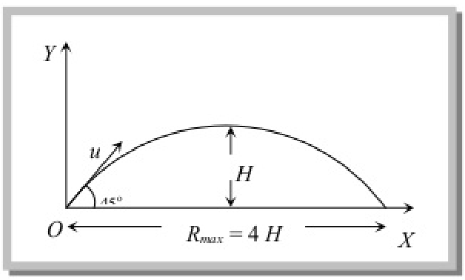
These angles θ and 90^o – θ are called complementary angles of projection and forcomplementary angles of projection

ratio of range $\frac{R_1}{R_2} = \frac{u^2 \sin 2\theta / g}{u^2 \sin[2(90^\circ - \theta)]/g} = 1 \Rightarrow \frac{R_1}{R_2} = 1$

(iii) For angle of projection θ_1 = (45 – α) and θ_2 = (45 + α), range will be same andequal to u^2 cos 2α/g.

θ_1 and θ_2 are also the complementary angles.

(iv) Maximum range : For range to be maximum



$$\frac{dR}{d\theta} = 0 \Rightarrow \frac{d}{d\theta}\left[\frac{u^2 \sin 2\theta}{g}\right] = 0$$

⇒cos 2θ = 0 i.e. 2θ = 90^o ⇒ θ = 45^o and Rmax = (u^2/g)

i.e., a projectile will have maximum range when it is projected at an angle of 45o tothe horizontal and the maximum range will be (u^2/g).

When the range is maximum, the height H reached by the projectile

$$H = \frac{u^2 \sin^2 \theta}{2g} = \frac{u^2 \sin^2 45}{2g} = \frac{u^2}{4g} = \frac{R_{\max}}{4}$$

i.e., if a person can throw a projectile to a maximum distance Rmax, The maximum height towhich it will rise is $\left(\frac{R_{\max}}{4}\right)$.

(v) Relation between horizontal range and maximum height : $R = \frac{u^2 \sin 2\theta}{g}$ and $H = \frac{u^2 \sin^2 \theta}{2g}$

$$\therefore \quad \frac{R}{H} = \frac{u^2 \sin 2\theta / g}{u^2 \sin^2 \theta / 2g} = 4 \cot \theta \qquad \Rightarrow \quad R = 4H \cot \theta$$

(vi) If in case of projectile motion range R is n times the maximum height H

$$i.e. \quad R = nH \quad \Rightarrow \quad \frac{u^2 \sin 2\theta}{g} = n \frac{u^2 \sin^2 \theta}{2g} \quad \Rightarrow \quad \tan \theta = [4/n] \quad \text{or} \quad \theta = \tan^{-1}[4/n]$$

The angle of projection is given by θ = $\tan^{-1}$[4/n]

Note :❑If R = H then θ = $\tan^{-1}$ (4) orθ = 76 .

If R = 4H thenθ = $\tan^{-1}$(1) orθ = 45 .

Sample problem:

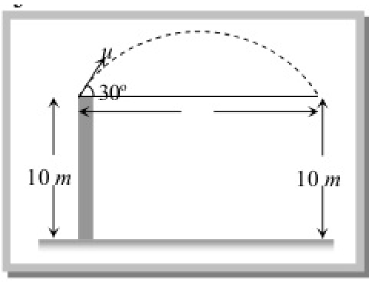
Problem 15. A boy playing on the roof of a 10m high building throws a ball with aspeed of 10 m/s at an angle of 30o with the horizontal. How far from thethrowing point will the ball be at the height of 10 m from the ground (g =10 m/s^2, $\sin 30^o = \frac{1}{2}$, $\cos 30^o = \frac{\sqrt{3}}{2}$)

(a) 8.66 m (b) 5.20 m (c) 4.33 m (d) 2.60 m

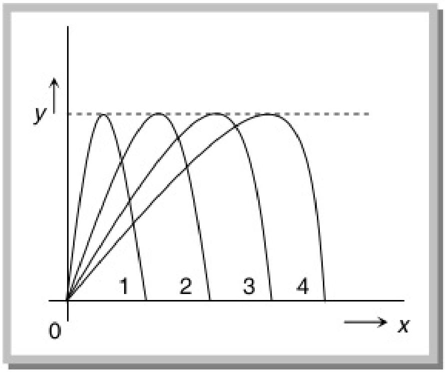
Solution : (a) Simply we have to calculate the range of projectile

$$R = \frac{u^2 \sin 2\theta}{g} = \frac{(10)^2 \sin(2 \times 30^\circ)}{10}$$

$$R = 5\sqrt{3} = 8.66\, meter$$



Problem 16. Figure shows four paths for a kicked football. Ignoring the effects of airon the flight, rank the paths according to initial horizontal velocitycomponent, highest first



(a) 1, 2, 3, 4 (b) 2, 3, 4, 1 (c) 3, 4, 1, 2 (d) 4, 3, 2, 1

Solution : (d) Range$\propto$ horizontal component of velocity. Graph 4 shows maximum range,so football possess maximum horizontal velocity in this case.

Problem 17. Four bodies P, Q, R and S are projected with equal velocities having anglesof projection 15^o, 30^o, 45^o and 60^o with the horizontal respectively. Thebody having shortest range is

(a) P (b) Q (c) R (d) S

Solution : (a) Range of projectile will be minimum for that angle which is farthest from 45°.

Problem 18. A large number of bullets are fired in al directions with same speed u.What is the maximum area on the ground on which these bullets will spread

(a) $\pi \frac{u^2}{g}$ (b) $\pi \frac{u^4}{g^2}$ (c) $\pi^2 \frac{u^4}{g^2}$ (d) $\pi^2 \frac{u^2}{g^2}$

Solution : (b) The maximum area will be equal to area of the circle with radius equal to

the maximum range of projectile

$$\text{Maximum area } \pi r^2 = \pi (R_{max})^2 = \pi \left(\frac{u^2}{g}\right)^2 = \pi \frac{u^4}{g^2} \text{ [As } r = R_{max} = u^2/g \text{ for } \theta = 45^o]$$

Problem 19. A projectile thrown with an initial speed u and angle of projection 15^o to thehorizontal has a range R. If the same projectile is thrown at an angle of $45^o$to the horizontal with speed 2u, its range will be

(a) 12 R (b) 3 R (c) 8 R (d) 4 R

$$\textit{Solution}: \text{(c)} \quad R = \frac{u^2 \sin 2\theta}{g} \quad \therefore R \propto u^2 \sin 2\theta$$

$$\frac{R_2}{R_1} = \left(\frac{u_2}{u_1}\right)^2 \left(\frac{\sin 2\theta_2}{\sin 2\theta_1}\right) \Rightarrow R_2 = R_1 \left(\frac{2u}{u}\right)^2 \left(\frac{\sin 90^o}{\sin 30^o}\right) = 8R_1$$

Problem 20. The velocity at the maximum height of a projectile is half of its initialvelocity of projection u. Its range on the horizontal plane is

(a) $\sqrt{3}u^2/2g$ (b) $u^2/3g$ (c) $3u^2/2g$ (d) $3u^2/g$

Solution : (a) If the velocity of projection is u then at the highest point body possesonly ucosθ

$u\cos\theta = \frac{u}{2}$ (given) $\therefore \theta = 60°$

Now $R = \frac{u^2 \sin(2 \times 60°)}{g} = \frac{\sqrt{3}}{2}\frac{u^2}{g}$

Problem 21. A projectile is thrown from a point in a horizontal place such that itshorizontal and vertical velocity component are 9.8 m/s and 19.6 m/srespectively. Its horizontal range is

(a) 4.9 m (b) 9.8 m (c) 19.6m (d) 39.2 m

Solution : (d) We know $R = \frac{2u_x u_y}{g} = \frac{2 \times 9.8 \times 19.6}{9.8} = 39.2m$

Where u_x = horizontal component of initial velocity, u_y = verticalcomponent of initial velocity.

Problem 22. A particle is projected with a velocity v such that its range on the horizontalplane is twice the greatest height at ained by it. The range of the projectileis (where g is acceleration due to gravity)

(a) $\frac{4v^2}{5g}$ (b) $\frac{4g}{5v^2}$ (c) $\frac{v^2}{g}$ (d) $\frac{4v^2}{\sqrt{5g}}$

Solution : (a) We know $R = 4H\cot\theta$

$2H = 4H\cot\theta \Rightarrow \cot\theta = \frac{1}{2}$; $\sin\theta = \frac{2}{\sqrt{5}}$; $\cos\theta = \frac{1}{\sqrt{5}}$

[As $R = 2H$ given]

$$\text{Range} = \frac{u^2 .2.\sin\theta.\cos\theta}{g} = \frac{2u^2 \frac{2}{\sqrt{5}}.\frac{1}{\sqrt{5}}}{g} = \frac{4u^2}{5g}$$

Problem 23. The range R of projectile is same when its maximum heights are h_1 and h_2.What is the relation between R and h_1 and h_2

(a) $R = \sqrt{h_1 h_2}$ (b) $R = \sqrt{2h_1 h_2}$ (c) $R = 2\sqrt{h_1 h_2}$ (d) $R = 4\sqrt{h_1 h_2}$

Solution : (d) For equal ranges body should be projected with angle θ or 9(0o -θ)from the horizontal.

And for these angles : $h_1 = \frac{u^2 \sin^2\theta}{2g}$ and $h_2 = \frac{u^2\cos^2\theta}{2g}$

by multiplication of both height : $h_1 h_2 = \frac{u^2 \sin^2\theta\cos^2\theta}{4g^2} = \frac{1}{16}\left(\frac{u^2\sin 2\theta}{g}\right)^2$

$\Rightarrow 16h_1 h_2 = R^2 \Rightarrow R = 4\sqrt{h_1 h_2}$

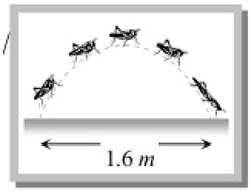
Problem 24. A grasshopper can jump maximum distance 1.6 m. It spends negligible timeon the ground. How far can it go in 10 seconds

(a) $5\sqrt{2}\,m$ (b) $10\sqrt{2}\,m$ (c) $20\sqrt{2}\,m$ (d) $40\sqrt{2}\,m$

Solution : (c) Horizontal distance travelled by grasshopper will be maximum for θ = 45^{o}

$$R_{max} = \frac{u^2}{g} = 1.6m \quad \Rightarrow \quad u = 4\,m/s.$$

Horizontal component of velocity of grasshopper ucosθ = 4cos45 = 2√2 m/ s



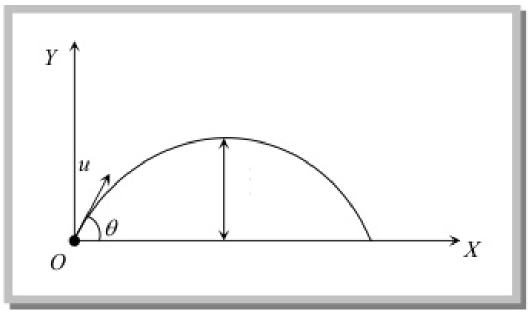
Total distance covered by it in10 sec. S = ucosθ×t = 22√2×10 = 20√2m1.6 m

(8) Maximum height : It is the maximum height from the point of projection, aprojectile can reach.

So, by using $v^2 = u^2 + 2as$

$$0 = (u\sin\theta)^2 - 2gH$$

$$H = \frac{u^2 \sin^2\theta}{2g}$$



(i) Maximum height can also be expressed as

$$H = \frac{u_y^2}{2g} \quad \text{(where } u_y \text{ is the vertical component of initial velocity).}$$

$$\text{(ii)} \quad H_{max} = \frac{u^2}{2g} \quad (\text{when } \sin^2\theta = \max = 1 \quad i.e.,\ \theta = 90^o)$$

i.e., for maximum height body should be projected vertically upward. So it falls backto the point of projection after reaching the maximum height.

(iii) For complementary angles of projection θ and 90^{o} – θ

$$\text{Ratio of maximum height} = \frac{H_1}{H_2} = \frac{u^2\sin^2\theta/2g}{u^2\sin^2(90^\circ - \theta)2g} = \frac{\sin^2\theta}{\cos^2\theta} = \tan^2\theta$$

$$\therefore \quad \frac{H_1}{H_2} = \tan^2\theta$$

Sample problem:

Problem 25. A cricketer can throw a ball to a maximum horizontal distance of 100 m.With the same effort, he throws the ball vertically upwards. The maximum height attained by the ball is

(a) 100 m (b) 80 m (c) 60 m (d) 50 m

Solution : (d) $R_{\max} = \frac{u^2}{g} = 100\,m$ (when $\theta = 45°$)

$\therefore u^2 = 100 \times 10 = 1000$

$H_{\max} = \frac{u^2}{2g} = \frac{1000}{2 \times 10} = 50\,metre.$ (when $\theta = 90°$)

Problem 26. A ball thrown by one player reaches the other in 2 sec. the maximumheight at ained by the ball above the point of projection will be about

(a) 10 m (b) 7.5 m (c) 5 m (d) 2.5 m

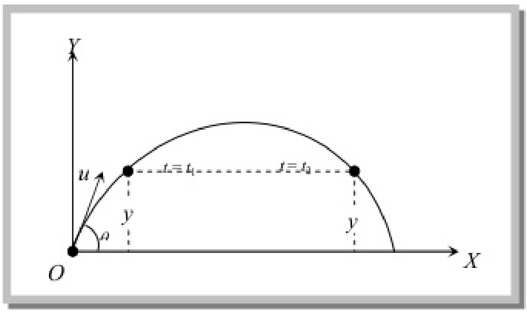
Solution : (c) $T = \frac{2u\sin\theta}{g} = 2\,sec$ (given) $\therefore u\sin\theta = 10$

Now $H = \frac{u^2\sin^2\theta}{2g} = \frac{(10)^2}{2 \times 10} = 5\,m.$

(7) Projectile passing through two different points on same height at time t_1 andt$_2$: If the particle passes two points situated at equal height y at t = t_1 and t = t_2, then

(i) **Height (y):** $y = (u\sin\theta)t_1 - \frac{1}{2}gt_1^2$ .....(i)

and $y = (u\sin\theta)t_2 - \frac{1}{2}gt_2^2$ .....(ii)



Comparing equation (i) with equation (ii)

$u\sin\theta = \frac{g(t_1 + t_2)}{2}$

Substituting this value in equation (i)

$$y = g\left(\frac{t_1 + t_2}{2}\right)t_1 - \frac{1}{2}gt_1^2 \Rightarrow y = \frac{gt_1t_2}{2}$$

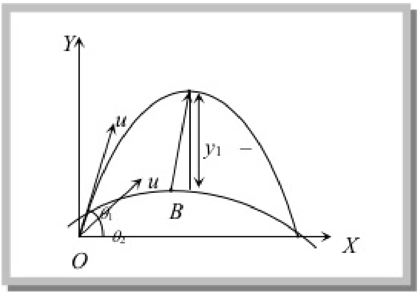
(ii) **Time (t_1 and t_2):** $y = u\sin\theta\, t - \frac{1}{2}gt^2$

$$t^2 - \frac{2u\sin\theta}{g}t + \frac{2y}{g} = 0 \Rightarrow t = \frac{u\sin\theta}{g}\left[1 \pm \sqrt{1 - \left(\frac{\sqrt{2gy}}{u\sin\theta}\right)^2}\right]$$

$$t_1 = \frac{u\sin\theta}{g}\left[1 + \sqrt{1 - \left(\frac{\sqrt{2gy}}{u\sin\theta}\right)^2}\right] \text{ and } t_2 = \frac{u\sin\theta}{g}\left[1 - \sqrt{1 - \left(\frac{\sqrt{2gy}}{u\sin\theta}\right)^2}\right]$$

(9) Motion of a projectile as observed from another projectile : Suppose two ballsA and B are projected simultaneously from the origin, with initial velocities u_1 and u_2 atangle θ_1 and θ_2, respectively with the horizontal.

The instantaneous positions of the two balls are given by



$$\text{Ball } A: \quad x_1 = (u_1 \cos\theta_1)t \qquad y_1 = (u_1 \sin\theta_1)t - \frac{1}{2}gt^2$$

$$\text{Ball } B: \quad x_2 = (u_2 \cos\theta_2)t \qquad y_2 = (u_2 \sin\theta_2)t - \frac{1}{2}gt^2$$

The position of the ball A with respect to ball B is given by

$$x = x_1 - x_2 = (u_1 \cos\theta_1 - u_2 \cos\theta_2)t$$

$$y = y_1 - y_2 = (u_1 \sin\theta_1 - u_2 \sin\theta_2)t$$

$$\text{Now} \quad \frac{y}{x} = \left(\frac{u_1 \sin\theta_1 - u_2 \sin\theta_2}{u_1 \cos\theta_1 - u_2 \cos\theta_2}\right) = \text{ constant}$$

Thus motion of a projectile relative to another projectile is a straight line.

(10) Change in momentum : In the vertical direction,.

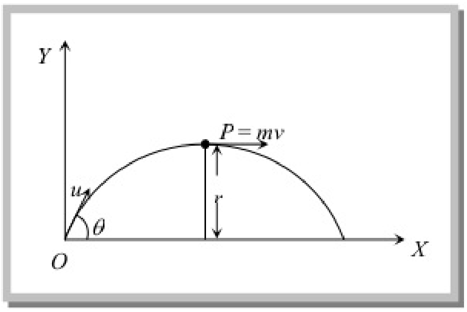
(i) Change in momentum (Between projection point and highest point) $\Delta p = \vec{p}_f - \vec{p}_i = -mu\sin\theta\,\hat{j}$

(ii) Change in momentum (For the complete projectile motion) $\Delta p = \vec{p}_f - \vec{p}_i = -2mu\sin\theta\,\hat{j}$

(11) Angular momentum : Angular momentum of projectile at highest point oftrajectory about the point of projection is given by

$$L = mvr \qquad \left[\text{Here } r = H = \frac{u^2 \sin^2\theta}{2g}\right]$$

$$\therefore \qquad L = m\,u\cos\theta \frac{u^2 \sin^2\theta}{2g} = \frac{m\,u^3 \cos\theta \sin^2\theta}{2g}$$



Sample problems :

Problem 7. A body of mass 0.5 kg is projected under gravity with a speed of 98 m/s atan angle of 30^o with the horizontal. The change in momentum (inmagnitude) of the body is

(a) 24.5 N–s (b) 49.0 N–s (c) 98.0 N–s (d) 50.0 N–s

Solution : (b) Change in momentum between complete projectile motion = 2mu sinθ= 2× 0.5× 98 × sin 30^{o} = 49 N–s.

Problem 8. A particle of mass 100 g is fired with a velocity 20 m sec–1 making an angleof 30^{o} with the horizontal. When it rises to the highest point of its path thenthe change in its momentum is

(a) $\sqrt{3} kg\, m\, sec^{-1}$ (b) $1/2\ kg\ m\ sec^{-1}$ (c) $\sqrt{2} kg\, m\, sec^{-1}$ (d) $1\ kg\ m\ sec^{-1}$

Solution : (d) Horizontal momentum remains always constant

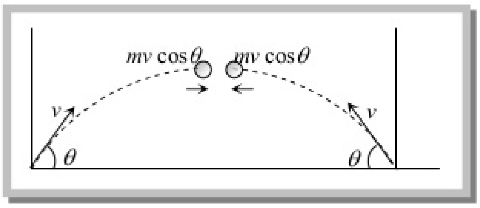
So change in vertical momentum$(\Delta \vec{p})$= Final vertical momentum – Initialvertical momentum = 0 - musinθ

$|\Delta P| = 0.1 \times 20 \times \sin 30^{o} \quad = 1 kg\, m / sec$.

Problem 9. Two equal masses (m) are projected at the same angle (θ) from two pointsseparated by their range with equal velocities (v). The momentum at thepoint of their collision is

(a) Zero (b) 2 mv cosθ (c) – 2 mv cosθ (d) None of these

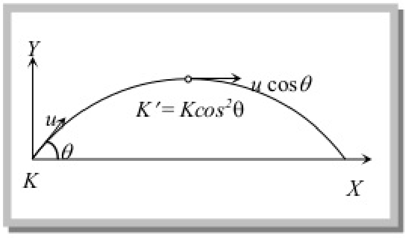
Solution : (a) Both masses will collide at the highest point of their trajectory with equaland opposite momentum. So net momentum of the system will be zero.



(12) Energy of projectile : When a projectile moves upward its kinetic energydecreases, potential energy increases but the total energy always remain constant.

If a body is projected with initial kinetic energy K(=1/2 mu2), with angle ofprojection θ with the horizontal then at the highest point of trajectory

(i) **Kinetic energy** $= \frac{1}{2}m(u\cos\theta)^2 = \frac{1}{2}mu^2\cos^2\theta$



$\therefore \quad K' = K\cos^2\theta$

(ii) **Potential energy** $= mgH = mg\frac{u^2\sin^2\theta}{2g} = \frac{1}{2}mu^2\sin^2\theta$

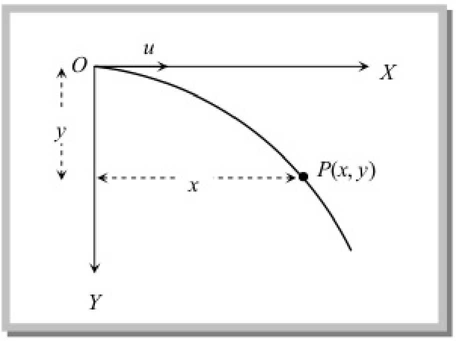
$\left(\text{As } H = \frac{u^2\sin^2\theta}{2g}\right)$

(iii) **Total energy** = Kinetic energy + Potential energy $= \frac{1}{2}mu^2\cos^2\theta + \frac{1}{2}mu^2\sin^2\theta$

$= \frac{1}{2}mu^2 =$ Energy at the point of projection.

This is in accordance with the law of conservation of energy.

(2) Projectile under horizontal projection: **(Do not treat it as a oblique projectile with angle to projection)**



(A) INITIAL CONDITIONS:

-An object thrown with an initial horizontal velocity u.

-Initial value of vertical velocity v is 0.

-Initial x component of displacement i.e x0 = 0 at t=0

-Initial y component of displacement i.e yo = 0 at t=0.

Note: The horizontal velocity u remains constant as there is no acceleration acting in thehorizontal direction , the vertical velocity v increases uniformly due to gravity.

(B) TRAJECTORY OF PROJECTILE:

After time t, suppose the body reaches at point D(x,y).

Since for non accelerated motion distance= speed X time.

Hence , for horizontal distance covered : x=ut , t= x/u.

Vertical distance covered :

From 2nd equation of motion

$S_y = u_y t + 1/2\, a_y t^2$.

Where s =y-y_o; y_o= 0, uy= 0, a_y= +g Hence,

$y=1/2\, gt^2$

From t=x/u , $y=1/2g\,(x/u)^2=(g/2u^2)\, x^2$

Let g/2u2= k (a constant)

Hence, $\boxed{y=kx^2}$ (this is an equation of parabola)

Hence, for an object thrown from a particular height above the ground coverrs aparabolic path.

(C) TIME OF FLIGHT(T)

The total time for which the projectile remains in its flight is called time of flight.

Considering the vertically downward motion,

$S=ut +1/2at^2$

$h=0xT + 1/2\, gT^2$, (let the object be thrown from a height h)

=> $2h/g=T^2$

$\boxed{\Rightarrow T= \sqrt{2h/g}}$

(D) Horizontal Range (R)

The horizontal distance covered by the projectile during the time of flight.

R= Horizontal velocity X Time of flight

$\boxed{\Rightarrow R= u\sqrt{2h/g}}$

(E) Velocity of the projectile at any instant

$V=\sqrt{v_x^2+v_y^2}$

$v_x= u_x + a_x t$

$V_y= u_y+ a_y t$

=> v_x= u (horizontal acceleration =0)

V_y=gt (initial vertical velocity=0)

Hence,

$V=\sqrt{u^2+g^2 t^2}$.

Let the velocity vector makes an angle of θ with horizontal

$\tan\theta= v_y / v_x$

= gt/u

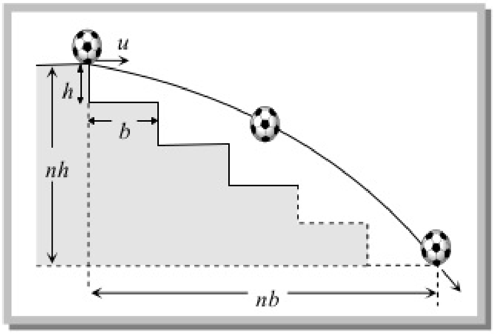
Hence $\theta= \tan^{-1}(gt/u)$.

Problem 27. A ball rolls off top of a staircase with a horizontal velocity u m/s. If the steps are h metre high and b mere wide, the ball will just hit the edge of nthstep if n equals to

(a) $\frac{hu^2}{gb^2}$ (b) $\frac{u^2 8}{gb^2}$ (c) $\frac{2hu^2}{gb^2}$ (d) $\frac{2u^2 g}{hb^2}$

Solution : (c) By using equation of trajectory $y = \frac{gx^2}{2u^2}$ for given condition

$$nh = \frac{g(nb)^2}{2u^2} \quad \therefore n = \frac{2hu^2}{gb^2}$$



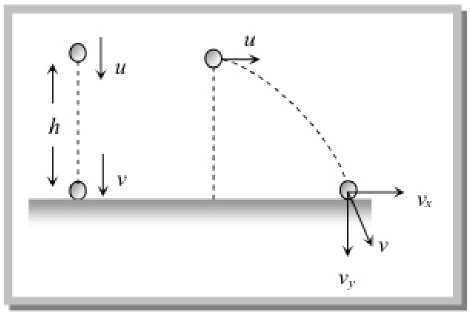
Problem 28. A man standing on the roof of a house of height h throws one particlevertically downwards and another particle horizontally with the samevelocity u. The ratio of their velocities when they reach the earth's surfacewill be

(a) $\sqrt{2gh+u^2} : u$ (b) 1 : 2 (c) 1 : 1 (d) $\sqrt{2gh+u^2} : \sqrt{2gh}$

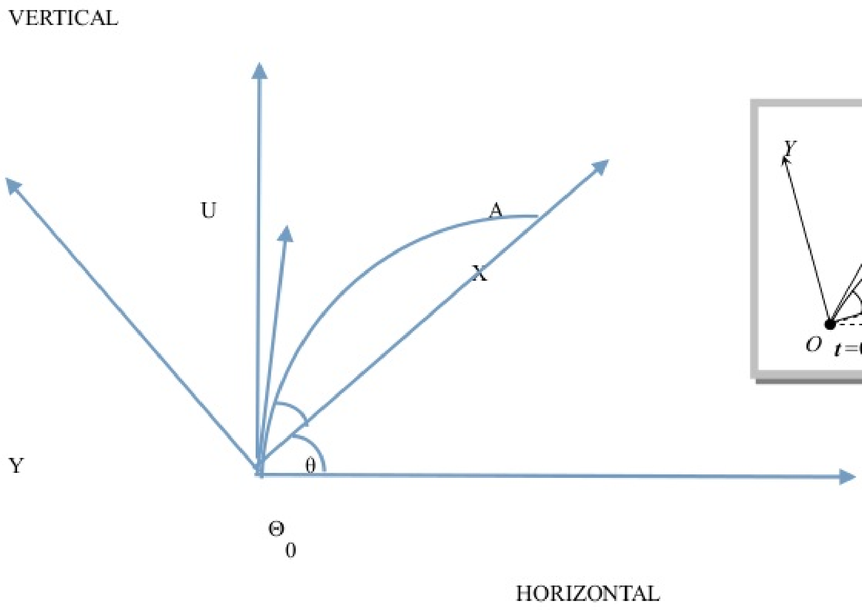
Solution : (c) For first particle : $v^2 = u^2 + 2gh \Rightarrow v = \sqrt{u^2 + 2gh}$

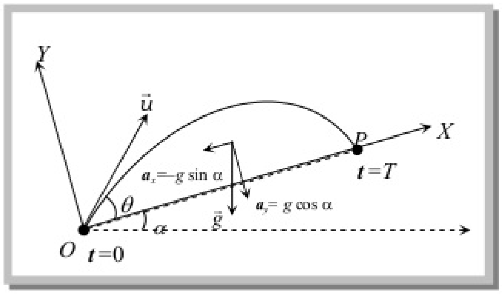
For second particle : $v = \sqrt{v_x^2 + v_y^2} = \sqrt{u^2 + \left(\sqrt{2gh}\right)^2} = \sqrt{u^2 + 2gh}$

So the ratio of velocities will be 1 : 1.



(3) RANGE AND TIME OF FLIGHT ON AN INCLINED PLANE.





(A) ***INITIAL CONDITIONS:***

-An inclined plane making an angle θ0 with the horizontal.

-Initial velocity vector making an angle θ with the horizontal.

-Rectangular components of u and g along x and y axis.

$U_x = u\cos(\theta-\theta_0)$ and $u_y = u\sin(\theta-\theta_0)$

$g_x = -g\sin\theta_0$ $g_y = -g\cos\theta_0$.

.- Initial x component of displacement i.e $x_0 = 0$ at t=0

-Initial y component of displacement i.e $y_o = 0$ at t=0.

(B) TIME OF FLIGHT

Displacement along y axis=0

$S= ut + 1/2\ at^2$

$0= u\sin(\theta-\theta_0)\ T + 1/2\ (-g\cos\theta_0)\ T^2$

$T= 2u\sin(\theta-\theta_0)/\ g\cos\theta_0$

(C) HORIZONTAL RANGE

Considering horizontal motion :

Using the second equation of motion and applying the initial conditions.

$R= u^2\ (\sin(2\theta-\theta_0)-\sin\theta_0)/\ g\cos^2(\theta)$

$R_{max}= u^2/g(1+\sin\theta_0)$ for $\theta= \theta_0/2 + ¶/4$

Problem 29. For a given velocity of projection from a point on the inclined plane, themaximum range down the plane is three times the maximum range up theincline. Then, the angle of inclination of the inclined plane is

(a) 30^o (b) 45^o (c) 60^o (d) 90^o

Solution : (a) Maximum range up the inclined plane $(R_{\max})_{up} = \dfrac{u^2}{g(1+\sin\alpha)}$

Maximum range down the inclined plane $(R_{\max})_{down} = \dfrac{u^2}{g(1-\sin\alpha)}$

and according to problem : $\dfrac{u^2}{g(1-\sin\alpha)} = 3 \times \dfrac{u^2}{g(1+\sin\alpha)}$

By solving $\alpha = 30^\circ$

Problem 30. A shell is fired from a gun from the bottom of a hil along its slope. Theslope of the hill is $\alpha = 30^\circ$, and the angle of the barrel to the horizontal $\beta=60^\circ$. The initial velocity v of the shell is 21 m/sec. Then distance of pointfrom the gun at which shel will fall

(a) 10 m (b) 20 m (c) 30 m (d) 40 m

Solution : (c) Here $u = 21\ m/sec$, $\alpha = 30^\circ$, $\theta = \beta - \alpha = 60^\circ - 30^\circ = 30^\circ$

Maximum range $R = \dfrac{2u^2}{g}\dfrac{\sin\theta\cos(\theta+\alpha)}{\cos^2\alpha} = \dfrac{2\times(21)^2\times\sin 30^o\cos 60^o}{9.8\times\cos^2 30^o} = 30\,m$

Problem 31. The maximum range of rifle bullet on the horizontal ground is 6 km itsmaximum range on an inclined of 30° will be

(a) 1 km (b) 2 km (c) 4 km (d) 6 km

Solution : (c) Maximum range on horizontal plane $R = \dfrac{u^2}{g} = 6km$ (given)

Maximum range on a inclined plane $R_{\max} = \dfrac{u^2}{g(1+\sin\alpha)}$

Putting $\alpha = 30^\circ$ $\quad R_{\max} = \dfrac{u^2}{g(1+\sin 30^\circ)} = \dfrac{2}{3}\left(\dfrac{u^2}{g}\right) = \dfrac{2}{3}\times 6 = 4\,km.$

ACTIVITY -2

ACTIVITY

Students are introduced to the concept of projectile motion, of which they are oftenfamiliar from life experiences, such as playing sports like basketball and baseball, eventhough they may not understand the physics involved. Students use tabletop-sized robotsto build projectile throwers and measure motion using sensors. They compute distancesand velocities using simple kinematic equations and confirm their results throughmeasurements by hand. To apply the concept, students calculate the necessary speed of anobject to reach a certain distance in a hypothetical scenario: A group of hikers stranded atthe bottom of a cliff need food, but rescuers cannot deliver it themselves, so they mustdevise a way to get the food to the hikers. A student worksheet is provided.

Learning Objectives

After this activity, students should be able to:

•Describe the trajectory of an object in projectile motion.

• Determine how far an object will travel based on initial conditions.

Procedure / Introduction

Have you ever wondered how far a ball can travel when you throw it? Or better yet, howhard you need to hit a baseball to get a homerun? These are real questions that not onlyapply to baseball, but other real-life situations including the paths of meteorites andtrajectories of rockets.

In today's activity, we will create a ball launcher that shoots balls in the direction of ourchoosing. Using simple math representing the forces that act on a ball, we can predict howfar it will travel in the air. We can even calculate its location at a given time.

Why is this important? Let's imagine that while hiking with friends, some of them end upstranded at the bottom of a cliff. We don't have the equipment to reach them or rescue them,and so we must cal for help. We're informed that rescuers will be able to come save ourfriends in the morning, but in the meantime, our friends are starving. It is our goal toconstruct a device that can shoot food down to them. By studying the motion of thingstraveling in the air, also known as projectiles, we can figure out just how fast the food needsto be launched in order for it to get to them. Be careful! If we shoot too low, the food will bedestroyed and if we shoot too high, we may attract unwanted creatures such as bears.

The motion of a projectile, a container of food in this case, traveling through the air is calledprojectile motion. We see projectile motion in action almost every day. Can you think ofany examples in which you have seen projectile motion?

Pre-Activity Assessment

Real-World Examples: Ask students to name everyday examples of projectile motion and explain why they are projectile motion. Make sure they know projectile motion is based on the trajectory of objects and their motions, not inertial forces. (Example: A baseball that has been pitched, bat ed or thrown.)

Activity Embedded Assessment

- *Observations:* As students work, circulate the room to assess their progress and offer assistance where needed.
- *Performance Predictions:* As part of the activity, students use two measurements of velocity and power to predict future performance of the launcher. Ask students to explain this process and describe or note any deviations from previous performance.

Real-World Examples: Ask students to name everyday examples of projectile motion and explain why they are projectile motion. Make sure they know projectile motion is based on the trajectory of objects and their motions, not inertial forces. (Example: A baseball that has been pitched, bat ed or thrown.)

Activity -3

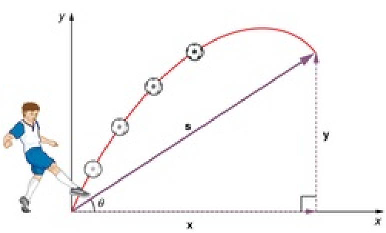
Discuss in groups and write your observations on “Applications on projectile motions in daily life”

Ballistics

Ballistics is the study of gunfire patterns for the purposes of crime-solving. Indeed, this application of ballistics is a significant part of police science, because it allows law-enforcement investigators to determine when, where, and how a firearm was used. In a larger sense, however, the term as applied to firearms refers to efforts toward creating a more effective, predictable, and longer bullet trajectory.

From the advent of firearms in the West during the fourteenth century until about 1500, muskets were hopelessly unreliable. This was because the lead balls they fired had not been fit ed to the barrel of the musket. When fired, they bounced erratically off the sides of the barrel, and this made their trajectories unpredictable. Compounding this was the unevenness of the lead balls themselves, and this irregularity of shape could lead to even greater irregularities in trajectory.

Soccer



In the concept of soccer, the amount of force a soccer player applies to the ball. For example, how hard the individual kick will determine the initial velocity of how fast the ball will travel. The acceleration is controller by how hard the person kicks. Thus, it also determines the angle as well. The angle of how the soccer player kick the ball also determines the height and distance it traveled. For example, if the ball is kicked at an angle of 45 degrees it will get the maximum range. It also affects the vertical and horizontal velocity. for gravity, there is always a force of 9.8 m/s^2 that acts downwards; thus affecting the vertical distance of how fat and high the ball travels.The size of the object also plays an important role in determining the air drag. The bigger the projectile, the bigger the air drag. The smaller the projectile, the smaller the air drag. The shape of the object will also affect the air drag. That is why soccer ball is sphere instead of a cube.Sphere has bet er aerodynamics than cubes do. Overall, projectile motion is very closely associated with soccer. Projectile motion is associated with almost all types of sports.

Conclusive remarks-

After knowing the basic concept of projectile motion e.g equation of trajectory, instantaneous velocity, position etc. learner will be able to fine analytical y and experimentally the dependence of greatest height, time of flight, horizontal range on

1.velocity of projection

2.angle of projection

References

http:/www.scienceclarified.com/everyday/Real-Life-Chemistry-Vol-3-Physics-Vol-1/Projectile-Motion-Real-life-applications.html

http:/ourwonderfulphysics.blogspot.ca/2012/10/how-are-principles-of-projectile-motion.html

QUALITATIVE ANALYSIS OF WAVE OPTICS

Introduction:

Optics is the branch of physics which involves the behaviour and properties of light, including its interactions with matter and the construction of instruments that use or detectit. Optics usually describes the behaviour of visible, ultraviolet, and infrared light. Because light is an electromagnetic wave, other forms of electromagnetic radiation such asX-rays, microwaves, and radio waves exhibit similar properties.

Most optical phenomena can be accounted for using the classical electromagnetic description of light. Complete electromagnetic description of light are, however, often difficult to apply in practice. Practical optics is usual y done using simplified models. The most common of these, geometric optics, treats light as a collection of rays that travel in straight lines and bend when they pass through or reflect from surfaces. Physical optics is a more comprehensive model of light, which includes wave effects such as diffraction and interference that cannot be accounted for in geometric optics. Historical y, the ray-based model of light was developed first, fol owed by the wave model of light. Progress in electromagnetic theory in the 19th century led to the discovery that light waves were in fact electromagnetic radiation.

Some phenomena depend on the fact that light has both wave-like and particle-like properties. Explanation of these effects requires quantum mechanics. When considering light's particle-like properties, the light is modelled as a collection of particles called "photons". Quantum optics deals with the application of quantum mechanics to optical systems.

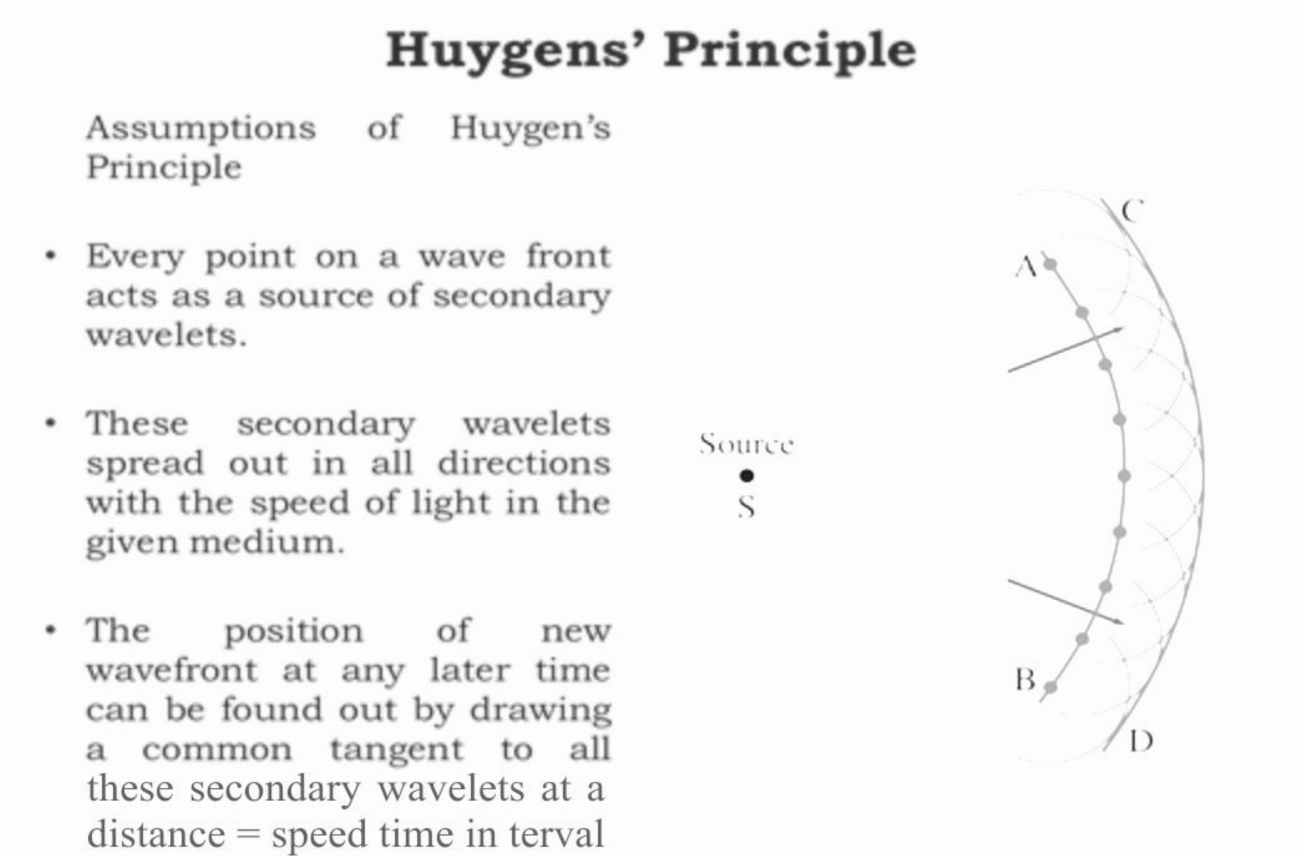
LEARNING OUT COMES

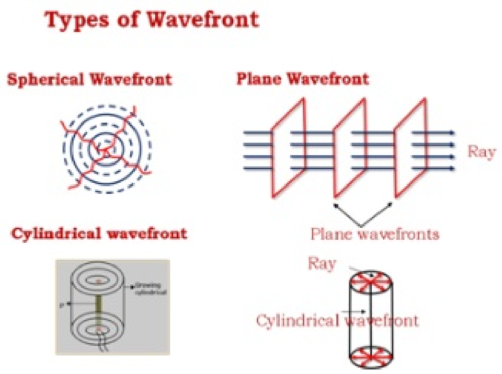
The learner will be able to

- Understand that Classical optics is divided into two main branches: geometrical (or ray) optics and physical (or wave) optics.
- Understand that In geometrical optics, light is considered to travel in straight lines, while in physical optics, light is considered as an electromagnetic wave.
- Know that Geometrical optics can be viewed as an approximation of physical optics that applies when the wavelength of the light used is much smaller than the size of the optical elements in the system being model ed.
- Understand how interaction of waves can be studied

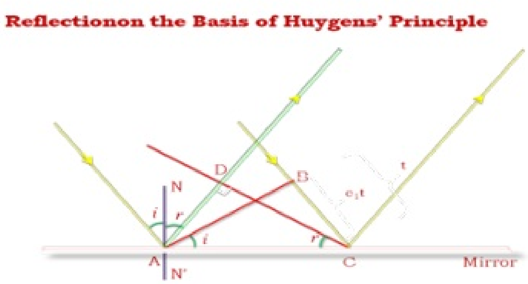
CONCEPTUAL UNDERSTANDING

A wavefront is defined as the continuous locus of al such points of the medium which are in the same phase at any instant.





$$\frac{Simi}{Simr} = \text{Constant Can be established}$$



Interference

If y_1 and y_2 are the displacements of the waves from two sources at any instant t with a phase dif erence of φ. Then, considering y1 = a Cosωt and y2 = a Cos(ωt +φ).

The resultant displacement will be given by

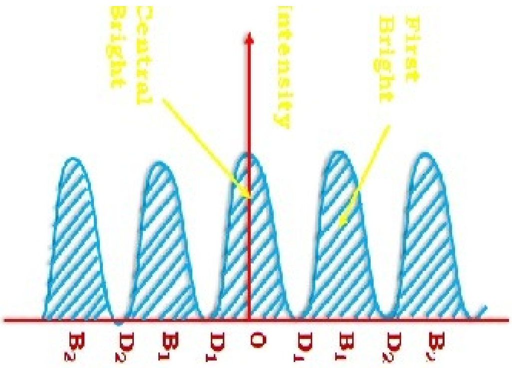
$$y = y1 + y2 = a \cos\omega t + a \cos(\omega t + \varphi) = 2 a \cos(\varphi/2) \cos(\omega t + \varphi/2)$$

The amplitude of the resultant displacement is given by $R = 2 a \cos(\varphi/2)$

As, intensity ∝(amplitude)2

i.e., $I_0 \propto a^2$ and $I \propto R^2$

Resultant intensity, $I = 4I_0\cos^2(\varphi/2)$ implying Phase Varying Amplitude and Intensity.



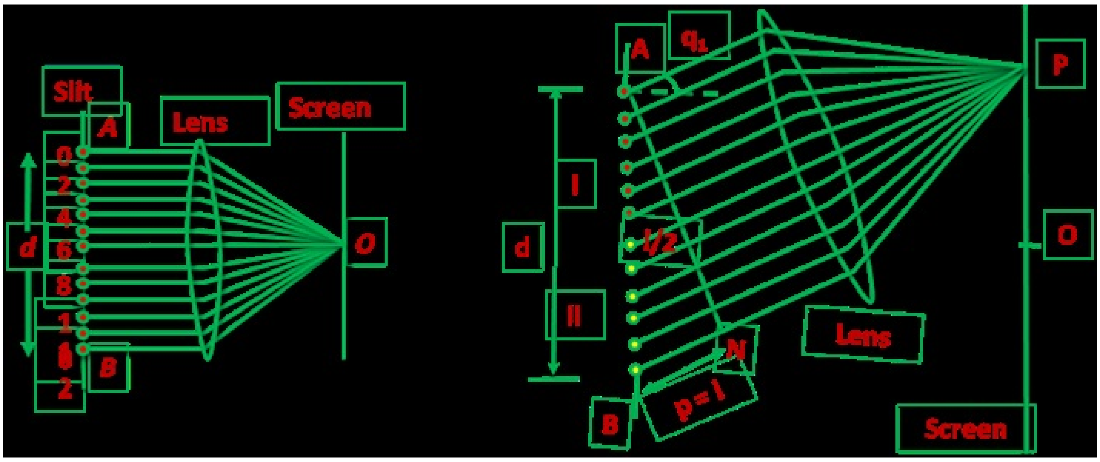
Is the law of conservation of energy valid? Yes. The average intensity on the screen is the sum of the maximum and minimum intensity

When can the fringe pattern have Good Visibility? Good Contrast when the amplitudes are equal.

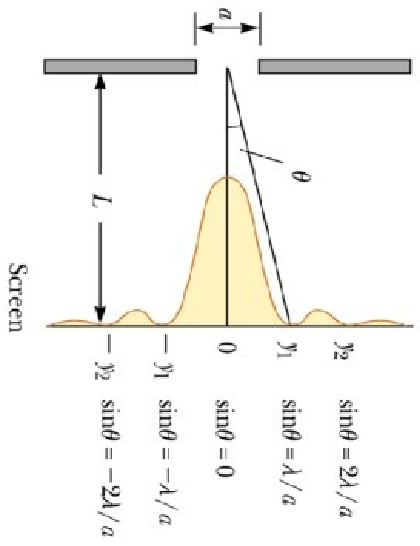
Why should one have Sources with Constant Phase Difference? Pattern is not Sustained

Diffraction

The phenomenon which bending of light around the corners of an obstacle happensis termed as Diffraction (No Medium Change).



Basically, Diffraction is a interference between light from two portions of the same Wavefront.

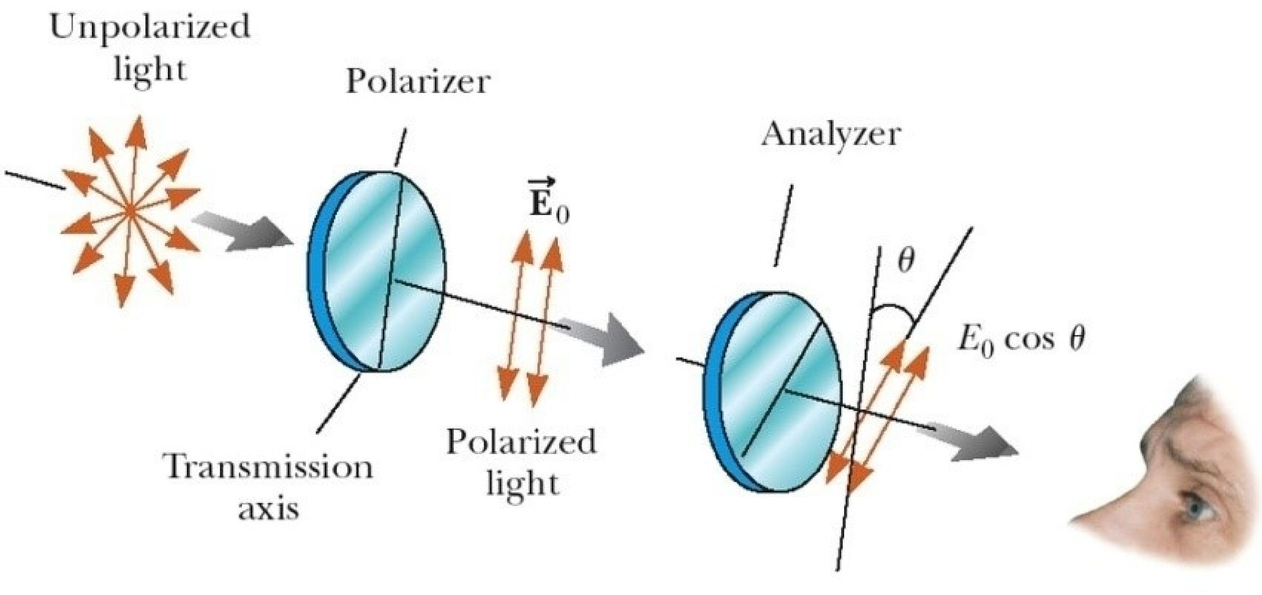


Condition for the first dark is a Sinθ = λ, where a is the shit Size

General Condition for dark will be a Sinθ = nλ

Polarization of Light

A wave is said to be linearly polarized, if the resultant electric field vibrates in the same direction at al times at a particular point



Malu's Law

When light passes through a polarizer, only the component parallel to the polarization axis is transmitted. If the incoming light is plane-polarized, the outgoing intensity will be I = I_0 Cos^{2}0 where is the angle between the axis of the two crystals and I0 is the intensity of the polarised light.

Example: 1 If two waves represented by $y_1 = 4\sin\omega t$ and $y_2 = 3\sin\left(\omega t + \frac{\pi}{3}\right)$ interfere at a point, the amplitude of the resulting wave will be about

(a) 7 (b) 6 (c) 5 (d) 3.

Solution:(b) By

$$A = \sqrt{a_1^2 + a_2^2 + 2a_1 a_2 \cos\phi} \Rightarrow A = \sqrt{(4)^2 + (3)^2 + 2 \times 4 \times 3 \cos\frac{\pi}{3}} = \sqrt{37} \approx 6.$$

Example: 2 The two slits at a distance of 1 mm are illuminated by the light of wavelength 6.5×10^{-7}m. The interference fringes are observed on a screen placed at a distance of 1 m. The distance between third dark fringe and fifth bright fringe will be

(a) 0.65 mm (b) 1.63 mm (c) 3.25 mm (d) 4.88 mm

Solution:(b) Distance between n^{th} bright and m^{th} dark fringe (n>m) is given as

$$x = \left(n - m + \frac{1}{2}\right)\beta = \left(n - m + \frac{1}{2}\right)\frac{\lambda D}{d}$$

$$\Rightarrow x = \left(5 - 3 + \frac{1}{2}\right) \times \frac{6.5 \times 10^{-7} \times 1}{1 \times 10^{-3}} = 1.63\,mm.$$

Example: 3 Two identical sources emit ed waves which produces intensity of k unit at a point on screen where path difference is λ. What will be intensity at a point on screen at which path difference is λ/4 **[RPET 1996]**

(a) k/4 (b) k/2 (c) k (d) Zero

Solution:(b)By using phase difference $\phi = \frac{2\pi}{\lambda}(\Delta)$

For path difference λ, phase differenceϕ_1 = 2π and for path difference λ /4,

phase difference π/2

Also by using

$$I = 4I_0 \cos^2\frac{\phi}{2} \Rightarrow \frac{I_1}{I_2} = \frac{\cos^2(\phi_1/2)}{\cos^2(\phi_2/2)} \Rightarrow \frac{k}{I_2} = \frac{\cos^2(2\pi/2)}{\cos^2\left(\frac{\pi/2}{2}\right)} = \frac{1}{1/2} \Rightarrow I_2 = \frac{k}{2}.$$

Activities

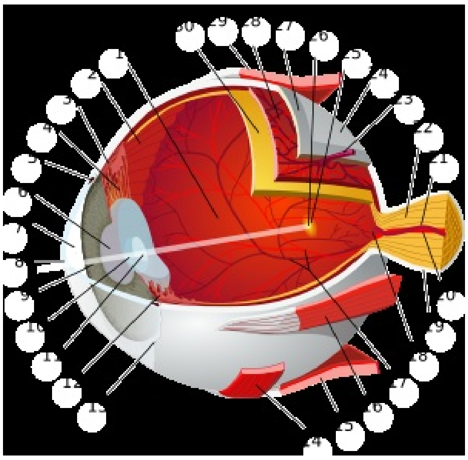
Activity 1

Discuss in groups and write points on ”Applications **Optics is part of everyday life**”

Optics is part of everyday life. The ubiquity of visual systems in biology indicates the central role optics plays as the science of one of the five senses. Many people benefit from eyeglasses or contact lenses, and optics are integral to the functioning of many consumer goods including cameras. Rainbows and mirages are examples of optical phenomena. Optical communication provides the backbone for both the Internet and modern telephony.

Group 1-

Give the group to discuss how the optics helps for -Human eye



Model of a human eye. Features mentioned in this article are 3. ciliary muscle, 6. pupil, 8. cornea, 10. lens cortex, 22. optic nerve, 26. fovea, 30. retina

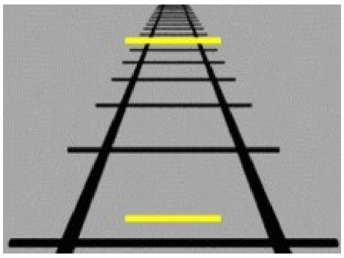
Hand OUT

The human eye functions by focusing light onto a layer of photoreceptor cells called the retina, which forms the inner lining of the back of the eye. The focusing is accomplished by a series of transparent media. Light entering the eye passes first through the cornea, which provides much of the eye's optical power. The light then continues through the fluid just behind the cornea—the anterior chamber, then passes through the pupil. The light then passes through the lens, which focuses the light further and allows adjustment of focus. The light then passes through the main body of fluid in the eye—the vitreous humour, and reaches the retina. The cel s in the retina line the back of the eye, except for where the optic nerve exits; this results in a blind spot.

Group 2-

Give the group to discuss how the optics helps for -Visual effects

For the visual effects used in film, video, and computer graphics, see visual effects.



The Ponzo Illusion relies on the fact that parallel lines appear to converge as they approach infinity.

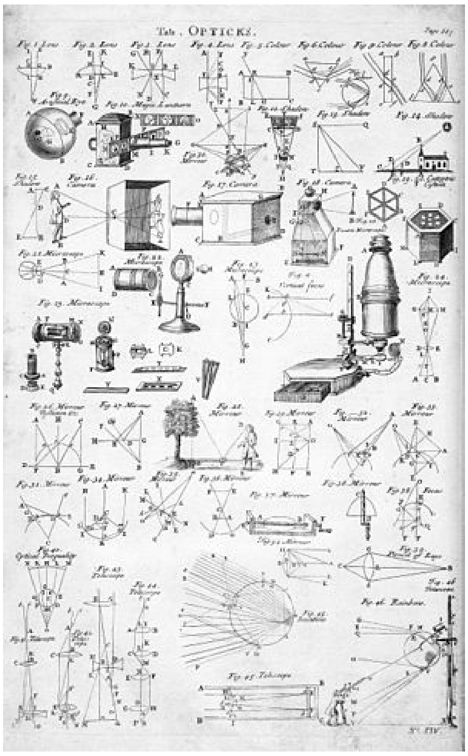
Hand OUT

Optical illusions (also called visual illusions) are characterized by visually perceived images that differ from objective reality. The information gathered by the eye is processed in the brain to give a percept that differs from the object being imaged. Optical illusions can be the result of a variety of phenomena including physical effects that create images that are different from the objects that make them, the physiological effects on the eyes and brain of excessive stimulation (e.g. brightness, tilt, colour, movement), and cognitive illusions where the eye and brain make unconscious inferences.

Cognitive illusions include some which result from the unconscious misapplication of certain optical principles.

Group 3-

Give the group to discuss how the optics helps for- Optical instruments



Illustrations of various optical instruments from the 1728 *Cyclopaedia*

Hand OUT

Single lenses have a variety of applications including photographic lenses, corrective lenses, and magnifying glasses while single mirrors are used in parabolic reflectors and rear-view mirrors. Combining a number of mirrors, prisms, and lenses produces compound optical instruments which have practical uses. For example, a periscope is simply two plane mirrors aligned to al ow for viewing around obstructions. The most famous compound optical instruments in science are the microscope and the telescope which were both invented by the Dutch in the late 16th century.[86]

Microscopes were first developed with just two lenses: an objective lens and an eyepiece.

The first telescopes, called *refracting telescopes* were also developed with a single objective and eyepiece lens.

Group 4-

Give the group to discuss how the optics helps for- Photography

Photograph taken with aperture f/32

Photograph taken with aperture f/5

Hand OUTs

The optics of photography involves both lenses and the medium in which electromagnetic radiation is recorded, whether it be a plate, film, or charge-coupled device.Photographers must consider the reciprocity of the camera and the shot which is summarized by the relation

Exposure ∝ Aperture Area × Exposure Time × Scene Luminance[88]

In other words, the smaller the aperture (giving greater depth of focus), the less light coming in, so the length of time has to be increased (leading to possible blurriness if motion occurs). An example of the use of the law of reciprocity is the Sunny 16 rule which gives a rough estimate for the set ings needed to estimate the proper exposure in daylight.[89]

The field of view that the lens will provide changes with the focal length of the lens.There are three basic classifications based on the relationship to the diagonal size of the film or sensor size of the camera to the focal length of the lens:[91]

- Normal lens: angle of view of about 50° (called normal because this angle considered roughly equivalent to human vision[91]) and a focal length approximately equal to the diagonal of the film or sensor.[92]
- Wide-angle lens: angle of view wider than 60° and focal length shorter than a normal lens.[93]
- ¬ Long focus lens: angle of view narrower than a normal lens. This is any lens with a focal length longer than the diagonal measure of the film or sensor.[94] The most common type of long focus lens is the telephoto lens, a design that uses a special telephoto group to be physical y shorter than its focal length.[95]

Modern zoom lenses may have some or all of these attributes.

Group 5-

Give the group to discuss how the optics helps for Atmospheric optics

A colorful sky is often due to scattering of light off particulates and pollution, as in this photograph of a sunset during the October 2007 California wildfires.

Hand OUTs

Mirages are optical phenomena in which light rays are bent due to thermal variations in the refraction index of air, producing displaced or heavily distorted images of distant objects. Other dramatic optical phenomena associated with this include the Novaya Zemlya effect where the sun appears to rise earlier than predicted with a distorted shape. A spectacular form of refraction occurs with a temperature inversion called the Fata Morgana where objects on the horizon or even beyond the horizon, such as islands, cliffs, ships or icebergs, appear elongated and elevated, like "fairy tale castles".

Rainbows are the result of a combination of internal reflection and dispersive refraction of light in raindrops. A single reflection off the backs of an array of raindrops produces a rainbow with an angular size on the sky that ranges from 40° to 42° with red on the outside. Double rainbows are produced by two internal reflections with angular size of 50.5° to 54° with violet on the outside. Because rainbows are seen with the sun 180° away from the centre of the rainbow, rainbows are more prominent the closer the sun is to the horizon.

Conclusive Remarks

Some phenomena depend on the fact that light has both wave-like and particle-like properties. Explanation of these effects requires quantum mechanics. When considering light's particle-like properties, the light is model ed as a collection of particles called "photons". Quantum optics deals with the application of quantum mechanics to optical systems.

Optical science is relevant to and studied in many related disciplines including astronomy, various engineering fields, photography, and medicine (particularly ophthalmology and optometry). Practical applications of optics are found in a variety of technologies and everyday objects, including mirrors, lenses, telescopes, microscopes, lasers, and fibre optics.

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- Optics and photonics: Physics enhancing our lives by Institute of Physics publications

Links-

- Optics on *In Our Time* at the BBC. (listen now)

CAPILLARY RISE METHOD

Introduction-

Capillary action is the ability of a liquid to flow in narrow spaces without the assistance or even in opposition to external forces like gravity. The effect can be seen in the drawing up of liquids between the hairs of a paint-brush, in a thin tube, in porous materials such as paper and plaster, in some non-porous materials such as sand and liquefied carbon fiber, or in a cell . It occurs because of intermolecular forces between the liquid and surrounding solid surfaces. If the diameter of the tube is sufficiently small, then the combination of surface tension (which is caused by cohesion within the liquid)and adhesive forces between the liquid and container wall act to lift the liquid.

If a Capillary is dipped in a liquid, it is found that the liquid in the Capillary either ascends or descends relative to the surrounding liquid. This phenomenon is called Capillarity.

The root cause of Capillarity is the difference in pressures on two sides of (concave and convex) curved surface of liquid.

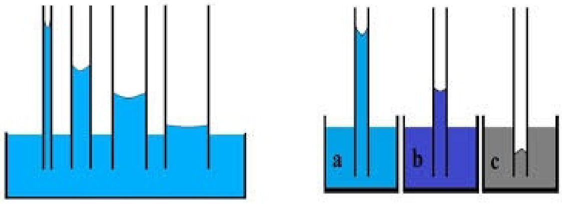


Figure Showing dependence of capillarity on Radius of tube and Density of liquid

Examples of Capillarity :

(i) Ink rises in the fine pores of blotting paper leaving the paper dry.

(ii) A towel soaks water.

(iii) Oil rises in the long narrow spaces between the threads of a wick.

(iv) Wood swells in rainy season due to rise of moisture from air in the pores.

(v) Ploughing of fields is essential for preserving moisture in the soil.

(vi) Sand is drier soil than clay. This is because holes between the sand particles are not so fine as compared to that of clay, to draw up water by Capillary action.

LEARNING OUTCOME-

Learner will be able to

1. Understand the rise or fall of liquid in Capillary.
2. Know the formation of liquid meniscus.
3. Measure the reading of travelling microscope.
4. know better understanding of focusing of image.
5. know significance of cross wire in travelling microscope.
6. Reason the ascend or descend

EXPERIMENT

AIM : To determine the surface tension of water by Capillary rise method.

APPARATUS AND MATERIAL REQUIRED

A glass/plastic Capillary tube, traveling microscope, beaker, cork with pin, clamps and stand, thermometer, dilute nitric acid solution, dilute caustic soda solution, water, plumb line.

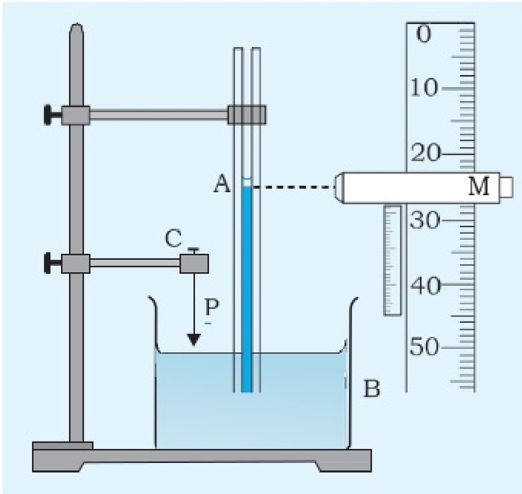
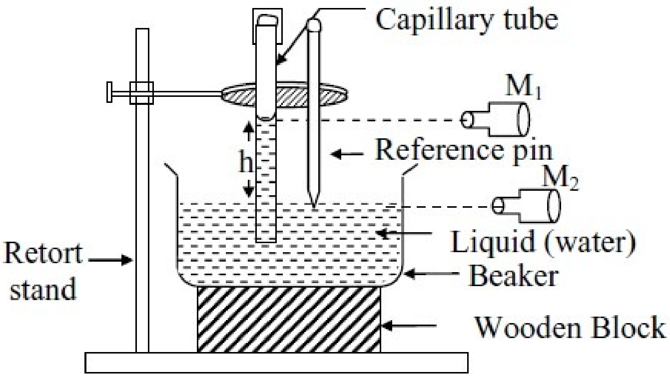


Fig. 12.1: Rise of liquid in a capillary tube



Experimental set up

M_1 - Travelling microscope focussed on liquid meniscus
M_2 - Travelling microscope focussed on tip of reference pin

PRINCIPLE

When a liquid rises in a capillary tube the weight of the column of the liquid of density ρ below the meniscus, is supported by the upward force of surface tension acting around the circumference of the points of contact. Therefore

PROCEDURE

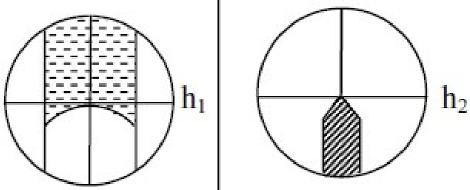
1. Do the experiment in a well-lit place for example, near a window or use an incandescent bulb.

2. Clean the Capillary tube and beaker successively in caustic soda and nitric acid and final y rinse thoroughly with water.

3. Fill the beaker with water and measure its temperature.

4. Clamp the Capillary tube near its upper end, keeping it above the beaker. Set it vertical with the help of a plumbline held near it. Move down the tube so that its lower end dips into the water in the beaker.

5. Push a pin P through a cork C, and fix it on another clamp such that the tip of the pin is just above the water surface as shown in Fig. E 12.1. Ensure that the pin does not touch the Capillary tube. Slowly lower the pin till its tip just touches the water surface. This can be done by coinciding the tip of the pin with its image in water.



3 - (i)
Inverted image of raised liquid in the capillary (meniscus)

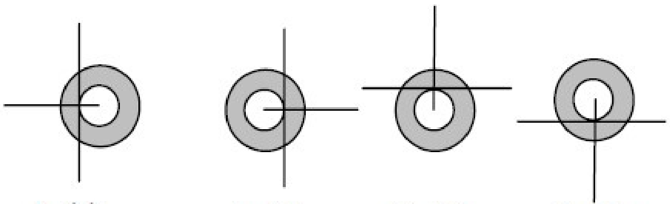
3 - (ii)
Inverted image of reference pin

6 . Now focus the traveling microscope M on the meniscus of the water in capillary A, and move the microscope until the horizontal crosswire is tangential to the lowest point of the meniscus, which is seen inverted in M. If there is any difficulty in focusing the m eniscus, hold a piece of paper at the lowest point of the meniscus outside the capillary tube and focus it first, as a guide. Note the reading of traveling microscope.

7. Mark the position of the meniscus on the Capillary with a pen. Now carefully remove the Capillary tube from the beaker, and then the beaker without disturbing the pin.

8. Focus the microscope on the tip of the pin and note the microscope reading.

9. Cut the capillary tube carefully at the point marked on it. Fix the Capillary tube horizontally on a stand. Focus the microscope on the transverse cross section of the tube and take readings to measure the internal diameter of the tube in two mutually perpendicular directions.



1- (a) 1- (b) 1- (c) 1- (d)

OBSERVATIONS

Determination of h

Least count (L.C.) of the microscope = ... mm

Table E 12.1 : Measurement of Capillary rise

S. No.	Reading along a diameter (cm)		Diameter d_1 (x_2-x_1)	Reading along perpendicular diameter		Diameter d_2 (y_2-y_1)	Mean diameter d
	One end	other end	(cm)	One end	other end	(cm)	$=\frac{d_1+d_2}{2}$
1	x_1	x_2		y_1	y_2		
2							
3							

Table E 12.2 : Measurement of diameter of the capillary tube

S. No.	Reading of meniscus h_1 (cm)			Reading to tip of pin touching surface of water h_2 (cm)			$h = h_1 - h_2$
	M.S.R. 5 (cm)	V.S.R. n	h1= (5+ n L.C.)	M.S.R. S (cm)	V.S.R. n	h2 = (5'+n' L.C.) (cm)	
1 2 3							

Mean radius r = ... cm;

Temperature of water θ

= ... °C; Density of water at

0° C = . . g cm–3

ALCULATION

Substitute the value of h and r and ρ g in the formula for T and calculate the surface tension.

RESULT

The surface tension of water at ... °C = ... ± . . Nm–1

PRECAUTIONS

1. To make capillary tube free of contamination, it must be rinsed first in a solution of caustic soda then with dilute nitric acid and finally cleaned with water thoroughly.

2. The capillary tube must be kept vertical while dipping it in water.

3. To ensure that capillary tube is sufficiently wet, raise and lower water level in container by lifting or lowering the beaker. It should have no effect on height of liquid level in the capillary tube.

4. Water level in the capillary tube should be slightly above the edge of the beaker/dish so that the edge does not obstruct observations.

5. Temperature should be recorded before and after the experiment.

6. Height of liquid column should be measured from lowest point of concave meniscus.

SOURCES OF ERROR

1. Inserting dry Capillary tube in the liquid can cause gross error in the measurement of surface tension as liquid level in Capillary tube may not fall back when the level in container is lowered.

2. Surface tension changes with impurities and temperature of the liquid.

3. Non-vertical placement of the Capillary tube may introduce error in the measurement of height of the liquid column in the tube.

4. Improper focusing of meniscus in microscope could cause an error in measurement of the height of liquid column in the Capillary tube.

DISCUSSION

1. In a fine capillary tube, the meniscus surface may be considered to be semispherical and the weight of the liquid above the lowest point of the meniscus as $\frac{1}{3} pr^3 \pi g.$ Taking this into account, the formula for surface tension is

modified to $T = \frac{1}{2}\, pgr \left(h + \frac{r}{3} \right).$. More precise calculation of surface tension can be done using this formula.

2. If the Capillary is dry from inside the water that rises to a certain height in it will not fall back, so the Capillary should be wet from inside. To wet the inside of the Capillary tube thoroughly, it is first dipped well down in the water and raised and clamped. Alternatively, the beaker may be lifted up and placed down.

SELF ASSESSMENT

1. Suppose the length of Capillary tube taken is less than the height upto which liquid could rise. What do you expect if such a tube is inserted inside the liquid? Explain your answer.

2. Two match sticks are floating parallel and quite close to each other. What would happen if a drop of soap solution or a drop of hot water falls between the two sticks? Explain your answer.

ACTIVITIES

Activity 1. Experiment can be performed at different temperatures and effect of temperature on surface tension can be studied.

Activity 2. Experiment can be performed by adding some impurities and effect of change in impurity concentration (like adding NaCl or sugar) on surface tension can be studied.

Activity 3. Study the effect of inclination of capillary tube on height of liquid rise in the Capillary tube.

Activity -4 Discuss and write in the in groups "the Applications on the use of Capillary action in our surrounding

Some applications :

1. Capillary action is essential for the drainage of constantly produced tear fluid from the eye. Two canaliculi of tiny diameter are present in the inner corner of the eyelid, also called the lacrimal ducts; their openings can be seen with the naked eye within the lacrymal sacs when the eyelids are everted.

2. Wicking is the absorption of a liquid by a material in the manner of a candle wick. Paper towels absorb liquid through Capillary action, al owing a fluid to be transferred from a surface to the towel. The small pores of a sponge act as small capillaries, causing it to absorb a large amount of fluid. Some textile fabrics are said to use Capillary action to "wick" sweat away from the skin. These are often referred to as wicking fabrics, after the Capillary properties of candle and lamp wicks.

3. Capillary action is observed in thin layer chromatography, in which a solvent moves vertically up a plate via Capillary action. In this case the pores are gaps between very small particles.

4. Capillary action draws ink to the tips of fountain pen nibs from a reservoir or cartridge inside the pen.

5. With some pairs of materials, such as mercury and glass, the intermolecular forces within the liquid exceed those between the solid and the liquid, so a convex meniscus forms and Capillary action works in reverse.

6. In hydrology, Capillary action describes the attraction of water molecules to soil particles. Capillary action is responsible for moving groundwater from wet areas of the soil to dry areas. Differences in soil potential ({\displaystyle \Psi_{m}}) drive Capillary action in soil.

Practice Questions based on Capillarity-

<u>**Problem 1.**</u> Water rises to a height of 10cm in a Capillary tube and mercury falls to a depth of 3.5cm in the same Capillary tube. If the density of mercury is 13.6 gm/cc and its angle of contact is 135^{o} and density of water is 1 gm/cc and its angle of contact is 0^{o}, then the ratio of surface tensions of the two liquids is ($\cos 135^{o} = 0.7$)

(a) 1 : 14 (b) 5 : 34 (c) 1 : 5 (d) 5 : 27

Solution : (b) $h = \frac{2T\cos\theta}{rdg}$ $\therefore \frac{h_W}{h_{Hg}} = \frac{T_W}{T_{Hg}} \frac{\cos\theta_W}{\cos\theta_{Hg}} \frac{d_{Hg}}{d_W}$ [as r and g are constants]

$$\Rightarrow \frac{10}{3.5} = \frac{T_W}{T_{Hg}} . \frac{\cos 0^o}{\cos 135} \frac{13.6}{1} \Rightarrow \frac{T_W}{T_{Hg}} = \frac{10 \times 0.7}{3.5 \times 13.6} = \frac{20}{136} = \frac{5}{34}$$

Problem 2. Water rises in a vertical Capillary tube up to a height of 2.0 cm. If the tube is inclined at an angle of 60^o with the vertical, then upto what length the water will rise in the tube

(a) 2.0 cm (b) 4.0 cm (c) 4 cm (d) 2 2 cm

(a) 2.0 *cm* (b) 4.0 *cm* (c) $\frac{4}{\sqrt{3}} cm$ (d) $2\sqrt{2}$ *cm*

Solution : (b) The height upto which water will rise $l = \frac{h}{\cos\alpha} = \frac{2cm}{\cos 60} = 4cm$. [$h$ = vertical height, α = angle with vertical]

Problem 3. Two Capillary tubes of same diameter are kept vertically one each in two liquids whose relative densities are 0.8 and 0.6 and surface tensions are 60 and 50 dyne/cm respectively. Ratio of heights of liquids in the two tubes h_1/h_2 is

Solution : (d) $h = \frac{2T\cos\theta}{rdg}$ [If diameter of capillaries are same and taking value of θ same for both liquids]

$$\therefore \frac{h_1}{h_2} = \left(\frac{T_1}{T_2}\right)\left(\frac{d_2}{d_1}\right) = \left(\frac{60}{50}\right) \times \left(\frac{0.6}{0.8}\right) = \left(\frac{36}{40}\right) = \frac{9}{10}.$$

Problem 4. A Capillary tube of radius R is immersed in water and water rises in it to a height H. Mass of water in the Capillary tube is M. If the radius of the tube is doubled, mass of water that will rise in the Capillary tube will now be

(a) M (b) 2M (c) M/2 (d) 4M

Solution : (b) Mass of the liquid in capillary tube $M = V\rho = (\pi r^2 h)\rho$

$\therefore M \propto r^2 h \propto r$ [As $h \propto \frac{1}{r}$]

So if radius of the tube is doubled, mass of water will becomes 2M, which will rise in Capillary tube.

Problem 5. Water rises to a height h in a Capillary at the surface of earth. On the surface of the moon the height of water column in the same capillary will be

(a) 6h (b) 1/6h (c) h (d) Zero

Solution : (a) $h = \frac{2T\cos\theta}{rdg}$ $\therefore h \propto \frac{1}{g}$ [If other quantities remains constant]

$\frac{h_{moon}}{h_{earth}} = \frac{g_{earth}}{g_{moon}} = 6 \Rightarrow$ $h_{moon} = 6h$ [As $g_{earth} = 6 g_{moon}$]

[As $h \propto \frac{1}{r}$]

Problem 6. Water rises upto a height h in a Capillary on the surface of earth in stationary condition. Value of h increases if this tube is taken

(a) On sun (b) On poles

(c) In a lift going upward with acceleration (d) In a lift going downward with acceleration

Solution : (d) $h \propto \frac{1}{g}$. In a lift going downward with acceleration (a), the effective acceleration decreases. So h increases.

Problem 7. If the surface tension of water is 0.06 N/m, then the Capillary rise in a tube of diameter 1mm is (θ=0^{O})

(a) 1.22 cm (b) 2.44 cm (c) 3.12 cm (d) 3.86 cm

Solution : (b) $h = \frac{2T\cos\theta}{rdg}$, $[\theta = 0,\ r = \frac{1}{2}mm = 0.5\times10^{-3}m,\ T = 0.06N/m,$

$d = 10^3 kg/m^3, g = 9.8\ m/s^2\ ]$

$$h = \frac{2\times0.06\times\cos\theta}{0.5\times10^{-3}\times10^{3}\times9.8} = 0.0244m = 2.44cm$$

Problem 8. Two capillaries made of same material but of different radii are dipped in a liquid. The rise of liquid in one Capillary is 2.2cm and that in the other is 6.6cm. The ratio of their radii is

(a) 9 : 1 (b) 1 : 9 (c) 3 : 1 (d) 1 : 3

Solution : (c) As $h \propto \frac{1}{r}$ $\quad \therefore \frac{h_1}{h_2} = \frac{r_2}{r_1}$ or $\frac{r_1}{r_2} = \frac{h_2}{h_1} = \frac{6.6}{2.2} = \frac{3}{1}$

Problem 9. The lower end of a Capillary tube is at a depth of 12cm and the water rises 3cm in it. The mouth pressure required to blow an air bubble at the lower end will be X cm of water column where X is **[CPMT 1989]**

(a) 3 (b) 9 (c) 12 (d) 15

Solution : (d) The lower end of Capillary tube is at a depth of 12 + 3 = 15 cm from the free surface of water in Capillary tube.

So, the pressure required = 15 cm of water column.

Problem 10. The lower end of a Capillary tube of radius r is placed vertically in water. Then with the rise of water in the Capillary, heat evolved is

(a) $+\frac{\pi^2 r^2 h^2}{J} dg$ (b) $+\frac{\pi r^2 h^2 dg}{2J}$ (c) $-\frac{\pi r^2 h^2 dg}{2J}$ (d) $-\frac{\pi r^2 h^2 dg}{J}$

***Solution* : (b)** When the tube is placed vertically in water, water rises through height h given by $h = \frac{2T\cos\theta}{rdg}$

Upward force $= 2\pi r \times T\cos\theta$

Work done by this force in raising water column through height h is given by

$$\Delta W = (2\pi r T\cos\theta)h = (2\pi r h\cos\theta)T = (2\pi r h\cos\theta)\left(\frac{rhdg}{2\cos\theta}\right) = \pi r^2 h^2 dg$$

However, the increase in potential energy ΔE_p of the raised water column

$$= mg\frac{h}{2}$$

where m is the mass of the raised column of water $\therefore m = \pi r^2 hd$

So, $\Delta E_P = (\pi r^2 hd)\left(\frac{hg}{2}\right) = \frac{\pi r^2 h^2 dg}{2}$

Further, $\Delta W - \Delta E_p = \frac{\pi r^2 h^2 dg}{2}$

The part $(\Delta W - \Delta E_P)$ is used in doing work against viscous forces and frictional forces between water and glass surface and appears as heat. So heat released $= \frac{\Delta W - \Delta E_p}{J} = \frac{\pi r^2 h^2 dg}{2J}$

Problem 11. Water rises in a capillary tube to a certain height such that the upward force

due to surface tension is balanced by 75×10^{-4}N force due to the weight of the liquid. If the surface tension of water is 6 ×10-2 N / m , the inner circumference of the Capillary must be

(a) $1.25\times10^{-2}\,m$ (b) $0.50\times10^{-2}\,m$ (c) $6.5\times10^{-2}\,m$ (d) $12.5\times10^{-2}\,m$

Solution : (d) Weight of liquid = upward force due to surface tension

$75\times10^{-4} = 2\pi r T$ Circumference $2\pi r = \frac{75\times10^{-4}}{T} = \frac{75\times10^{-4}}{6\times10^{-2}} = 0.125 = 12.5\times10^{-2} m$

Conclusive Remarks

A common apparatus used to demonstrate the first phenomenon is the *Capillary tube.* When the lower end of a vertical glass tube is placed in a liquid, such as water, a concave meniscus forms. Adhesion occurs between the fluid and the solid inner wall pulling the liquid column up until there is a sufficient mass of liquid for gravitational forces to overcome these intermolecular forces. The contact length (around the edge) between the top of the liquid column and the tube is proportional to the radius of the tube, while the weight of the liquid column is proportional to the square of the tube's radius. So, a narrow tube will draw a liquid column higher than a wider tube will, given that the inner water molecules cohere sufficiently to the outer ones.

Reference

- de Gennes, Pierre-Gilles; Brochard-Wyart, Françoise; Quéré, David (2004). *Capillarity and Wet ing Phenomena.* Springer New York.
- Wiki source has the text of the1911 Encyclopædia *Britannica* article ***Capillary Action* **
- Wikimedia Commons has media related to Capillary action.

TOPIC :USE OF MEDIA IN ENHANCING PHYSICS

TEACHING –LEARNING STRATEGIES

Introduction about – Using ICT in Enhancing Teaching –Learning Strategies

When we were in school, a class period (or two!) dedicated to watching a film wasdefinitely a highlight for us as students . Now, my learners consistently request movies or

television shows as learning aids, but as an instructor I struggle with how and when to usethem in class.

1. Showing films in the classroom to get the most mileage out of a movie day

How can instructors utilize visual media in a way that enhances rather thaninterrupts learning? A few key strategies can help ensure that the time invested inmovie day is worthwhile.

2. Content to-dos for classroom movies

The focus on the curriculum is essential not just for legal purposes, but to ensure thatyour movie day contributes to forward momentum in your classroom. The storylineof the movie should enhance or iterate course material. a using visual media that isrelevant to the educational questions and larger goals of the classroom.

3. Helping students study films in class: Note-taking, discussion and analysis

Consider what the best use of time is with films and whether teachers wish to show amovie in its entirety, lift specific scenes, or, in the case of teaching

4. it is essential to teach students how to encounter movies as academics rather thansimple observers. Strategies he uses to get the most out of classroom films includeactive listening, note-taking, and occasional interruptions for discussion.

5. “A movie, used strategical y and with accountability pieces, can build inferencingskills, practice identification and analysis of symbols and motifs, and is a natural fitfor exploring method, meaning, and so what.” students can be held accountablewhile they are watching by stopping the film after small sections and asking studentspointed questions about directorial choices and other techniques used in the piece.

6. Movies can show real-world examples of textbook subjects

7. Replays the scene, encouraging the students to cal out when they witness somethingthey have studied. The multiple viewings and active engagement with the clip helphim avoid what might otherwise be a boring lecture but also helps students seereal-world examples of the rather dry textbook definitions they’ve just finishedreading about.

8. This strategy always results in a boisterous affair with the students active andengaged with the material. After the experience, students are welcome to discussany remaining questions or clarifications they need. While my colleague does notshow the movie in its entirety, he shared that often his students will watch the fullmovie at home to prepare for their next in-class clip.

9. movies can play an interesting role in our classrooms, engaging auditory and visuallearners in ways that the textbook or discussions cannot. With a little forethought

and planning, ful movies and movie clips can become an essential piece of ourclassrooms, enhancing rather than interrupting learning.

Movie Time -The Inception

Welcome to the dream world. A tremendously exciting science-fiction thriller that's asdisturbing as it sounds. This is a popular entertainment with a knockout punch so intenseand unnerving it'll have you worrying if it's safe to close your eyes at night.

Introduction of

Inception is a science-fiction action thriller film .A thief, who steals corporatesecrets through use of dream-sharing technology, is given the inverse task of planting anidea into the mind of a CEO.

Synopsis

Dom Cobb (Leonardo DiCaprio) and his partner Arthur (Joseph Gordon-Levit) performillegal corporate espionage by entering the subconscious minds of their targets, usingtwo-level "dream within a dream" strategies to "extract" valuable information. Each of the"extractors" carries a "totem", a personalized small object whose behavior is unpredictableto anyone except to the totem's owner, to determine if they are within another person'sdream. Cobb's totem is a spinning top which spins perpetual y in the dream state. Cobbstruggles with memories of his dead wife Mal (Marion Cotillard) that manifest within thedream and try to sabotage his efforts.

Cobb is approached by the wealthy Mr. Saito (Ken Watanabe) asking them to perform theact of "inception", planting an idea within the person's subconscious mind. Saito wishes tobreak up the vast energy empire of his competitor, the ailing Maurice Fischer (PetePostlethwaite), by suggesting this idea to his son Robert Fischer (Cillian Murphy) who wilinherit the empire when his father dies. Should Cobb succeed, Saito promises to use hisinfluence to clear Cobb of the murder charges for his wife's death, al owing Cobb tore-enter the United States and reunite with his children. Cobb assembles his team: Eames(Tom Hardy), an identity forger; Yusuf (Dileep Rao), a chemist who concocts the powerfulsedative needed to stabilize the layers of the shared dream; and Ariadne (Ellen Page), ayoung student architect tasked with designing the labyrinth of the dream landscapes. Whileplanning the inception, Ariadne learns of the guilt Cobb struggles with from Mal's suicideand his separation from his children when he fled the country as a fugitive.

The job is set into motion when Maurice Fischer dies and his son accompanies his father'sbody from Sydney to Los Angeles. During the flight, Cobb sedates Fischer, and the teambring him into a three-level shared dream. At each stage, the member of the team who is"creating" the dream remains while the other team members fall asleep within the dream totravel further down into Fischer's subconscious. The dreamers will then ride a synchronizedsystem of "kicks" (a car diving off a bridge, a falling elevator, and a collapsing building)back up the levels to wake up to reality. In the first level, Yusuf's dream of a rainy city, theteam successfully abducts Fischer, but the team is attacked by Fischer's militarizedsubconscious projections, which have been trained to hunt and kill extractors. Saito ismortal y wounded during the shoot-out, but due to the strength of Yusuf's sedative, dying inthe dream will send them into limbo, a deep subconscious level where they may lose theirgrip on reality and be trapped indefinitely.

Eames takes the appearance of Fischer's godfather Peter Browning (Tom Berenger) tosuggest that he reconsider his opinion of his father's will . Yusuf remains on the first leveldriving a van through the streets, while the remaining characters enter Arthur's dream,taking place in a corporate hotel. Cobb turns Fischer against Browning and persuades himto join the team as Arthur runs point, and they descend to the third dream level, a snowymountain fortress dreamed by Eames, which Fischer is told represents Browning'ssubconscious. Yusuf's evasive driving on the first level manifests as distorted gravityeffects on the second and an avalanche on the third.

Saito succumbs to his wounds, and Cobb's projection of Mal sabotages the plan by shootingFischer dead.[11] Cobb and Ariadne elect to enter limbo to find Fischer and Saito. There,Cobb confronts his projection of Mal, who tries to convince him to stay with her and hiskids in limbo. Cobb refuses and confesses that he was responsible for Mal's suicide: to helpher escape from limbo during a shared dream experience, he inspired in her the idea that herworld wasn't real. Once she had returned to reality, she became convinced that she was stilldreaming and needed to die in order to wake up. Through his confession, Cobb attainscatharsis and chooses to remain in limbo to search for Saito; Eames defibril ates Fischer tobring him back up to the third-level mountain fortress, where he enters a safe room anddiscovers and accepts the idea to split up his father's business empire.

Leaving Cobb behind, the team members escape by riding the kicks back up the levels ofthe dream. Cobb eventually finds an elderly Saito who has been waiting in limbo fordecades in dream time (just a few hours in real time), and the two help each other toremember their arrangement. The team awakens on the flight; Saito arranges for Cobb toget through U.S. customs, and he goes home to reunite with his children. Cobb uses hisspinning top to test reality but is distracted by his children before he sees the result.

In the last two frames of the movie the top begins swaying and is about to fall just as thescreen goes black.

Activity 1

After watching movie- discussion on the Theme-**Reality and dreams**

In *Inception*, Nolan wanted to explore "the idea of people sharing a dream space...That gives you the ability to access somebody's unconscious mind. What would that be used and abused for?" The majority of the film's plot takes place in these interconnected dream worlds. This structure creates a framework where actions in the real or dream worlds ripple across others. The dream is always in a state of production, and shifts across the levels as the characters navigate it. By contrast, the world of *The Matrix*(1999) is an authoritarian, computer-controlled one, alluding to theories of social control developed by Michel Foucault and Jean Baudrillard. Nolan's world has more in common with the works of Gilles Deleuze and Félix Guattari.

David Denby in *The New Yorker* compared Nolan's cinematic treatment of dreams to Luis Buñuel's in Bel e de Jour (1967) and The Discreet Charm of the Bourgeoisie(1972).[65] He criticized Nolan's "literal-minded" action level sequencing compared to Buñuel, who "silently pushed us into reveries and left us alone to enjoy our wonderment, but Nolan is working on so many levels of representation at once that he has to lay in pages of dialogue just to explain what's going on." The latter captures "the peculiar malign intensity of actual dreams.

Deirdre Barret , a dream researcher at Harvard University, said that Nolan did not get every detail accurate regarding dreams, but their illogical, rambling, disjointed plots would not make for a great thriller anyway. However, "he did get many aspects right," she said, citing the scene in which a sleeping Cobb is shoved into a full bath, and in the dream world water gushes into the windows of the building, waking him up. "That's very much how real stimuli get incorporated, and you very often wake up right after that intrusion".

Nolan himself said, "I tried to work that idea of manipulation and management of a conscious dream being a skill that these people have. really the script is based on those common, very basic experiences and concepts, and where can those take you? And the only outlandish idea that the film presents, really, is the existence of a technology that allows you to enter and share the same dream as someone else.

Activity-2 After watching movie- discussion on the Theme Dreams and cinema

Others have argued that the film is itself a metaphor for film-making, and that the filmgoing experience itself, images flashing before one's eyes in a darkened room, is akin to a dream. Writing in Wired, Jonah Lehrer supported this interpretation and presented neurological evidence that brain activity is strikingly similar during film-watching and sleeping. In both, the visual cortex is highly active and the prefrontal cortex, which deals with logic, deliberate analysis, and self-awareness, is quiet.[67] Paul argued that the experience of going to a picture house is itself an exercise in shared dreaming, particularly when viewing *Inception:* the film's sharp cutting between scenes forces the viewer to create larger narrative arcs to stitch the pieces together. This demand of production parallel to consumption of the images, on the part of the audience is analogous to dreaming itself. As in the film's story, in a cinema one enters into the space of another's dream, in this case Nolan's, as with any work of art, one's reading of it is ultimately influenced by one's own subjective desires and subconscious.[64] At Bir-Hakeim bridge in Paris, Ariadne creates an illusion of infinity by adding facing mirrors underneath its struts, Stephanie Dreyfus in *la Croix* asked "Is this not a strong, beautiful metaphor for the cinema and its power of illusion?

Activity -3 Discussions on the questions after the movie in groups

1. **Critical responses?**
2. **How to visualize this movie from physics point of view?**
3. **How would you react on being offered a chance to have his criminal history erased as payment for a task considered to be impossible: "inception", the implantation of another person's idea into a target's subconscious?**

Activity -4 what are the dreaming rules within Inception?

[ANSWER] – There are very specific rules surrounding how the world of the dream works. Rules as to how you enter and leave a dream. Rules surrounding Limbo and also for leaving Limbo too. basically they amount to:

1. Dying in dream is a kick & wakes you up, one layer anyway.

2. Dying in a deep dream sends you to limbo

3. Dreaming in too many layers too deeply sends you to limbo

4. Dying in limbo wakes you up total y

Obviously these different rules fold back in on themselves as the situation becomes more complex and the location of the dreamer becomes in question. Some of these will come up later on in the list here – but for now this is a good basic framework to work with.

Activity -5 What exactly is Limbo?

[Answer] – Limbo is defined within the movie as "Unstructured Dream Space". The only way Limbo is filled is if there was previous inhabitants who filled it from previous visits. Which, of course, Cobb was the last visitor there. So it has been filled with Mal's disintegrating city and it is that city we see falling into the ocean upon Ariadne & Cobb's arrival.

Activity -6 Who dreams each dream in your dream diagram?

[Answer]- The dream within the dream within a dream business can get pretty confusing really very fast. And even some of the characters within the movie even comment on it – like when Ariadne objected – "Wait, who's dream exactly are we going into?" So, in an effort to clarify the various layers and their dream spaces here is a list of the dreamers for each. And please make sure, if you get confused, to consult the **7 layer dream diagram** I created.

– **Level One** – Reality – Dreamer: No one

– **Level Two** – Inception's "Reality" – Dreamer: Cobb

– **Level Three** – Van Chase – Dreamer: Yusaf's

– **Layer Four** – Hotel/Bar – Dreamer: Arthur

– **Layer Five** – Snow Fortress – Dreamer: Fischer Jr.

– **Layer Six** – Cobb's Limbo – Dreamer: Ariadne?

– **Layer Seven** – Saito's Limbo – Dreamer: Saito

Obviously it is unclear which of the two, Ariadne or Cobb Actually execute the dream when leaving the Snow Fortress – so this is unclear. Others have argued that neither Limbo locations have a dreamer as they are shared dream space. Which very well could be true. Which leads us to our next question.

Activity -7 How do Ariadne & Cobb get to Limbo?

[Answer] – Think back to the Snow Fortress. There on the floor as Ariadne begins to posit how they could salvage the entire mission – they could dream down another layer, find him, and kick back all the way to the surface with everyone else. We saw a dream machine on the floor. They basically intimated that they didn't commit suicide to get down to Limbo (which is possible) they Actually dreamed down another layer into Limbo.

Now as for the Saito bit – that is a little more complicated. There are three different possibilities here and it basically depends on how you think Limbo works as to which one is the correct answer. But ultimately either Cobb shot himself, Dove another dream layer deeper or hoofed it on foot to find him. Cobb's shooting himself makes zero sense if Cobb really is in Limbo and not in a dream state. We just watched Ariadne jump and wake up in the Van Chase layer. So this option can't be right. Cobb's dreaming himself another layer deeper is very plausible, but we don't see a dream machine near by like we did in the Snow Fortress. Cobb's hiking himself around Limbo until he found him is a bit of a stretch. The walk-about option suffers dramatically in that we actually see Cobb get spat up on the beach of Saito's Limbo layer at the beginning of the movie.

So, with that said, now you know why in my dream layer map I went with the second option. Even though we don't see a dream machine its the only option that really makes any sense. Cobb must have dreamed down one more layer to get Saito back. Definitely open to hearing other theories here, but it makes the most sense to me.

Activity -7 What happens when the main dreamer wakes up?

[Answer] -You would think that either everyone would wake up, or that everything populated by the dreamer's brain would disappear. But what happens is a little different. basically the dream begins to unravel and it takes more sedative to try and keep the mark under. Remember the initial dream sequences at the beginning of the movie? Two layers, one was the architect, the other was Arthur. But Cobb cuts his time in his own dream short with a bullet to the head. This sends him up a layer. But that then means that the dream gets unpredictable and all wobbly-like. And Arthur goes running to Saito while he was dreaming in an attempt to juice him up a bit more and keep him under.

The second bit of the question is brought to us by Coexist – and its quite a bit more theoretical than the previous answer. Because we never saw the Mark wake up first everything we posit here will be conjecture. But my guess is that it would be exactly like when the team went to inspect a dream space? They walked the streets of the dream and there was no one there. The Mark enters the dream and fills it with his psyche & projections. If he were to awaken, the team would be left standing there with an empty architected dream space on their hands and no one to bamboozle.

Activity -8 How do the totems work?

[Answer] – This is such a huge question I wrote an entire blog to discuss the various Totems throughout inception. But, *since brevity is the soul of wit,* and tediousness the limbs and outward flourishes, I will be brief. Totems were created by Mal as a way to keep track of when you were in someone else's dream and when you were in reality. Because dreaming was so realistic it became possible that you may be getting manipulated by a dreamer and you would never know. Without a totem that is. The various totems identified in the movie:

Mal – Spinning Top

Eames – Poker Chips

Ariadne – Chess Bishop Piece

Arthur – Loaded Dice

Cobb – Mal's Top

One thing you must note. Many people get this wrong. Totems do not tell you whether you are in your own dream or not. They only tell you if you are in someone else's dream.

Activity -8 What caused Cobb and Saito to "wake-up"?

[Answer] – Quincy brought us this question over on the 7 Layers blog – and its a good one that delves into those pesky dream rules. So, lets review Question #1's answer above. What are the rules on which the dream layers are governed? The final rule being that death in a dream layer causes one to wake up. Sow with that in mind, my assumption has always been Cobb killed Saito then himself. Or vice versa. The rules on moving between layers and into limbo are pretty complicated and contradictory at times. But remember the head on the track business? Definitely their only way back to the surface was by killing themselves. So unless Cobb and Saito chose to build a train in Saito's living room and lay on the tracks… I'm guessing the gun was the kick back to reality.

Activity -9 Why is Saito so much older than Cobb in the final dream level?

[Answer] – There are two potential explanations for this. The first is that Cobb took a while to find Saito. And it was during this time where Saito aged 10 times faster every layer you go deeper. If you don't believe that Saito's world is a sub-layer of Limbo, then the only other option is that Saito had forgot en he was in Limbo and therefore he aged while Cobb held on to the truth of where they were and subsequently he did not age. Actually another option now that I'm sitting here staring at this one – is that since we are seeing all this from Cobb's perspective, his vision of himself could have been of himself as a young man. So I guess there are THREE potential explanations here.

Activity -10 How do Mal & Cobb end up in Limbo the first time?

[Answer] – The only evidence we have here is Cobb's explanation of how he came to need an inception. basically he tells us that Mal & he jointly experimented on the various ways to fully utilize the dream machine. They continued to push the limits of the dreamstates and ultimately ended up going too far. Either they used extremely deep sedatives and then kil ed themselves intending to kick back up a layer or they pushed too deeply and lost perspective. But I would argue that the movie seems to suggest that going too deep is how Ariadne & Cobb arrived in Limbo after going to find Fischer Jr. So it was most likely that they just went too deep and completely lost track of al reality while they were there.

Activity -11 If the whole thing is a dream – why did the top stop earlier?

[Answer] – This question is the whole crux of my entire argument for blog 1 & blog 2 so it is really near and dear to my heart. Its the premise upon which I got so fixate with this entire movie. But its also the question that has alienated me from my friends, my family and roaming street salesmen. If the movie's a dream – then why the heck does the totem stop spinning two separate times in the movie? COUNT THEM – TWO!

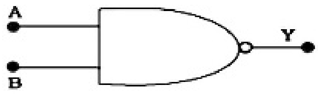
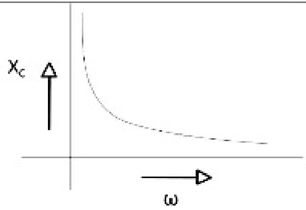
Conclusive Remarks

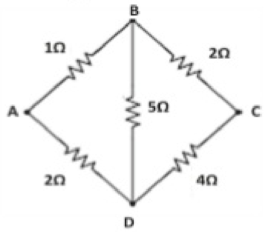
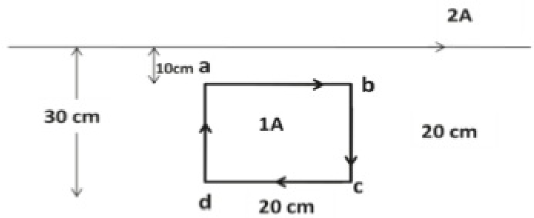
well, this is Actually easier than it would seem to explain. But within my dream layer map I show the top layer to be Cobb's dream – which is the whole Inception Movie. The reason for this is simple. Although I found that thinking of Cobb being trapped in Mal's dream more romantic and gorgeous a though – it was not supportable as his dream would have been WAY WAY unstable. And Mal would have had to work to keep him a sleep – and in fact she is working for the opposite so this made no sense. But Cobb being adrift in his own dream is elegant in many ways.

But, basically because your totem only tells you when you are in someone else's dream, not when you are in your own dream Cobb wouldn't know if he were stuck in his own dream state. By why did it specifical y STOP spinning in his dream, and continue to spin in dream? well, that is explained by the fact that its his dream, it'l do whatever he thinks it should do. Remember when Cobb asks Mal, "well, if this is a dream, why can't I control you?" What was Mal's response? "BECAUSE YOU DON'T KNOW YOU ARE DREAMING." Right? Same with the top. His brain just tells it to do what he thinks it ought to be doing.

So therefore, if you ascribe to this theory, that al of Inception is a dream – like I vehemently do – then you believe that Cobb has lossed grasp of reality with al his various dream-comings-and-goings. Mal continues to wait for him in the upper most reality layer and Cobb's mind continues to weave fascinating tableux's for our summer box office amusement. Can't wait to see what Cobb's mind weaves for us for the sequel! If you have others to add to this post – don't hesitate to drop them in below and as we define their answers as canon I'l add them here.

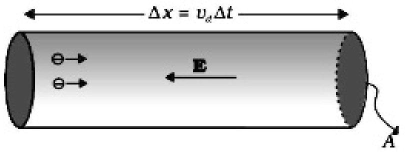
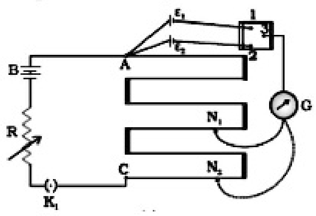
MARKING SCHEME
SET 55/1(Compartment)

Q. No.	Expected Answer / Value Points	Marks	Total Marks
	Section A		
Set1,Q1 Set2,Q5 Set3,Q4	If it were not so, the presence of a component of the field along the surface would violate its equipotential nature. [Accept any other correct explanation)	1	1
Set1,Q2 Set2,Q1 Set3,Q5	It would decrease. **[NOTE: Also accept if the student just writes 'yes']**	1	1
Set1,Q3 Set2,Q2 Set3,Q1	 A B Y / 0 0 1 / 0 1 1 / 1 0 1 / 1 1 0	½ + ½	1
Set1,Q4 Set2,Q3 Set3,Q2	 	1	1
Set1,Q5 Set2,Q4 Set3,Q3	In amplitude modulation, the amplitude, of the carrier wave, changes in accordance with the modulating signal, while in frequency modulation, frequency of the carrier wave varies in accordance with the modulating signal. **[NOTE: Also accept if the student draws graphs for the two types of modulation]**	1	1
	Section B		
Set1,Q6 Set2,Q10 Set3,Q9	Definition of electric flux ½ S.I. unit ½ Calculation of flux 1 The 'electric flux', through an elemental area $d\vec{s}$, equals the dot product of $d\vec{s}$, with the electric field, $\vec{E}$. [**Alternatively:** Electric flux is the number of electric field lines passing through a given area.] [Also accept, $d\phi = \vec{E}.d\vec{s}$ Or $\phi = \oint_s \vec{E}.d\vec{s}$] S.I. units: $\left(\frac{\text{N-m}^2}{\text{C}}\right)$ or (V-m) $\phi = \vec{E}.\vec{S} = ES(as\ \theta = 0^o)$	½ ½ ½	

	$= 3 \times 10^3 \times (10 \times 10^{-2})^2 \frac{\text{N-m}^2}{\text{C}}$ $= 30 \; \frac{\text{N-m}^2}{\text{C}}$	½	2
Set1,Q7 Set2,Q6 Set3,Q10	Calculation of Equivalent Resistance of the network 1½ Calculation of current ½ The given network has the form given below:  It is a balanced wheatstone Bridge. Its equivalent resistance, R, is given by $\frac{1}{R} = \frac{1}{1+2} + \frac{1}{2+4} = \frac{1}{2}$ $R = 2\Omega$ ∴ Current drawn= $\frac{4\text{V}}{2\Omega} = 2\text{A}$	½ ½ ½ ½	2
Set1,Q8 Set2,Q7 Set3,Q6	Formula ½ Calculation of net force on the loop 1 Direction of the net force ½  Here I_1=2A ; I_2=1A d_1 =10 cm ; d_2=30 cm $\mu_o = 4\pi \times 10^{-7}$ Tm A^{-1} We have $F = \frac{\mu_o I_1 I_2}{2\pi d} l$ ∴ Net force on sides ab and cd $= \frac{\mu_o \, 2\times1}{2\pi} \times 20 \times 10^{-2} \left[\frac{1}{10\times10^{-2}} - \frac{1}{30\times10^{-2}}\right]\text{N}$ $= 4 \times 10^{-7} \times 20 \left[\frac{20}{10 \times 30}\right] \text{N}$ $= \frac{16}{3} \times 10^{-7}\text{N} \quad = 5.33 \times 10^{-7}\text{N}$ This net force is directed towards the infinitely long straight wire.	 ½ ½	

	Net force on sides bc and da = zero. ∴ Net force on the loop = 5.33×10^{-7} N The force is directed towards the infinitely long straight wire. **OR** Formula ½ Calculation of angle between $\overrightarrow{\mu_m}$ and $\vec{B}$ ½ Calculation of $\lvert\overrightarrow{\mu_m}\rvert$ and torque ½ + ½ Torque = $\overrightarrow{\mu_m} \times \vec{B}$ $\lvert\overrightarrow{\mu_m}\rvert = nI \times A = 200 \times 5 \times 100 \times 10^{-4} A\text{-}m^2$ $= 10\ A\text{-}m^2$ Angle between $\overrightarrow{\mu_m}$ and $\vec{B} = 90^o - 60^o = 30^o$ ∴ $\lvert Torque\rvert = 10 \times 0.2 \times \sin 30^o$ =1 N-m	½ ½ ½ ½ ½ ½	2 2
Set1,Q9 Set2,Q10 Set3,Q7	Naming of the three waves ½ + ½ + ½ Method of production (any one) ½ i. γ rays (or X-rays) ii. Ultraviolet rays iii. Infrared rays Production γ rays : (radioactive decay of nuclei) X-rays : (x-ray tubes or inner shell electrons) UV- rays: (Movement from one inner energy level to another) Infrared rays: (vibration of atoms and molecules) (Any one)	 ½ ½ ½ ½	2
Set1,Q10 Set2,Q9 Set3,Q8	(a) Finding the transition 1 (b) Radiation of maximum wavelength ½ Justification ½ (a) For hydrogen atom, E_1= -13.6 eV ; E_2 = -3.4 eV ; E_3 = -1.51 eV; E_4 = -0.85eV h=6.63×10^{-34} Js ; c=$3\times10^8 ms^{-1}$ Photon Energy= $\frac{hc}{\lambda}$ $= \frac{6.63 \times 10^{-34} \times 3 \times 10^8}{496 \times 10^{-9} \times 1.6 \times 10^{-19}}$ eV ≅ 2.5 eV This equals (nearly) the difference (E_4-E_2). Hence the required transition is (n=4) to (n=2) **[Alternatively :** If the candidate calculates by using Rydberg formula, and identifies correctly the required transition, full credit may be given.] (b) The transition n=4 to n=3 corresponds to emission of radiation of maximum wavelength. It is so because this transmission gives out the photon of least energy.	 ½ ½ ½ ½	 2

Section C

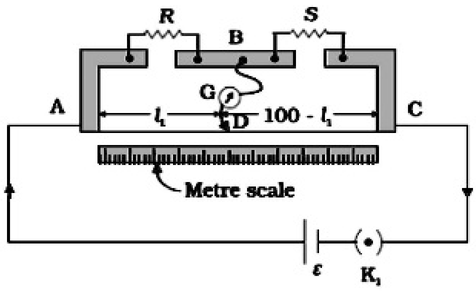
Set1,Q11 Set2,Q19 Set3,Q16	(a) Derivation of the relation between I and $\lvert\vec{v_d}\rvert$ — 2 (b) Calculation of the charge flowing in 10 s — 1		
	(a) According to the figure, $\Delta x = v_d st$ Hence, amount of charge crossing area A in time Δt	½	
		½	
	$\therefore \Delta Q = I\Delta t = neA\lvert v_d\rvert\Delta t$	½	
	$\therefore I = neAv_d$	½	
	(b) Charge flowing $= \sum I\Delta t$ =area under the curve	½	
	$= \left[\frac{1}{2} \times 5 \times 5 + 5(10-5)\right] C$ =37.5 C	½	3
Set1,Q12 Set2,Q20 Set3,Q17	Circuit Diagram — 1 Working Principle — ½ Derivation of necessary formula — 1 ½		
	The circuit diagram , of the potentiometer, is as shown here: 	1	
	Working Principle: The potential drop, V, across a length l of a uniform wire, is proportional to the length l of the wire. (or $V \propto l$ (for a uniform wire)	½	
	Derivation: Let the points 1 and 3 be connected together. Let the balance point be at the point N_1 where $AN_1=l_1$ Next let the points 2 and 3 be connected together. Let the balance point be at the point N_2 where $AN_2=l_2$.	½	
	We then have $\varepsilon_1 = kl_1$ $and\ \varepsilon_2 = kl_2$	½	

$\therefore \frac{\varepsilon_1}{\varepsilon_2} = \frac{l_1}{l_2}$ ½ 3

OR

Circuit Diagram	½
Working Principle	1
Determination of unknown resistance	1
Precautions	½

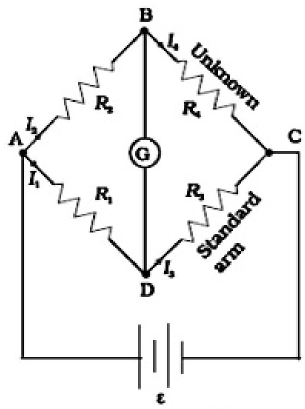
The circuit diagram of the meter bridge is as shown below:



½

Working Principle: The working principle of the meter bridge is the same as that of a wheatstone bridge. The Wheatstone bridge gets balanced when:

$$\frac{R_2}{R_1} = \frac{R_4}{R_3}$$



½

For the meter bridge, circuit shown above, this relation takes the form

$$\frac{R}{S} = \frac{l_1}{(100 - l_1)}$$ ½

Determination of unknown Resistance (*R*):

In the circuit diagram shown above, *S* is taken as a known standard resistance. We find the value of the balncing length l_1, corresponding to a given value of *S*. We then use the relation:

½

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$$\frac{R}{S} = \frac{l_1}{(100 - l_1)}$$

to calculate R.
By choosing (at least three) different value of S, we calculate R each time.
The average of these values of R gives the value of the unknown resistance.

Precautions:
(1) Make all contacts in a neat, clean and tight manner
(2) Select those values of S for which the balancing length is close to the middle point of the wire.**[Any one]**
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½</td>
<td>3</td>
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<tr>
<td>Set1,Q13
Set2,Q21
Set3,Q18</td>
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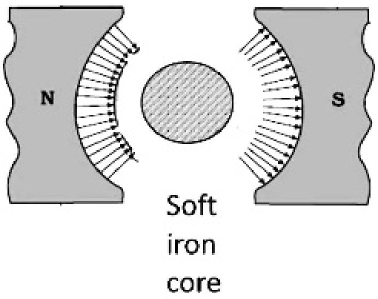
(a) Need for having a radial Magnetic field	1
Achieving the radial field	½
(b) Formula	½
Calculation of the required resistance	1

(a) Need for a radial magnetic field:
The relation between the current (i) flowing through the galvanometer coil, and the angular deflection (ϕ) of the coil (from its equilibrium position), is

$$\phi = \left(\frac{NABI \sin\theta}{k}\right)$$

where θ is the angle between the magnetic field $\vec{B}$ and the equivalent magnetic moment $\overrightarrow{\mu_m}$ of the current carrying coil.
Thus I is not directly proportional to ϕ. We can ensure this proportionality by having $\theta = 90^o$. This is possible only when the magnetic field, $\vec{B}$, is a radial magnetic field. In such a field, the plane of the rotating coil is always parallel to $\vec{B}$.
To get a radial magnetic field, the pole pieces of the magnet, are made concave in shape. Also a soft iron cylinder is used as the core.
[**Alternatively** : Accept if the candidate draws the following diagram to achieve the radial magnetic field.]



(b) We have $R = \left[\frac{V}{I_m} - G\right]$

$$\therefore I_m = \frac{V}{R + G}$$

We must also have

$$I_m = \frac{\left(\frac{V}{2}\right)}{R' + G}$$
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<td>where R' = Resistance required to change the range from) 0 to $V/2$
$$\therefore 1 = \frac{2(R' + G)}{R + G}$$
$$\therefore R' = \frac{R - G}{2}$$</td>
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<td>3</td>
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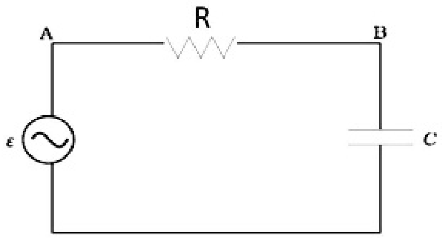
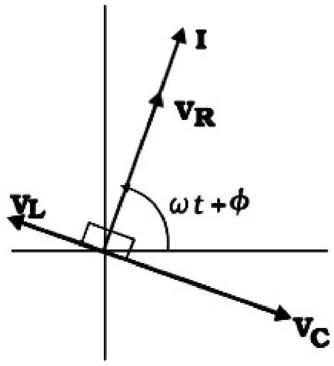
<tr>
<td>Set1,Q14
Set2,Q22
Set3,Q19</td>
<td>

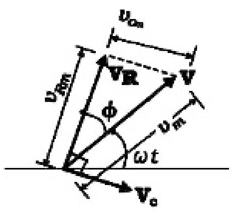
Circuit diagram	½
Phasor Diagram	½
Obtaining the expression for:	
(i) Impedence	1 ½
(ii) Phase angle	½

The circuit diagram and the phasor diagram, for the given circuit, are as shown.





<u>Derivation</u>:
The voltage equation, for the circuit, can be written as:
$$v_r + v_c = v$$
The phasor relation, whose vertical component gives the above equation, is
$$\mathbf{V_R} + \mathbf{V_C} = \mathbf{V}$$



The Pythagoras theorem gives</td>
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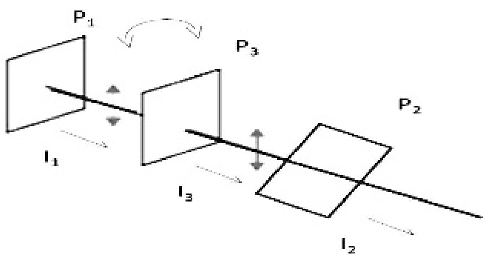
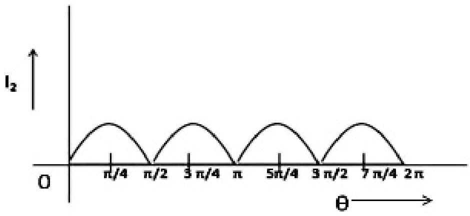
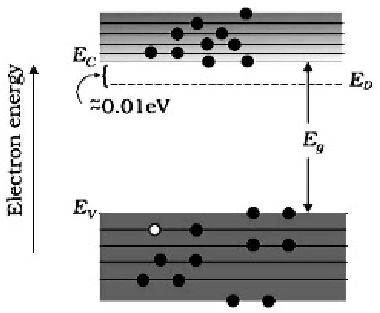
	$v_m^2 = v_{RM}^2 + v_{cm}^2$ Substituting the values of v_{RM} and v_{cm}, into this equation, gives $v_m^2 = (i_m R)^2 + (i_m X_C)^2 = i_m^2(R^2 + X_c^2)$ $\therefore i_m = \frac{v_m}{\sqrt{R^2 + X_c^2}}$ ∴ The impedance of the circuit is given by: $Z = \sqrt{R^2 + X_c^2} = \sqrt{R^2 + \frac{1}{\omega^2 C^2}}$ The phase angle ϕ is the angle between V_R and V. Hence $\tan\phi = \frac{X_C}{R} = \frac{1}{\omega CR}$	½ ½ ½	3
Set1,Q15 Set2,Q11 Set3,Q20	(i) Formula for magnetic moment ½ Calculation of magnetic moment 1 (ii) Formula for torque ½ Calculation of torque 1 (i) Associated magnetic moment $\mu_m = niA$ $= 2000 \times 4 \times 1.6 \times 10^{-4}$ A − m² $= 1.28$ A − m² (ii) torque $= \mu_m B \sin\theta$ $= 1.28 \times 7.5 \times 10^{-2} \times \sin 30^o$ $= 0.048$ N − m	½ ½ ½ ½ ½ ½	3
Set1,Q16 Set2,Q12 Set3,Q21	(a) Formula ½ Calculation of the ratio 1 (b) Answering about Conservation of Energy ½ Explanation 1 (a) $\frac{I_{max}}{I_{min}} = \left\|\frac{a_1+a_2}{a_1-a_2}\right\|^2$ Here $\frac{a_1}{a_2} = \sqrt{\frac{W_2}{W_1}} = \sqrt{\frac{4}{1}} = \frac{2}{1}$ $\therefore \frac{I_{max}}{I_{min}} = \left\|\frac{2a_2 + a_2}{2a_2 - a_2}\right\|^2 = 9:1$ (b) There is NO violation of the conservation of energy. The appearance of the bright and dark fringes is simply due to a 'redistribution of energy'.	½ ½ ½ ½ 1	3
Set1,Q17 Set2,Q13 Set3,Q22	(a) Factors by which the resolving power can be increased. 1 (b) Formula ½ Estimation of angular separation 1 ½ (a) The resolving power of a telescope can be increased by		

	(i) increasing the diameter of its objective (ii) using light of short wavelength **[Note: Give full credit even if a student writes just the first of these two factors.]** (b) Position of Maxima: $\theta \approx \left(n+\frac{1}{2}\right)\frac{\lambda}{a}$; position of minima = $\frac{n\lambda}{a}$ For first order maxima, $\theta = \frac{3\lambda}{2a}$ and for third order minima, $\theta = \frac{3\lambda}{a}$ ∴ Required angular separation $= \frac{3\lambda}{2a} = \frac{3 \times 600 \times 10^{-9}}{2 \times 1 \times 10^{-3}}$ radian $=9 \times 10^{-4}$ radian	1 ½ ½ ½ ½	3
Set1,Q18 Set2,Q14 Set3,Q11	(a) Reason for preferring sun glasses made up of polaroids 1 (b) Formula for intensity of light transmitted through P_2 1 ½ Plot of I vs θ ½ (a) Polaroid sunglasses are preferred because they can be much more effective than coloured sunglasses in cutting off the harmful (UV) rays of the sun. **[Alternatively :** Poloroid sun glasses are prefered over coloured sun glasses because they are more effective in reducing the glare due to reflections from horizontal surfaces.**]** **[Alternatively :** Poloroid sun glasses are prefered over coloured sun glasses because they provide a better protection to our eyes.**]** (b)  Let θ be the angle between the pass axis of P_1 and P_3. The angle between the pass axis of P_3 and P_2 would then be $\left(\frac{\pi}{2}-\theta\right)$. By Malus' law, $I_3 = I_1 cos^2\theta$ and $I_2 = I_3 \cos^2\left(\frac{\pi}{2}-\theta\right) = I_3 \sin^2\theta$ $\therefore I_2 = I_1 \cos^2\theta \sin^2\theta = \frac{I_1(\sin 2\theta)^2}{4}$ The plot of I_2 vs θ, therefore, has the form shown below:	 1 ½ ½ ½	

		½	3
Set1,Q19 Set2,Q15 Set3,Q12	(a) Completing the reactions ½ + ½ (b) Basic processes involved in β^- and β^+ decay ½ + ½ (c) Reason for difficulty in dejecting neutrinos 1 (a) We have (i) ${}^{208}_{84}\mathrm{Po} \rightarrow {}^{204}_{82}\mathrm{Pb} + {}^{4}_{2}\mathrm{He} + Q$ (Also accept if Q is not written) (ii) ${}^{32}_{15}\mathrm{P} \longrightarrow {}^{32}_{16}\mathrm{S} + {}^{0}_{-1}e + \bar{\upsilon}$ [Also accept if $\bar{\upsilon}$ *is not written*] (b) The basic processes involved are (i) ${}^{1}_{0}n \longrightarrow {}^{1}_{1}p + {}^{0}_{-1}\beta^- + \bar{\upsilon}$ (ii) ${}^{1}_{1}P \longrightarrow {}^{1}_{0}n + {}^{0}_{1}\beta^+ + \upsilon$ (c) Neutrinos are difficult to detect because: (i) they have only weak interactions with other particles (ii) they can penetrate large quantity of matter without any interaction. **[Any one]**	½ ½ ½ ½ 1	3
Set1,Q20 Set2,Q16 Set3,Q13	Energy Band Diagrams ½ + ½ Explaining the role of donor and acceptor energy levels 1+1  (i) n-type semiconductor at T > 0K	½	

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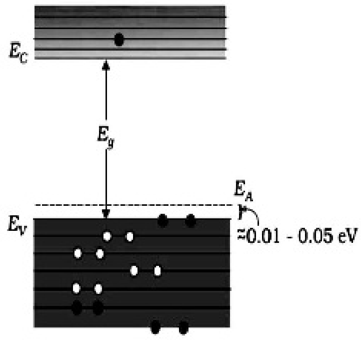

(ii) p-type semiconductor at T > 0K
For a n-type semiconductor
The electrons, from the donor impurity atoms, can move into the conduction band with very small supply of energy. The conduction band, therefore, has electrons as the majority charge carriers.
For a p-type semiconductor
In these semiconductors, a very small supply of energy can cause an electron from its valence band to jump to the acceptor energy level. The valence band, therefore, has a dominant density of holes in it. This effectively implies that the holes are the majority charge carriers in a p-type semiconductor.
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1

1</td>
<td>3</td>
</tr>
<tr>
<td>Set1,Q21
Set2,Q17
Set3,Q14</td>
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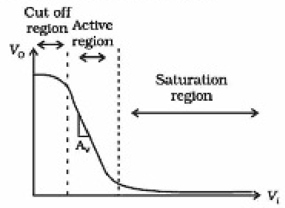
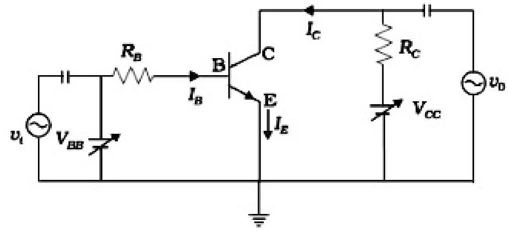
Plot of transfer characteristics; use & reason	½ + ½
Circuit diagram	1
Working	1

The transfer characteristic has the form shown:


The Active Region of the transfer characteristic is used for amplification because in this region, I_C increases almost linearly with increase of V_i
The circuit diagram of the base biased transistor amplifier, in CE configuration, is shown below:


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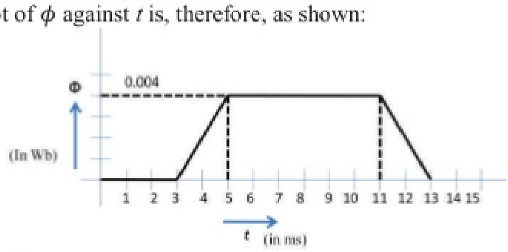
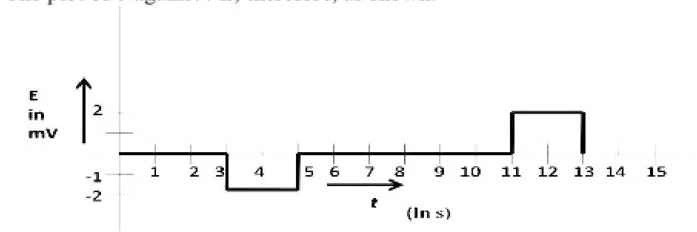
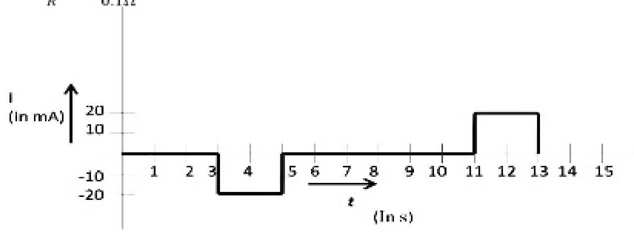
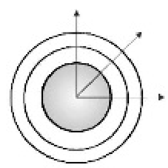
	Working: The sinusoidal voltage, superposed on the dc base bias, causes the base current to have sinusoidal variations. As a result the collector current, also has similar sinusoidal variations present in it. The output, between the collector and the ground, is an amplified version of the input sinusoidal voltage. (Also accept 'other forms' for explanation of 'working'	1	3
Set1,Q22 Set2,Q18 Set3,Q15	Explanation of each of three terms 1+1+1 (i) Internet Surfing Visiting, or using, the different websites on the internet. (ii) Social networking Social networking implies using site like (a) Facebook, Twitter, etc, to share ideas and information with a large number of people. (b) Using internet for chatting, video sharing, etc, among friends and acquaintances. (Any one) (iii) E-mail Using internet(rather than the post office) for exchanging (multimedia) communication between different persons and organizations.	1 1 1	3
	Section D		
Set1,Q23 Set2,Q23 Set3,Q23	(1) Value displayed by Dr. Kapoor Bimla's parents 1+1 (2) Reason for safety 1 (3) Definition and Significance ½ + ½ (1) Dr. Kapoor : Helpful & Considerate Bimla's Parents: Gratefulness (2) It is considered safe to be inside a car during lightening and thunderstorm as the electric field inside a conductor is zero. (3) Dielectric strength of a dielectric indicates the strength of the electric field that a dielectric can withstand without breaking down. This signifies the maximum electric field up to which the dielectric can safely play its role.	1 1 1 ½ ½	4
	Section E		
Set1,Q24 Set2,Q26 Set3,Q25	(a) Statement of Lenz's law 1 Predicting the polarity 1 (b) (i) Formula ½ Substitution and Calculation 1½ (ii) Effect on voltage 1 (a) Lenz's law: The polarity of induced emf is such that it tends to produce a current which opposes the change in magnetic flux that produced it.	1	

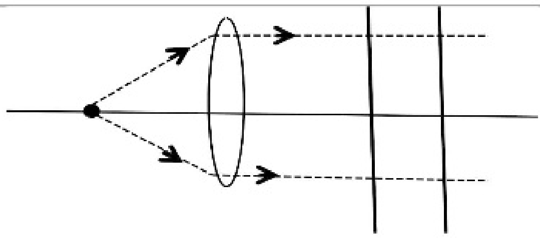
	Polarity A → $(+ve)$; B → $(-ve)$	½ + ½	
	(b) (i) $V = Bl\vartheta$ Here B = vertical component of Earth's magnetic field	½	
	B= $(5\times10^{-4}\sin 30^{o})$T = 2.5×10^{-4} T $\therefore V = \left[2.5\times10^{-4}\times 25\times\frac{1800\times10^{3}}{60\times 60}\right]$ volt	½	
	$= 3.125$ volt	½	
	(ii) Now B =horizontal component of Earth's magnetic field $=B\cos 30^{o} = \frac{B\sqrt{3}}{2}$	½	
	$\therefore\ V' = \sqrt{3}V = 1.732\times 3.125$ volt $\cong 5.4$ volt	½ ½	5

OR

Definition of mutual inductance	1
Factors affecting mutual inductance	1
Formulae for the three cases	½
Calculations for plotting the graphs	1
Plots of three graphs	½ + ½ + ½

	Mutual Inductance: The mutual inductance, of a pair of coils, equals the magnetic flux linked with one of them due to a unit current in the other. **Alternatively**, The mutual inductance, of a pair of coils, equals the emf induced in one of them when the rate of change of current in the other is unity.	1	
	Factors affecting the mutual inductance of a pair of coils (i) The sizes of the two coils (ii) The shape of the two coils (iii) the distance of separation between the two coils (iv) The nature of the medium between the two coils (v) The relative orientation of the two coils. [NOTE: Any two]	½ + ½	
	From t = 0 to t =3s $\left(=\frac{30\text{ cm}}{10\text{ cm/s}}\right)$, the flux through the coil is zero. From t = 3s to t = 5s, the flux through the coil increases from 0 to $\left[0.1\times\left(\frac{20}{100}\right)^{2}\right]$ Wb, ie 0.004 Wb. From t = 5s to t =11s, the flux remains constant at the value 0.004 Wb. From t = 11s to t =13s, the flux through the coil remains zero. (i) The plot of ϕ against t is, therefore, as shown:		
		1	
	(ii) $\varepsilon = -\frac{d\phi}{dt}$		

	The plot of ε against t is, therefore, as shown:  (iii) $i = \frac{\varepsilon}{R} = \frac{2\times10^{-3}}{0.1\Omega} = 20\ \text{mA}$ 	1 1	5
Set1,Q25 Set2,Q24 Set3,Q26	(a) Definition of wavefront — 1 Difference from a ray — 1 (b) Shape of the wavefront in three cases — 1+1+1 (a) A wavefront is defined as a surface of constant phase. [**Alternatively:** A wavefront is the locus of all points in the medium that have the same phase.] Difference from a ray: (i) The ray, at each point of a wavefront, is normal to the wavefront at that point. (ii) The ray indicates the direction of propagation of wave while the wavefront is the surface of constant phase. **(Any one)** (b) The shape of the wavefront, in the three cases, are as shown. (i)  (ii)	1 1 1	



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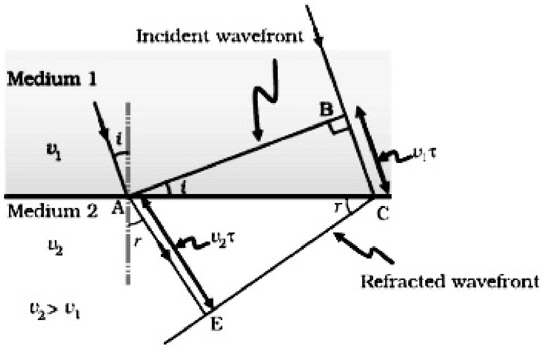
(iii)

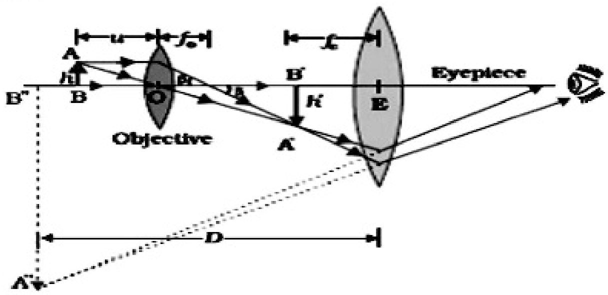


1 5

OR

(a) Ray diagram of compound microscope	1
Expression for total magnification	2
(b) Effect on resolving power in cases (i) and (ii)	½ + ½
Reasons for each case	½ + ½

(a) The ray diagram, showing image formation by a compound microscope, is given below:



1

Linear magnification due to the objective $= \frac{h'}{h} = \frac{L}{f_o}$ ½

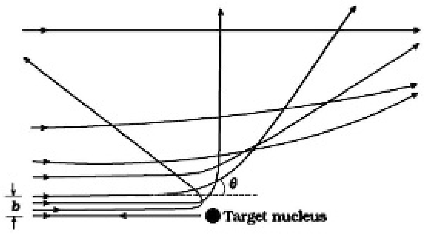
$$\left(\because \tan\beta = \frac{h}{f_o} = \frac{h'}{L}\right)$$ ½

Here L=tube length=distance between the second focal point of the objective and the first focal point of the eyepiece.

	When the final image is formed at infinity, the angular magnification due to the eye piece equals $\frac{D}{f_e}$. (D=least distance of distinct vision) ∴ Total magnification when the final image is formed at infinity $= \left(\frac{L}{f_o} \cdot \frac{D}{f_e}\right)$ (c) (i) Resolving power increases when the focal length of the objective is decreased. (d) This is because the minimum separation, $d_{min}\left(= \frac{1.22\, f\lambda}{D}\right)$ decreases when f is decreased. (ii) Resolving power decreases when the wavelength of light is increased. This is because the minimum separation, $d_{min}\left(= \frac{1.22\, f\lambda}{d}\right)$ increases when λ is increased.	½ ½ ½ ½ ½ ½	 5
Set1,Q26 Set2,Q25 Set3,Q24	(a) Writing three features ½ + ½ + ½ Explanation on the basis of Einstein's photoelectric equation ½ + ½ + ½ (b) (i) Reason for equality of the two slopes 1 (ii) Identification of material 1 (a) Three features, of photoelectric effect, which cannot be explained by the wave theory of light, are: (i) Maximum kinetic energy of emitted electrons is independent of the intensity of incident light. (ii) There exists a 'threshold frequency' for each photosensitive material. (iii) 'Photoelectric effect' is instantaneous in nature. Einstein's photoelectric equation $K_{max} = h\nu - \phi_o$ [**Alternatively**: $eV_o = h\nu - \phi_o$] can be used to explain these features as follows. (i) Einstein's equation shows that $K_{max} \propto \nu$. However, K_{max} does not depend on the intensity of light. (ii) Einstein's equation shows that for $\nu < \frac{\phi_o}{h}$, K_{max} becomes negative, i.e, there cannot be any photoemission for $\nu < \nu_o (\nu_o = \frac{\phi_o}{h})$ (iii) The free electrons in the metal, that absorb completely the energy of the incident photons, get emitted instantaneously. (b) (i) Slope of the graph between V_o and ν (from Einstein's equation) equals (*h/e*). Hence it does not depend on the nature of the material. (ii) Emitted electrons have greater energy for material M_1. This is because $\phi_o (= h\nu_o)$ has a lower value for material M_1. **OR**	 ½ ½ ½ ½ ½ ½ 1 1	 5

(a) Drawing the Trajectory	1
Estimating the size of the nucleus	1
(b) Establishment of wave nature	1
(c) Estimating the ratio of deBroglie wavelengths	2

(a) The trajectory, traced by the α –particles in the Coulomb field of target nucleus, has the form shown below.



1

The size of the nucleus was estimated by observing the distance (d) of closest approach, of the α-particles. This distance is given by:

$$\frac{1}{4\pi\varepsilon_o}.\frac{(Ze)(2e)}{d} = K$$

where K=kinetic energy of the α-particles when they are far away from the target nuclei. 1

(b) The wave nature of moving electrons was established through the Davisson-Germer experiment. ½

In this experiment, it was observed that a beam of electrons, when scattered by a nickel target, showed 'maxima' in certain directions; (like the 'maxima' observed in interference/diffraction experiments with light.) ½

(c) We have: $\lambda = \frac{h}{p} = \frac{h}{\sqrt{2mqV}}$ ½ + ½

$\therefore \frac{\lambda_d}{\lambda_\alpha} = \sqrt{\frac{m_\alpha q_\alpha}{m_d q_d}}$ ½

$= \sqrt{2 \times 2} = 2$ ½ 5

SET – 1

Series : SSO/C

कोड नं.
Code No. **55/1**

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 **12** 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 जायेगा । 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 **12** 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 minutes 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 घंटे] *[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

$h = 6.63 \times 10^{-34}$ Js

$e = 1.6 \times 10^{-19}$ C

$\mu_0 = 4\pi \times 10^{-7}$ T m A^{-1}

$\varepsilon_0 = 8.854 \times 10^{-12}$ C^2 N^{-1} m^{-2}

$\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9$ N m^2 C^{-2}

$m_e = 9.1 \times 10^{-31}$ kg

न्यूट्रॉन का द्रव्यमान = 1.675×10^{-27} kg

प्रोटॉन का द्रव्यमान = 1.673×10^{-27} kg

आवोगाद्रो संख्या = 6.023×10^{23} प्रति ग्राम मोल

बोल्ट्ज़मान नियतांक = 1.38×10^{-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

$h = 6.63 \times 10^{-34}$ Js

$e = 1.6 \times 10^{-19}$ C

$\mu_0 = 4\pi \times 10^{-7}$ T m A^{-1}

$\varepsilon_0 = 8.854 \times 10^{-12}$ C^2 N^{-1} m^{-2}

$\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9$ N m^2 C^{-2}

$m_e = 9.1 \times 10^{-31}$ kg

mass of neutron = 1.675×10^{-27} kg

mass of proton = 1.673×10^{-27} kg

Avogadro's number = 6.023×10^{23} per gram mole

Boltzmann constant = 1.38×10^{-23} JK^{-1}

खण्ड – अ
Section – A

1. किसी चालक के समविभव पृष्ठ के किसी बिन्दु पर विद्युत क्षेत्र रेखाएँ पृष्ठ के लम्बवत क्यों होती हैं ? **1**
Why are electric field lines perpendicular at a point on an equipotential surface of a conductor ?

2. किसी संधारित्र को किसी परिवर्ती आवृत्ति के AC स्रोत से संयोजित किया गया है । यदि AC स्रोत की आवृत्ति घटा दी जाए, तो क्या विस्थापन धारा परिवर्तित हो जाएगी ? **1**
A variable frequency AC source is connected to a capacitor. Will the displacement current change if the frequency of the AC source is decreased ?

3. NAND गेट का तर्क प्रतीक खींचिए और इसकी सत्यमान सारणी दीजिए । **1**
Draw the logic symbol of NAND gate and give its Truth Table.

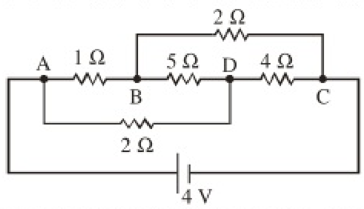
4. AC स्रोत की आवृत्ति में परिवर्तन के साथ संधारित्र प्रतिघात में विचरण को दर्शाने के लिए ग्राफ खींचिए । **1**
Plot a graph showing variation of capacitive reactance with the change in the frequency of the AC source.

5. आयाम मॉडुलन और आवृत्ति मॉडुलन के बीच विभेदन कीजिए । **1**
Distinguish between amplitude modulation and frequency modulation.

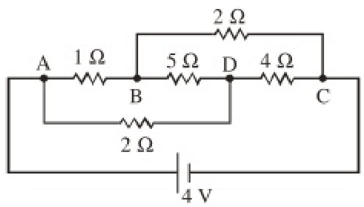
खण्ड – ब
Section – B

6. 'विद्युत फ्लक्स' की परिभाषा और इसका SI मात्रक लिखिए । विद्युत क्षेत्र $\vec{E} = 3 \times 10^3 \hat{i}$ N/C के कारण किसी 10 cm भुजा वाले वर्ग से गुजरने वाला फ्लक्स कितना है, जबकि इसे $\vec{E}$ के अभिलम्बवत् रखा गया है । **2**
Define the term 'electric flux'. Write its SI units. What is the flux due to electric field $\vec{E} = 3 \times 10^3 \hat{i}$ N/C through a square of side 10 cm, when it is held normal to $\vec{E}$?

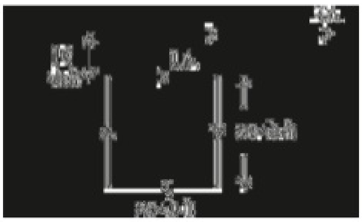
7. चित्र में दर्शाए गए प्रतिरोधकों के नेटवर्क द्वारा बैटरी से ली गयी धारा परिकलित कीजिए । **2**



Calculate the current drawn from the battery by the network of resistors shown in the figure.



8. 20 cm भुजा वाले किसी वर्गाकार लूप जिससे 1A धारा प्रवाहित हो रही है, को किसी अनन्त लम्बाई के सीधे तार जिससे 2A धारा प्रवाहित हो रही है के निकट चित्र में दर्शाए अनुसार समान तल में रखा गया है । **2**

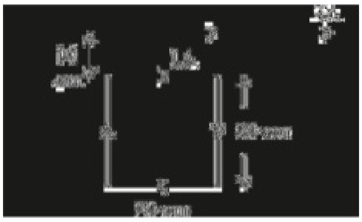


धारावाही चालक के कारण लूप पर आरोपित नेट बल का परिमाण और दिशा परिकलित कीजिए ।

अथवा

200 फेरों और 100 cm^2 क्षेत्रफल की किसी वर्गाकार समतल कुण्डली से 5A अपरिवर्ती धारा प्रवाहित हो रही है । यह कुण्डली 0.2 T के ऐसे एकसमान चुम्बकीय क्षेत्र में स्थित है, जिसकी दिशा कुण्डली के तल के लम्बवत है । जब इस कुण्डली का तल चुम्बकीय क्षेत्र से 60° का कोण बनाता है तब उस स्थिति में कुण्डली पर लगा बल-आघूर्ण परिकलित कीजिए । किस विन्यास में यह कुण्डली स्थायी साम्यावस्था में होगी ?

A square loop of side 20 cm carrying current of 1A is kept near an infinite long straight wire carrying a current of 2A in the same plane as shown in the figure.



Calculate the magnitude and direction of the net force exerted on the loop due to the current carrying conductor.

OR

A square shaped plane coil of area 100 cm^2 of 200 turns carries a steady current of 5A. It is placed in a uniform magnetic field of 0.2 T acting perpendicular to the plane of the coil. Calculate the torque on the coil when its plane makes an angle of 60° with the direction of the field. In which orientation will the coil be in stable equilibrium ?

9. उन वैद्युत चुम्बकीय विकिरणों का नाम लिखिए (i) जिनका उपयोग कैंसर की कोशिकाओं को नष्ट करने में किया जाता है, (ii) जिनसे त्वचा ताम्र रंग की हो जाती है, (iii) पृथ्वी की उष्णता बनाए रखते हैं । **2**

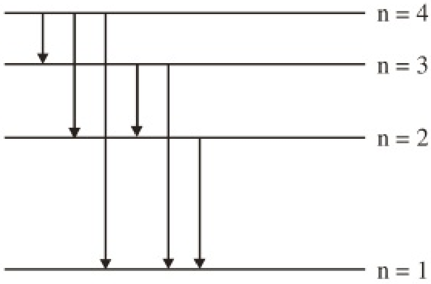
इनमें से किसी एक प्रकार की तरंगों को उत्पन्न करने की विधि का संक्षेप में वर्णन कीजिए ।

Name the types of e.m. radiations which (i) are used in destroying cancer cells, (ii) cause tanning of the skin and (iii) maintain the earth's warmth.

Write briefly a method of producing any one of these waves.

10. चित्र में हाइड्रोजन परमाणु का ऊर्जा स्तर आरेख दर्शाया गया है : **2**

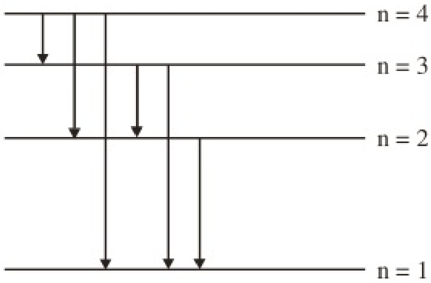
(a) वह संक्रमण ज्ञात कीजिए जिसमें 496 nm तरंगदैर्ध्य के फोटॉन का उत्सर्जन होता है ।



(b) किस संक्रमण के संगत अधिकतम तरंगदैर्ध्य के विकिरण उत्सर्जित होते हैं ? अपने उत्तर की पुष्टि कीजिए ।

The figure shows energy level diagram of hydrogen atom.

(a) Find out the transition which results in the emission of a photon of wavelength 496 nm.



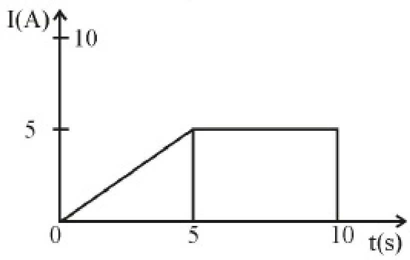
(b) Which transition corresponds to the emission of radiation of maximum wavelength ? Justify your answer.

खण्ड – स

Section – C

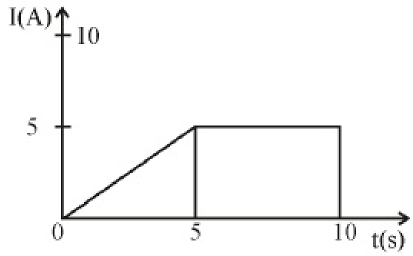
11. (a) किसी चालक में प्रवाहित धारा 'I' और इलेक्ट्रॉन के अपवाह वेग $\vec{v}_d$ के बीच संबंध व्युत्पन्न कीजिए । **3**

(b) चित्र में किसी तार की अनुप्रस्थ काट से प्रवाहित धारा 'I' और समय 't' के बीच ग्राफ दर्शाया गया है । इस ग्राफ का उपयोग करके तार से 10s में प्रवाहित आवेश ज्ञात कीजिए ।



(a) Deduce the relation between current I flowing through a conductor and drift velocity $\vec{v_d}$ of the electrons.

(b) Figure shows a plot of current 'I' flowing through the cross-section of a wire versus the time 't'. Use the plot to find the charge flowing in 10s through the wire.



12. किसी पोटैन्शियोमीटर का परिपथ आरेख खींचकर इसका कार्यकारी सिद्धान्त लिखिए । दो सेलों की emf की तुलना करने में इसका उपयोग किस प्रकार किया जाता है इसका वर्णन करने वाला आवश्यक सूत्र व्युत्पन्न कीजिए । **3**

अथवा

परिपथ आरेख की सहायता से मीटर सेतु के कार्यकारी सिद्धान्त की व्याख्या कीजिए । इसका उपयोग किसी दिए गए तार का अज्ञात प्रतिरोध निर्धारित करने में किस प्रकार किया जाता है ? परिणाम में न्यूनतम त्रुटि के लिए बरती जाने वाली आवश्यक सावधानियाँ लिखिए ।

Draw a circuit diagram of a potentiometer. State its working principle. Derive the necessary formula to describe how it is used to compare the emfs of the two cells.

OR

With the help of the circuit diagram, explain the working principle of meter bridge. How is it used to determine the unknown resistance of a given wire ? Write the necessary precautions to minimize the error in the result.

13. (a) किसी चल कुण्डली गैल्वेनोमीटर में चुम्बकीय क्षेत्र त्रिज्य (अरीय) क्यों बनाया जाता है ? समझाइए यह किस प्रकार बनाया जाता है । **3**

(b) किसी गैल्वेनोमीटर जिसका प्रतिरोध 'G' है, को इसके श्रेणी में कोई प्रतिरोध 'R' संयोजित करके (0-V) वोल्ट परिसर के वोल्टमीटर में परिवर्तित किया जा सकता है । यदि इसे 0 से V/2 परिसर के वोल्टमीटर में परिवर्तित करना हो, तो कितने प्रतिरोध की आवश्यकता होगी ?

(a) Why is the magnetic field radial in a moving coil galvanometer ? Explain how it is achieved.

(b) A galvanometer of resistance 'G' can be converted into a voltmeter of range (0-V) volts by connecting a resistance 'R' in series with it. How much resistance will be required to change its range from 0 to V/2 ?

14. किसी ac वोल्टता $V = V_0 \sin \omega t$ के स्रोत को प्रतिरोध 'R' और संधारित्र 'C' के श्रेणी संयोजन से जोड़ा गया है । इसके लिए फेज़र आरेख खींचिए और इसका उपयोग (i) परिपथ की प्रतिबाधा और (ii) कला-कोण के लिए व्यंजक प्राप्त करने में कीजिए । **3**

A source of ac voltage $V = V_0 \sin \omega t$ is connected to a series combination of a resistor 'R' and a capacitor 'C'. Draw the phasor diagram and use it to obtain the expression for (i) impedance of the circuit and (ii) phase angle.

15. अनुप्रस्थ काट-क्षेत्रफल $1.6 \times 10^{-4} m^2$ और कसकर पास-पास लपेटे गए 2000 फेरों की परिनालिका जिससे 4.0 A धारा प्रवाहित हो रही है इसके केन्द्र से होकर निलम्बित है और यह क्षैतिज तल में घूम सकती है । (i) इस परिनालिका से संबद्ध चुम्बकीय आघूर्ण, (ii) यदि परिनालिका के अक्ष से 30° कोण पर कोई 7.5×10^{-2} T का क्षैतिज चुम्बकीय क्षेत्र व्यवस्थित किया गया है, तो परिनालिका पर लगे बल-आघूर्ण का परिमाण और दिशा ज्ञात कीजिए । **3**

A closely wound solenoid of 2000 turns and cross sectional area $1.6 \times 10^{-4} m^2$ carrying a current of 4.0 A is suspended through its centre allowing it to turn in a horizontal plane. Find (i) the magnetic moment associated with the solenoid, (ii) magnitude and direction of the torque on the solenoid if a horizontal magnetic field of 7.5×10^{-2} T is set up at an angle of 30° with the axis of the solenoid.

16. (a) यंग के द्विझिरी प्रयोग में दो झिरियों की मोटाई का अनुपात 4:1 है । व्यतिकरण पैटर्न में उच्चिष्ठ और निम्निष्ठ की तीव्रताओं के अनुपात का मूल्यांकन कीजिए । **3**

(b) क्या व्यतिकरण पैटर्न ने चमकीली और काली फ्रिन्जें दिखाई देना, किसी भी रूप में, ऊर्जा संरक्षण नियम का उल्लंघन है ? व्याख्या कीजिए ।

(a) The ratio of the widths of two slits in Young's double slit experiment is 4 : 1. Evaluate the ratio of intensities at maxima and minima in the interference pattern.

(b) Does the appearance of bright and dark fringes in the interference pattern violate, in any way, conservation of energy ? Explain.

17. (a) उन कारकों को लिखिए जिनके द्वारा किसी दूरदर्शक की विभेदन क्षमता में वृद्धि की जा सकती है । **3**

(b) 1 mm चौड़ाई की एकल झिरी पर जब झिरी के अभिलम्बवत 600 nm तरंगदैर्ध्य का प्रकाश आपतन करता है, तो इसके कारण प्राप्त विवर्तन पैटर्न के प्रथम कोटि उच्चिष्ठ और तृतीय कोटि निम्निष्ठ के बीच कोणीय पृथक्कन का आकलन कीजिए ।

(a) Write the factors by which the resolving power of a telescope can be increased.

(b) Estimate the angular separation between first order maximum and third order minimum of the diffraction pattern due to a single slit of width 1 mm, when light of wavelength 600 nm is incident normal on it.

18. (a) साधारण रंगीन काँच के चश्मों की तुलना में अच्छी गुणता के पोलरॉयडों के बने चश्मों को प्रायिकता क्यों दी जाती है ? कारण देकर स्पष्ट कीजिए । **3**

(b) दो पोलरॉयडों P_1 तथा P_2 को क्रासित स्थितियों में रखा गया है । P_1 और P_2 के बीच कोई तीसरा पोलरॉयड P_3 इस प्रकार रखा जाता है कि P_3 का पारित अक्ष P_1 के समान्तर है । P_2 से पारगमित प्रकाश की तीव्रता (I_2) P_3 को घूर्णन कराने पर किस प्रकार परिवर्तन होगी ? P_1 और P_3 के परित अक्षों के बीच कोण 'θ' और तीव्रता 'I_2' के बीच ग्राफ खींचिए ।

(a) Good quality sun-glasses made of polaroids are preferred over ordinary coloured glasses. Justifying your answer.

(b) Two polaroids P_1 and P_2 are placed in crossed positions. A third polaroid P_3 is kept between P_1 and P_2 such that pass axis of P_3 is parallel to that of P_1. How would the intensity of light (I_2) transmitted through P_2 vary as P_3 is rotated ? Draw a plot of intensity 'I_2' Vs the angle 'θ', between pass axes of P_1 and P_3.

19. (a) नीचे दी गयी नाभिकीय अभिक्रियाओं को पूरा कीजिए : **3**

(i) $^{208}_{84}Po \rightarrow ^{204}_{82}Pb + \ldots$

(ii) $^{32}_{15}P \rightarrow ^{32}_{16}S + \ldots$

(b) (i) β^- और (ii) β^+ क्षय के लिए उत्तरदायी नाभिक में अन्तर्ग्रस्त मूल प्रक्रिया लिखिए ।

(c) न्यूट्रिनों का प्रायोगिक संसूचन कठिन क्यों पाया गया ?

(a) Complete the following nuclear reactions :

(i) $^{208}_{84}Po \rightarrow ^{204}_{82}Pb + \ldots$

(ii) $^{32}_{15}P \rightarrow ^{32}_{16}S + \ldots$

(b) Write the basic process involved in nuclei responsible for (i) β^- and (ii) β^+ decay.

(c) Why is it found experimentally difficult to detect neutrinos ?

20. ताप $T > 0K$ पर (i) n-प्रकार और (ii) p-प्रकार के अर्धचालकों के ऊर्जा-बैण्ड आरेख खींचिए ।
n-प्रकार के प्रकरण में Si-अर्धचालकों के ऊर्जा-बैण्ड आरेख में दाता ऊर्जा स्तर चालक बैण्ड की तली के कुछ नीचे तथा p-प्रकार के अर्धचालकों में ग्राही ऊर्जा स्तर संयोजी बैण्ड के शीर्ष से कुछ ऊपर होता है । स्पष्ट कीजिए कि चालक और संयोजी बैण्डों में इन ऊर्जा-स्तरों की क्या भूमिका होती है । **3**

Draw the energy band diagrams of (i) n-type and (ii) p-type semiconductor at temperature, $T > 0K$.

In the case n-type Si semiconductor, the donor energy level is slightly below the bottom of conduction band whereas in p-type semiconductor, the acceptor energy level is slightly above the top of the valence band. Explain, what role do these energy levels play in conduction and valence bands.

21. अंतरण अभिलक्षण (V_0 और V_i के बीच) का ग्राफ खींचिए और दर्शाइए कि इस अभिलक्षण का कौन सा भाग प्रवर्धन के लिए उपयोग किया जाता है और क्यों ? **3**
किसी आधार बायसित ट्रांजिस्टर प्रवर्धक का CE विन्यास में परिपथ आरेख खींचिए और संक्षेप में इसकी कार्यविधि की व्याख्या कीजिए ।

Draw a plot of transfer characteristic (V_0 vs V_i) and show which portion of the characteristic is used in amplification and why ?

Draw the circuit diagram of base bias transistor amplifier in CE configuration and briefly explain its working.

22. इन्टरनेट के उपयोग में नीचे दिए गए पदों की व्याख्या कीजिए : **3**

(i) इन्टरनेट सर्फिन्ग

(ii) सोशल नेटवर्किंग

(iii) ई-मेल

Explain the following terms in relation to the use of internet :

(i) Internet surfing

(ii) Social networking

(iii) E-mail

खण्ड – द

Section – D

23. विद्यालय की छुट्टी के तुरन्त बाद जैसे ही बिमला अपनी सहेलियों के साथ बाहर निकली उसने देखा कि अचानक बादलों की गर्जन के साथ बिजली चमकने लगी है । उन्हें शरण के लिए कोई उपयुक्त स्थान नहीं मिल पाया । डॉ. कपूर जो वहीं से अपनी कार से गुजर रहे थे उन्होंने इन बच्चों को देखा और उन्हें अपनी कार में बैठने का प्रस्ताव दिया, यही नहीं उन्होंने इन बच्चों को इनके घरों के निकट की बस्ती में छोड़ा । बिमला के माता-पिता जो बिमला का इन्तजार कर रहे थे, यह देखा और उन्होंने डॉ. कपूर का आभार व्यक्त किया । **4**

(1) डॉ. कपूर और बिमला के माता-पिता द्वारा किन मूल्यों को दर्शाया गया ?

(2) विशेषकर तड़ित और गर्जन के समय कार के भीतर होना सुरक्षित क्यों माना जाता है ?

(3) "परावैद्युत सामर्थ्य" पद की परिभाषा लिखिए । यह क्या सूचित करती है ?

Immediately after school hour, as Bimla with her friends came out, they noticed that there was a sudden thunderstorm accompanied by the lightening. They could not find any suitable place for shelter. Dr. Kapoor who was passing thereby in his car noticed these children and offered them to come in their car. He even took care to drop them to the locality where they were staying. Bimla's parents, who were waiting, saw this and expressed their gratitude to Dr. Kapoor.

(1) What values did Dr. Kapoor and Bimla's parents displayed ?

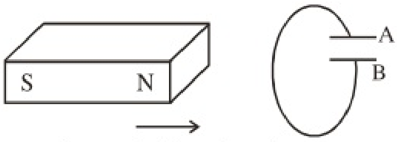
(2) Why is it considered safe to be inside a car especially during lightening and thunderstorm ?

(3) Define the term 'dielectric strength'. What does this term signify ?

खण्ड – य

Section – E

24. (a) लेंज का नियम लिखिए । नीचे दी गयी स्थिति में संधारित्र की ध्रुवणता का अनुमान लगाने में इस नियम का उपयोग कीजिए । **5**



(b) कोई जेटयान 1800 km/h की चाल से पश्चिम दिशा में गमन कर रहा है ।

(i) यदि जिस जगह वह गमन कर रहा है वहाँ पृथ्वी के चुम्बकीय क्षेत्र का परिमाण 5×10^{-4} T और नति कोण 30° है, तो 25 m विस्तार की जेटयान की पंखुड़ियों के दो सिरों के बीच उत्पन्न वोल्टता-अन्तर का अनुमान लगाइए ।

(ii) यदि जेटयान की दिशा पश्चिम से उत्तर की ओर हो जाए, तो उत्पन्न वोल्टता पर क्या प्रभाव पड़ेगा ?

अथवा

कुण्डलियों के युगल के अन्योन्य प्रेरकत्व की परिभाषा लिखिए और जिन कारकों पर यह निर्भर करता है उनका उल्लेख कीजिए ।

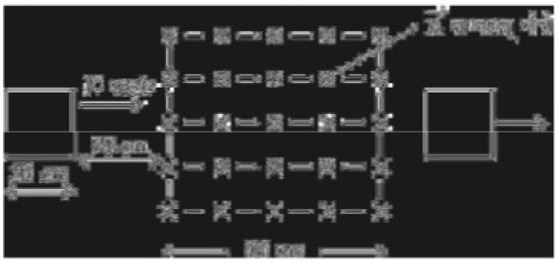
चित्र में दर्शाए अनुसार 20 cm भुजा का कोई वर्ग-लूप 0.1 T के एकसमान चुम्बकीय क्षेत्र के प्रभाव क्षेत्र से प्रारम्भ में 30 cm दूरी पर है । इसके पश्चात इसे दायीं ओर 10 cm s^{-1} के वेग से उस समय तक गमन कराया जाता है, जब तक कि यह इस क्षेत्र के प्रभाव क्षेत्र से बाहर नहीं निकल जाता ।

नीचे दिए गए विचरणों को दर्शाने के लिए ग्राफ खींचिए :

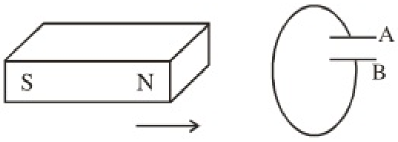
(i) समय (t) के साथ लूप से गुजरने वाले चुम्बकीय फ्लक्स (ϕ) का विचरण

(ii) समय (t) के साथ लूप में प्रेरित emf (ε)

(iii) यदि लूप का प्रतिरोध 0.1 Ω है, तो लूप में प्रेरित धारा में विचरण



(a) State Lenz's law. Use it to predict the polarity of the capacitor in the situation given below :



(b) A jet plane is travelling towards west at a speed of 1800 km/h.

(i) Estimate voltage difference developed between the ends of the wing having a span of 25 m if the earth's magnetic field at the location has a magnitude of 5×10^{-4} T and dip angle is 30°.

(ii) How will the voltage developed be affected if the jet changes its direction from west to north ?

OR

Define mutual inductance of a pair of coils and write on which factors does it depend.

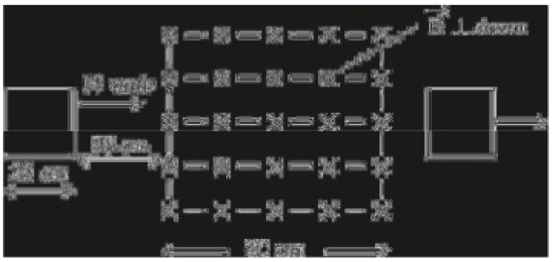
A square loop of side 20 cm is initially kept 30 cm away from a region of uniform magnetic field of 0.1 T as shown in the figure. It is then moved towards the right with a velocity of 10 cm s^{-1} till it goes out of the field.

Plot a graph showing the variation of

(i) magnetic flux (ϕ) through the loop with time (t).

(ii) induced emf (ε) in the loop with time t.

(iii) induced current in the loop if it has resistance of 0.1 Ω.



25. (a) तरंगाग्र की परिभाषा लिखिए । यह किरण से किस प्रकार भिन्न है ? 5

(b) नीचे दिए गए प्रत्येक प्रकरण के लिए तरंगाग्र की आकृति दर्शाइए ।

(i) किसी बिन्दु स्रोत से प्रकाश का अपसारित होना ।

(ii) जब बिन्दु स्रोत किसी उत्तल लेंस के फोकस पर है, तब लेंस से प्रकाश निर्गत होते हुए

(iii) हाइगेन्स के द्वितीयक तरंगिका के निर्माण का उपयोग करते हुए, सघन माध्यम से विरल माध्यम में किसी समतल तरंगाग्र के गमन को दर्शाने के लिए आरेख खींचिए ।

अथवा

(a) किसी संयुक्त सूक्ष्मदर्शी द्वारा प्रतिबिम्ब बनना दर्शाने के लिए किरण आरेख खींचिए । उस स्थिति में कुल आवर्धन के लिए व्यंजक प्राप्त कीजिए जब प्रतिबिम्ब अनन्त पर बनता है ।

(b) किसी संयुक्त सूक्ष्मदर्शी की विभेदन क्षमता किस प्रकार प्रभावित होती है, जब

(i) अभिदृश्यक की फोकस दूरी घट जाती है ।

(ii) प्रकाश की तरंगदैर्ध्य अधिक हो जाती है ?

अपने उत्तर की पुष्टि कारण सहित कीजिए ।

(a) Define a wavefront. How is it different from a ray ?

(b) Depict the shape of a wavefront in each of the following cases.

(i) Light diverging from point source.

(ii) Light emerging out of a convex lens when a point source is placed at its focus.

(iii) Using Huygen's construction of secondary wavelets, draw a diagram showing the passage of a plane wavefront from a denser into a rarer medium.

OR

(a) Draw a ray diagram showing the image formation by a compound microscope. Obtain expression for total magnification when the image is formed at infinity.

(b) How does the resolving power of a compound microscope get affected, when

(i) focal length of the objective is decreased.

(ii) the wavelength of light is increased ?

Give reasons to justify your answer.

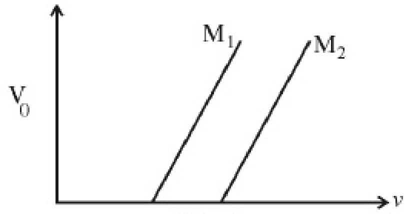
26. (a) प्रकाश-विद्युत प्रभाव के उन तीन प्रेक्षित अभिलक्षणों को लिखिए जिनकी व्याख्या प्रकाश के तरंग सिद्धान्त द्वारा नहीं की जा सकती ।

स्पष्ट कीजिए कि आइंस्टीन के प्रकाश-विद्युत समीकरण का उपयोग इनका संतोषजनक वर्णन करने के लिए किस प्रकार किया जाता है । 5

(b) चित्र में दो प्रकाश-सुग्राही पदार्थों M_1 तथा M_2 के लिए आपतित विकिरणों की आवृत्ति (ν) और निरोधी विभव (V_0) के बीच ग्राफ दर्शाया गया है । स्पष्ट कीजिए कि

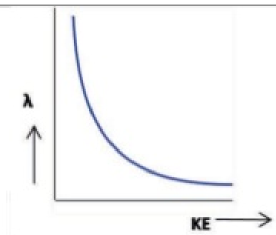
(i) दोनों रेखाओं का ढलान समान क्यों है ?

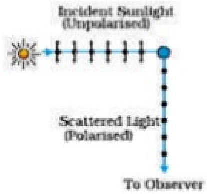
(ii) आपतित विकिरणों की समान आवृत्ति के लिए किस पदार्थ से उत्सर्जित इलेक्ट्रॉनों की गतिज ऊर्जा अधिक है ?

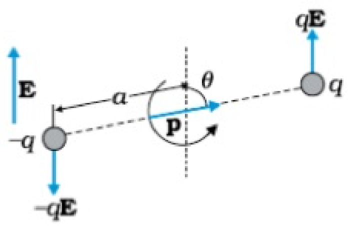


अथवा

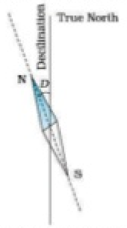
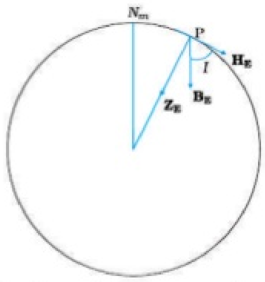
MARKING SCHEME
SET 55/1/1 (Compartment)

Q. No.	Expected Answer / Value Points	Marks	Total Marks
	Section A		
Set1,Q1 Set2,Q4 Set3,Q3	Kinetic energy will not be affected.	1	1
Set1,Q2 Set2,Q5 Set3,Q4	Clockwise on the side of the observer. [**Alternatively** :The candidate who draws diagram with arrow indicating the direction correctly, may also be given full credit.]	1	1
Set1,Q3 Set2,Q1 Set3,Q5	(i) Real (ii) magnified	½ + ½	1
Set1,Q4 Set2,Q2 Set3,Q1		1	1
Set1,Q5 Set2,Q3 Set3,Q2	To avoid overlapping of the two signals	1	1
	Section B		
Set1,Q6 Set2,Q10 Set3,Q8	Derivation of Relationship between current density and resistivity 2 Drift velocity $v_d = \frac{eE}{m}\tau$ ($\tau =$ relaxation time) The current $I = neA\,v_d$ (n = number of charge carriers per unit volume.) $= \|j\|A$ $j = \frac{ne^2}{m}\tau E$ $j = \frac{1}{\rho}E$	½ ½ ½ ½	2
Set1,Q7 Set2,Q6 Set3,Q9	Unpolarised light and linearly polarized light ½ + ½ Diagram & description ½ + ½ For unpolarised light electric vector associated with light, is oscillating randomly in all directions in a plane perpendicular to the direction of propagation of light. In linearly polarised light oscillating electric vector gets aligned along one direction perpendicular to the direction of propagation of light.	½ ½	

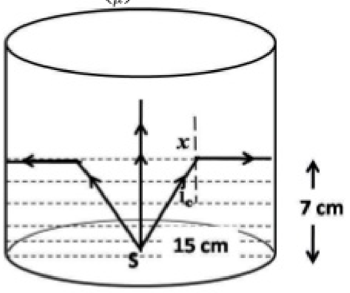
	[Under the influence of the electric field of the incident wave, the electrons (of the scattering molecules), accelerated parallel to the double arrows, do not radiate energy towards the observer. Hence, the scattered light gets polarized.] 	½ + ½	2
Set1,Q8 Set2,Q7 Set3,Q10	Reason for dispersion 1 Dependence of focal length of the lens on colour 1 The refractive index of the glass of the prism is different for different wavelengths(colours). Hence, different colours get bent along different directions. Using lens maker's formula $\frac{1}{f} = (n_{21} - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right), n_{21} = \frac{n_2}{n_1}$ As the refractive index of the medium with respect to air (medium 1) depends on the wavelength or colour of light, focal length of the lens would change with colour.	1 1	2
Set1,Q9 Set2,Q8 Set3,Q6	Calculation of the value of Plank's constant 2 According to Einstein's photoelectric equation $V_o = \frac{h}{e}\nu - \frac{\phi_o}{e}$ In the given graph: Stopping potential V_o = 1.23 V Change in frequency $\Delta\nu = 3 \times 10^{14}$Hz (Alternatively : slope of the line = $\frac{h}{e}$) $\frac{h}{e} = \frac{V_o}{\Delta\nu} = \frac{1.23}{3 \times 10^{14}}$ $\therefore h = \frac{1.23 \times 1.6 \times 10^{-19}}{3 \times 10^{14}}$J-s $= 6.6 \times 10^{-34}$ J-s	½ ½ ½ ½	2
Set1,Q10 Set2,Q9 Set3,Q7	Completion of nuclear reaction (a) 1 Completion of nuclear reaction (b) 1 (a) ${}^{10}_{5}B + {}^{1}_{0}n \rightarrow {}^{4}_{2}He + {}^{7}_{3}Li$ (b) ${}^{94}_{42}MO + {}^{2}_{1}H \rightarrow {}^{95}_{43}Te + {}^{1}_{0}n$ [**Note:** For reaction (a) even if the candidate writes ${}^{7}_{3}X$, award 1 mark] **OR**	1 1	

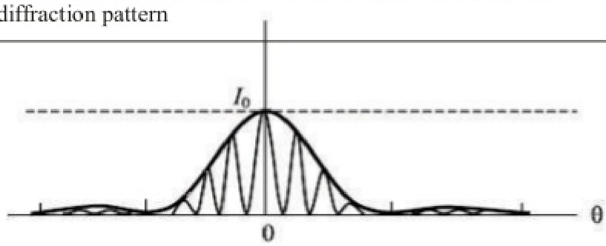
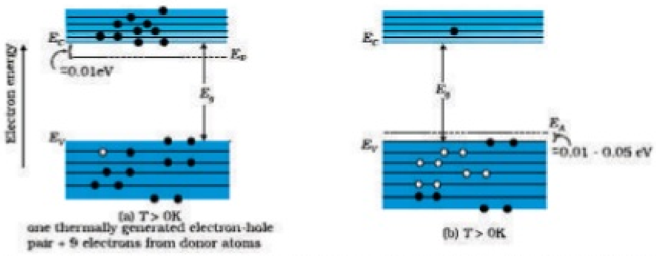
	Explanation of conversion of mass into energy (vice versa) 1 Example 1 Since proton number and neutron number are conserved, the total rest mass of neutron and protons is the same on either side of the nuclear reaction. But total binding energy of nuclei on the left side need not be the same as that on the right hand side. The difference in binding energy causes a release of energy in the reaction. Example : ${}^{2}_{1}\mathrm{H} + {}^{2}_{1}\mathrm{H} \rightarrow {}^{3}_{2}\mathrm{He} + {}^{1}_{0}n + \text{energy}$ Or $({}^{235}_{92}\mathrm{U} + {}^{1}_{0}n \rightarrow {}^{144}_{56}\mathrm{Ba} + {}^{89}_{36}\mathrm{Kr} + 3{}^{1}_{0}n + \text{energy})$ (Give full credit for any other one correct example.)	1 1	2
	Section C		
Set1,Q11 Set2,Q20 Set3,Q17	(i) Figure ½ (ii) Derivation of torque 1 ½ (iii) Identification of two pairs ½ + ½  The force on charge +q is $+q\vec{E}$ and on charge –q is $-q\vec{E}$. These, two parallel forces, acting in the opposite direction, constitute a couple resulting in the torque τ. Magnitude of torque= $qE \times 2a \sin\theta$ $= 2qa\, E \sin\theta$ Therefore, $\vec{\tau} = \vec{p} \times \vec{E}$ where $\vec{p} = 2q\vec{a}$ (ii) Two pairs of perpendicular vectors: (i) $\vec{\tau}$ is perpendicular to $\vec{p}$ (ii) $\vec{\tau}$ is perpendicular to $\vec{E}$	½ ½ ½ ½ ½ ½	3
Set1,Q12 Set2,Q21 Set3,Q18	(a) Ratio of surface charge densities 2 (b) Identifying the constant quantity 1 We have, $V = \frac{q_1}{C_1} = \frac{q_2}{C_2}$	½	

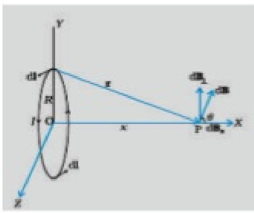
	$\frac{q_1}{4\pi\varepsilon_o R_1} = \frac{q_2}{4\pi\varepsilon_o R_1} \Rightarrow \frac{q_1}{R_1} = \frac{q_2}{R_2}$ $\frac{\sigma_1}{\sigma_2} = \frac{q_1}{4\pi\varepsilon_o {R_1}^2} \times \frac{4\pi\varepsilon_o {R_2}^2}{q_2}$ $= \frac{q_1}{q_2} \times \frac{{R_2}^2}{{R_1}^2}$ $= \frac{R_1}{R_2} \times \frac{{R_2}^2}{{R_1}^2} = \frac{R_2}{R_1}$ (b) Current	½ ½ ½ 1	3
Set1,Q13 Set2,Q22 Set3,Q19	Readings of ideal ammeter and ideal voltmeter in fig (a) and (b) 1 ½ + 1 ½ In circuit (a) Total emf=15 V Total Resistance = 2Ω Current *i*= (15/2)A = 7.5 A Potential Difference between the terminals of 6 V battery *V=E-iR* =[6-(7.5×1)]V =-1.5 V In circuit (b) Effective emf=(9-6) V =3V Current i=(3/2)A=1.5 A Potential Difference across 6V cell *V=E+iR* =6+1.5×1 =7.5 V **OR** Finding current through each resistor 3 Total emf in the circuit = 8V – 4V = 4V Total resistance of the circuit = 8Ω Hence current flowing in the circuit $i = \frac{V}{R} = \frac{4}{8}$ A= 0.5 A Current flowing through the resistors: Current throgh 0.5Ω, 1.0Ω and 4.5Ω is 0.5 A Current through 3.0Ω is $\frac{1}{3}$ A Current through 6.0Ω is $\frac{1}{6}$ A	 ½ ½ 1 ½ ½ 1 ½ ½ ½ ½ ½ ½	 3

Set1,Q14 Set2,Q11 Set3,Q20	Definition of (i) Magnetic declination and diagram ½ + ½ (ii) Angle of dip and diagram ½ + ½ Direction of compass needle at the (i) Poles ½ (ii) Equator ½		
	Magnetic declination : Angle between the magnetic axis and geographical axis. **Alternatively:** Angle between magnetic meridian and geographical meridian.	½	
		½	
	Angle of dip: It is the angle which the magnetic needle makes with the horizontal in the magnetic meridian. **Alternatively:** The angle which the total magnetic field of the earth makes with the surface of the earth.	½	
		½	
	Direction of compass needle is vertical to the earth's surface at poles and is parallel to the earth's surface at equator.	½ + ½	3
Set1,Q15 Set2,Q12 Set3,Q21	Derivation of magnetic energy 2 Comparison of magnetic energy per unit volume with Electrostatic energy density 1		
	Rate of work done $\frac{dW}{dt} = \lvert\varepsilon\rvert I$ $= \left(LI\,\frac{dI}{dt}\right)$ $dW = LIdI$	½	
	Total amount of work done $\int dW = \int LIdI$ $W = \frac{1}{2}LI^2$	½	

	For the solenoid : Inductance, $L = \mu_0 n^2 Al$; also B = $\mu_0 nI$ $\therefore$ W = $U_B = \frac{1}{2}LI^2$ $\frac{1}{2}(\mu_o n^2 A\ell)\left(\frac{B}{\mu_o n}\right)^2$ $= \frac{B^2 A\ell}{2\mu_o}$ ⇨ Magnetic energy per unt volume = $\frac{B^2}{2\mu_o}$ Also, Electrostatic energy stored per unit volume = $\frac{1}{2}\varepsilon_o E^2$	½ ½ ½ ½	3
Set1,Q16 Set2,Q13 Set3,Q22	(i) Calculation of rms value of current 2 (ii) Calculation of total average power consumed. 1 (i) $X_L = \omega L = 100 \times 80 \times 10^{-3} = 8\ \Omega$ $X_C = \frac{1}{\omega C} = \frac{1}{100 \times 250 \times 10^{-6}}\ \Omega$ $= 40\ \Omega$ Total Impedence (Z) = $X_C - X_L$ $= 32\ \Omega$ $I_{rms} = \frac{240}{32}$ A= 7.5A (ii) Average power consumed = 0 (As there is no ohmic resistance in the current.)	½ ½ ½ ½ 1	3
Set1,Q17 Set2,Q14 Set3,Q11	Answers of part (i) and (ii) 1 ½ + 1 ½ (i) It absorbs ultraviolet radiations from sun and prevents them from reaching on the earth's surface causing damage to life. Identification : ultraviolet radiations **one correct application** (=sanitization, forensics) (ii) Water molecules present in most materials readily absorbs infra red waves. Hence, their thermal motion increases. Therefore, they heat their surroundings. They are produced by hot bodies and molecules. Incoming visible light is absorbed by earth's surface and radiated as infra red radiations. These radiation are trapped by green house gases.	½ ½ ½ ½ ½ ½	3

Set1,Q18 Set2,Q15 Set3,Q12	Definition of critical angle ½ Drawing of Ray diagram 1 Calculation of area of water surface. 1 ½ For an incident ray, travelling from an optically denser medium to optically rarer medium, the angle of incidence, for which the angle of refraction is 90°, is called the critical angle. **Alternatively:** $\mu = \frac{1}{\sin i_c}$ $i_c = \sin^{-1}\left(\frac{1}{\mu}\right)$  $\mu = \frac{1}{\sin i_c}$ $\sin i_c = \frac{3}{4}$ $\cos i_c = \frac{\sqrt{7}}{4}$ $\tan i_c = \frac{3}{\sqrt{7}}$ From figure, $\tan i_c = \frac{x}{7} \Rightarrow \frac{3}{\sqrt{7}} \Rightarrow \frac{x}{7} \Rightarrow x = 3\sqrt{7}$cm Area = $\pi x^2 = 63\pi\ \text{cm}^2$	½ 1 ½ ½ ½	 3
Set1,Q19 Set2,Q16 Set3,Q13	Selection of lens for objective and eyepiece of (i) Telescope 1 ½ (ii) Microscope 1 ½ (i) Telescope L_2 : objective L_3 : eyepiece Reason : Light gathering power and magnifying power will be larger. (ii) Microscope L_3 : objective L_1 : eyepiece Reason : Angular magnification is more for short focal length of objective and eyepiece.	½ ½ ½ ½ ½ ½	 3

Set1,Q20 Set2,Q17 Set3,Q14	Explanation by drawing a suitable diagram 1 Two basic features distinguishing interference pattern from diffraction pattern 1+1  The diagram, given here, shows several fringes, due to double slit interference, 'contained' in a broad diffraction peak. When the seperation between the slits is large compared to their width, the diffraction pattern becomes very flat and we observe the two slit interference pattern. **[Note:** The students may be awarded 1 mark even if they just draw the diagram.] Two basic features: (i) The interference pattern has a number of equally spaced bright and dark bands while differaction pattern has a central bright maximum which is twice as wide as the other maxima. (ii) Interference pattern is the superimposition of two waves slits originating from two narrow sects. The differaction pattern is a superposition of a continuous family of waves originating from each point on a single slit. (iii) For a single slit of width 'a' the first null of differaction pattern occurs at an angle of $\frac{\lambda}{a}$. At the same angle of λ/a, we get a maxima for two narrow slits seperated by a distance a. **[Any two of the above distinguishing features.]**	½ ½ 1 1	3
Set1,Q21 Set2,Q18 Set3,Q15	Distinction between n – type and p-type semi conductors on the basis of Energy band diagrams 2 Comparison of conductivities 1  (i) In n - type semi conductors an extra energy level (called donor energy level) is produced just below the bottom of the conduction band, while in the p-type ssemiconductor, this extra energy band (called acceptor energy level) is just above the top of the balance band. (ii) In n – type semiconductors, most of the electrons come from the donor impurity while in p-type semi conductor, the density of holes in	½ ½ 1	

	the valence band is predominantlly due to the impurity in the extrinsic semiconductors. **[Any one of the above, or any one, other, correct distinguishing feature.]** At absolute zero temperature conductivities of both type of semi-conductors will be zero. For equal doping, an n-type semi conductor will have more conductivity than a p-type semiconductor, at room temperature.	½ ½	3
Set1,Q22 Set2,Q19 Set3,Q16	(a) Identification of X and Y ½ + ½ Their functions ½ + ½ (b) Distinction between point to point and broadcast mode. 1 (a) X : Transmitter Y: Channel Their functions: Transmitter : To convert the message signal into suitables form for transmission through channel. Channel : It sends the signal to the reciever. (b) In point to point mode, communication takes place between a single transmitter and receiver. In broadcast mode, large number of receivers are connected to a single transmitter.	½ ½ ½ ½ 1	3
Section D			
Set1,Q23 Set2,Q23 Set3,Q23	(i) Qualities / values of Rohit. 1 (ii) Advantage of CFLs/ LEDs over traditional incandescent lamps. 1 (iii) Role of earthing in reduction of electricity bills 1 (i) Co-operative attitude and scientific temperament. **(or any other two correct values.)** (ii) a) Low operational voltage and less power. b) fast action and no warm up time required. **(Any one)** (iii) In the absence of proper earthing, the consumer can get (extra) charges for the electrical energy NOT consumed by the devices in her/his premises.	1+ 1 1 1	4
Section E			
Set1,Q24 Set2,Q26 Set3,Q26	(a) Derivation of the expression 2 (b) Magnetic field lines due to the coil 1 (c) Magnetic field at the center of the loop 2 (a) 	½	

According to Biot- Savart law,

$$d\vec{B} = \frac{\mu_o}{4\pi}\frac{I(\vec{dl} \times \vec{r})}{r^3}$$ ½

$$dB = \frac{\mu_o}{4\pi}\frac{I\,dl}{(x^2+R^2)} \qquad \left[\begin{array}{l} \because |\vec{dl} \times \vec{r}| = r\,dl; \\ r = (x^2+R^2)^{\frac{1}{2}} \end{array}\right]$$

From figure

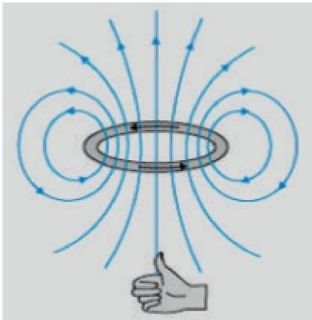
$$\cos\theta = \frac{R}{(x^2+R^2)^{\frac{1}{2}}}$$

∴ Net contribution along x-direction

$B = \sum dB\cos\theta = \int dB\cos\theta$ ½

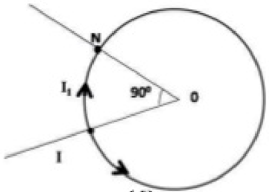
$= \int_0^{2\pi R} \frac{\mu_o I dl}{4\pi}\,\frac{R}{(x^2+R^2)^{\frac{3}{2}}}$

$\vec{B} = \frac{\mu_o I R^2}{2\,(R^2+x^2)^{\frac{3}{2}}}\,\hat{\imath}$ ½



1

(b) Let current I be divided at point M into two parts I_1 and I_2 ; in bigger and smaller parts of the loop respectively.



Magnetic field of current I_1 at point O ½

$\vec{B_1} = \frac{\mu_o I_1}{2R} \times \frac{1}{4} \otimes$

Magnetic field of current I_2 at point O

$\vec{B_2} = \frac{\mu_o I_2}{2R} \times \frac{3}{4} \odot$

Net magnetic field $\vec{B} = \vec{B_1} + \vec{B_2}$

$|\vec{B}| = \frac{\mu_o I_1}{8R} - \frac{\mu_o I_2}{8R}$ ----------------------------(1) ½

But $I_1 = 3I_2$ (As resistance of bigger part is three times that of the smaller part of the loop.) ½

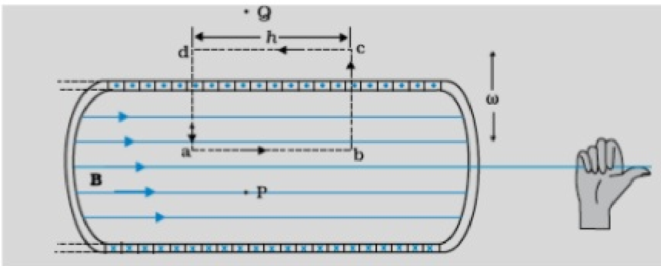
Substituting $I_1 = 3I_2$ in equation (1)

$\Rightarrow |\vec{B}| = 0$ ½ 5

OR

(a) Derivation of expression of magnetic field inside solenoid	3
(b) Finding the magnitude and direction of Magnetic field	2

Any surface carrying current can be divided into small line elements, each of length '*dl*'. Considering the tangential components of the magnetic field and finding $\vec{B}.\vec{dl}$, sum of all elements tends to the integral, which can be expressed in the following form. : $\oint \vec{B}.\vec{dl} = \mu_o i$, This form is known as Ampers's circuital law. ½



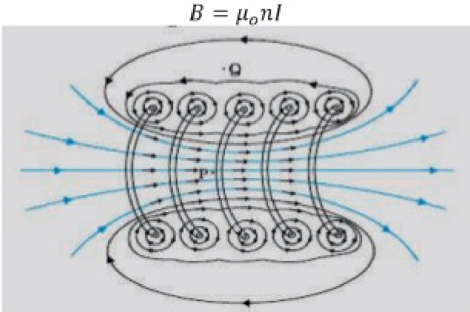
½

Let '*n*' be the number of turns per unit length. Then total number of turns in the length '*h*' is *nh*.
Hence, total enclosed current = *nhI*
Using Ampere's circuital law

$$\oint \vec{B}.\vec{dl} = \mu_o nhI$$ ½

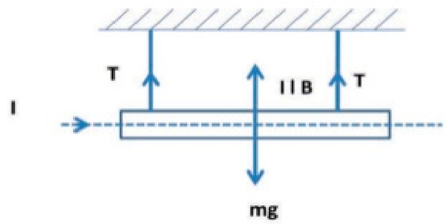
$$Bh = \mu_o nhI$$

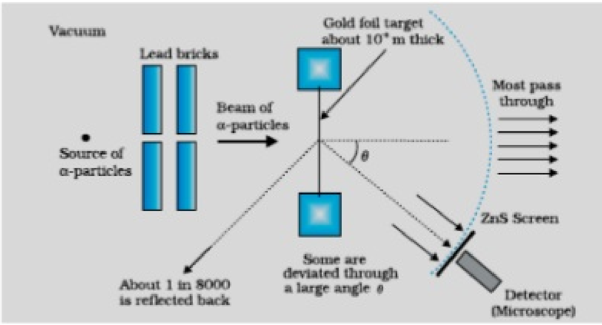
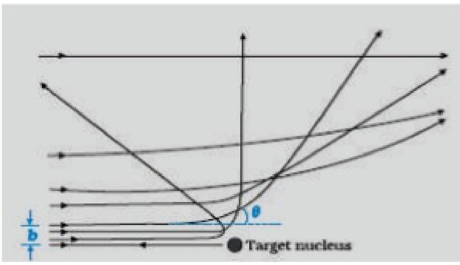
$$B = \mu_o nI$$ ½



1

(b)



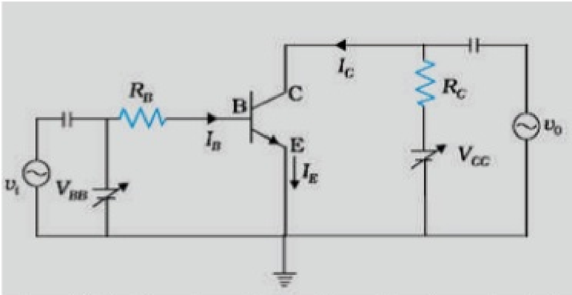
	As per the given figure, magnetic field must be vertically inwards, to make tension zero, (If a student shows current in opposite direction the magnetic field should be set up vertically upwards. $IlB = mg$ For tension to be zero $B = \frac{mg}{Il} = \frac{60\times10^{-3}\times9.8}{5.0\times0.45}$ T = 0.26 T	½ ½ ½ ½	5
Set1,Q25 Set2,Q24 Set3,Q25	(a) Schematic arrangement of Greiger-Marsden Experiment 1 Reason 1 Trajectory of α-particles and significance of Impact Parameter ½ + ½ (b) Estimation of the distance of closest approach 2 (a)  For most of the α-particles, impact parameter is large, hence they suffer very small repulsion due to nucleus and go right through the foil.  It gives an estimate of the size of nucleus. (b) K.E of the α-particle = potential energy possesed by beam at distance of closest approach. $\frac{1}{2}mv^2 = \frac{1}{4\pi\epsilon_o}.\frac{(2e)(Ze)}{r_0}$	1 1 ½ ½ ½	

	$$7.7\times1.6\times10^{-13}=\frac{9\times10^{9}\times2\times2.56\times10^{-38}\times80}{r_o}$$	½	
	$$r_o=\frac{9\times10^{9}\times2\times2.56\times10^{-38}\times80}{7.7\times1.6\times10^{-13}}\text{m}$$ $$=299\times10^{-16}\text{ m}$$		
	$$=29.9\times10^{-15}\text{m}\approx30\ \times10^{-15}\text{m}$$	½	5
	OR		
	(a) Two important limitations of Rutherford model ½ + ½ Explanation of these limitations in Bohr's model ½ + ½ Calculation of wavelength of the H_α line 1 (b) Derivation of the expression for the radius of the n[th] orbit. 2		
	(a) (i) Electron moving in a circular orbit around the nucleus would get accelerated, therefore it would spiral into the nucleus, as it looses its energy.	½	
	(ii) It must emit a continuous spectrum.	½	
	According to Bohr's model of hydrogen atom,		
	(i) Electron in an atom can revolve in certain stable orbits without the emission of radiant energy.	½	
	(ii) Energy is released /absorbed only, when an electron jumps from one stable orbit to another stable orbit. This results in a discrete spectrum.	½	
	$$\frac{1}{\lambda}=R\left(\frac{1}{2^2}-\frac{1}{3^2}\right)$$	½	
	$$\frac{1}{\lambda}=1.1\times10^{7}\left(\frac{1}{4}-\frac{1}{9}\right)$$ $$\lambda=656.3\text{ nm}$$	½	
	(b) We have $\frac{mv^2}{r_n}=\frac{1}{4\pi\varepsilon_o}\cdot\frac{e^2}{r_n{}^2}$		
	$\Rightarrow r_n=\frac{e^2}{4\pi\varepsilon_o v_n^2}$ -----------------------------------(`1)	½	
	From Bohr's Postulates: $$mv_nr_n=\frac{nh}{2\pi}$$ $$v_n=\frac{nh}{2\pi mr_n}$$	½	
	Substituting for v_n , in equation (1), we get $$r_n=\frac{\varepsilon_o n^2h^2}{\pi me^2}$$	1	5

Set1,Q26
Set2,Q25
Set3,Q24

(a) Naming the device and working with proper circuit	2
Derivation of expression for voltage gain and power gain	1 ½
(b) Drawing of transfer characteristics	1
Region used for amplifier	½

(a) Common emitter amplifier ½



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When the sinusoidal voltage is applied on the emitter base circuit, it gets amplified and its phase is reversed.

Input sinusoidal voltage:

$v_i = \Delta I_B(R_B + r_i) = \Delta I_B r$ ½

Also $\beta_{ac} = \frac{\Delta I_c}{\Delta I_B} \Rightarrow \Delta I_C = \beta_{ac}\Delta I_B$

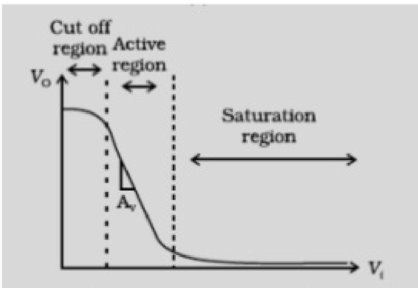
$\Delta V_{CE} = -R_L\Delta I_C = -R_L\beta_{ac}\Delta I_B = v_o$ ½

$\because$ Voltage gain $A_v = \frac{v_o}{v_i}, = -\beta_{ac}\frac{R_L}{r}$

Power gain $A_p = \beta_{ac}A_v$

$= \beta_{ac}^2\frac{R_L}{r}$ ½

(b) ½



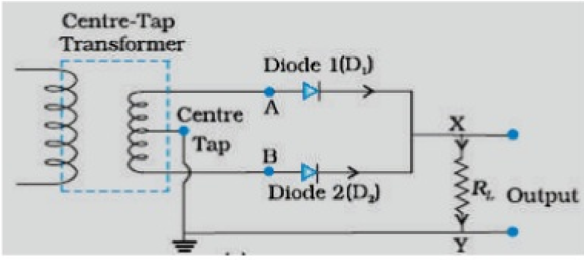
1

Transistor acts as an amplifier in the Active Region ½ 5

OR

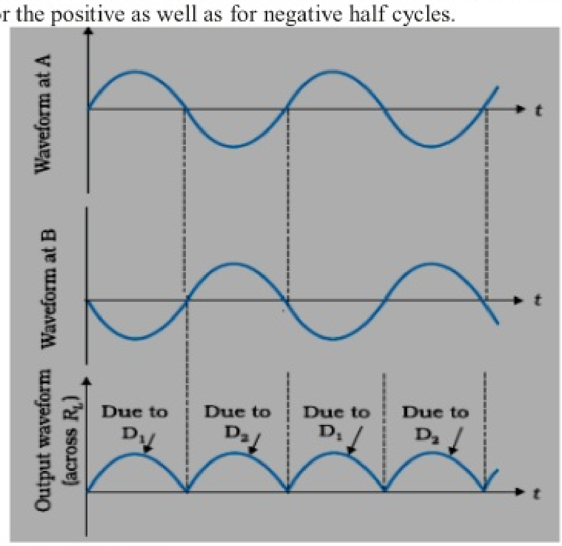
(a) Brief explanation of working of full wave rectifier	2
Drawing of input and output wave forms	1
(b) Identification of Logic gate	1
Truth table	

a)



1

For half cycle of input ac, one diode out of the two, will get forward biased and will conduct, while the other diode, being reverse biased, will not conduct. For other cycle of input signal, the diode, which was reverse biased, will get forward biased and will conduct, and the other diode will get reverse biased and will stop conducting. Hence we obtain a unidirectional output voltage for the positive as well as for negative half cycles. 1



½

½

(b) Identification: AND Gate 1

Truth Table:

Input		Output
A	B	Y
0	0	0
0	1	0
1	0	0
	1	1

1

5

NOTES

Document Outline