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FOR SEMESTER 1 (2021-22)

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CISCE BOARD SPECIMEN QUESTION PAPER 2021-22 (Fully Solved) released on 25 AUGUST 2021

ICSE MCQs CHAPTERWISE QUESTION BANK CLASS 10 PHYSICS

Strictly as per the Latest CISCE Reduced & Bifurcated Syllabus (Aug 6, 2021)

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SYLLABUS COVERED

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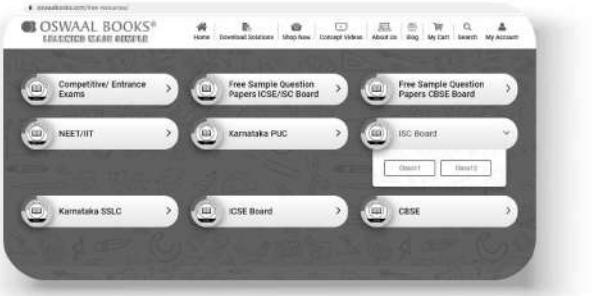

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TWIST IN THE TEST

"To improve is to change; to be perfect is to change often."

- Winston Churchill

CISCE's Modified Plan for Assessment, introduced on August 6, 2021, has radically transformed the evaluation landscape. As per this new plan, the Academic Session 2021-22 will be divided into two semesters with approximately 50% syllabus in each semester, thereby easing the burden on students and learning with a progressively flexible curriculum.

This change has made our examination systems compatible with semester-based systems followed in higher education institutions across the country and across the globe, making our school evaluation system more contemporary and forward-looking.

How to prepare for Semester 1 Board exams?

There is a lot of emphasis on MCQs in the assessment policy as they are a robust evaluation technique. They offer the advantages of versatility (can be used to assess application & problem solving), and are a much more reliable test of understanding. They also test Higher Order Thinking Skills (HOTS).

The Semester-1 examinations will have only Multiple-Choice Questions (MCQs) including case-based MCQs and MCQs on assertion-reason type. This focus on MCQs will better prepare students to face competitive examinations in the future.

Oswaal ICSE MCQs Chapter-wise Question Bank for Semester-1, are strictly as per the latest Bifurcated Syllabus issued by CISCE for Semester-1 board examination. For extensive practice of MCQs based questions and for deep understanding of core-concepts these books include:

1. Largest pool of Topic wise MCQs based on different typologies as per the latest CISCE Specimen Paper for Semester-1 released on 25th August 2021.
2. Revision Notes, Mnemonics, Mind Maps, Answer key with Explanations, Topics generally found difficult, Suggestions & Concept videos, all of which enhance learning experiences and improve learning outcomes.
3. Dynamic QR code to keep the students updated for 2021 Exam paper or any further CISCE notifications/circulars.

Our Heartfelt Gratitude

Finally, we would like to thank our authors, editors, and reviewers. We promise to always strive towards **'Making Learning Simple'** for all of you.

Wish you all Happy Learning and a Successful 2021-22!!

HOW TO USE THIS BOOK?

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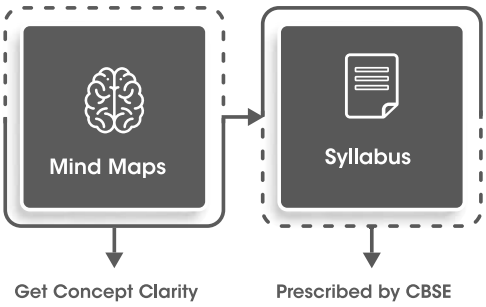

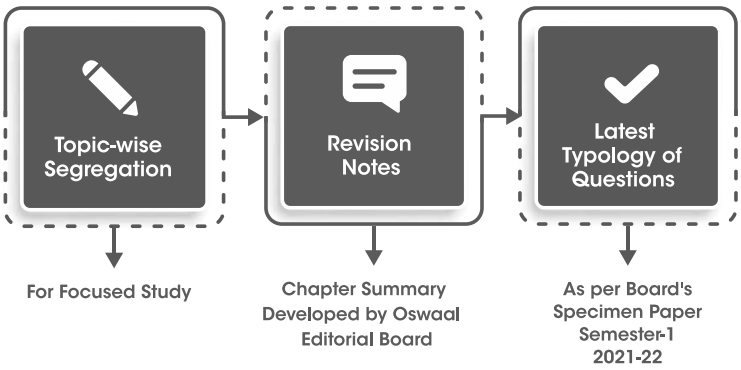

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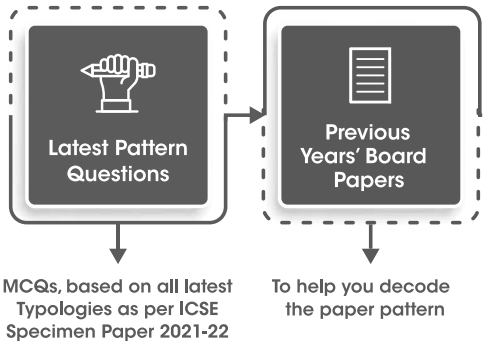

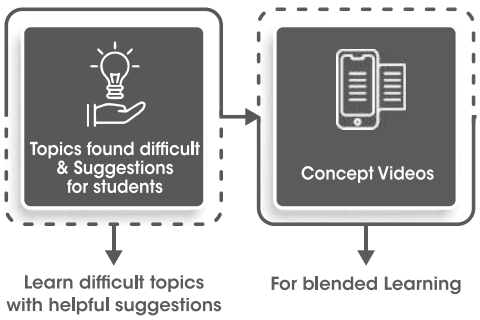

CISCE CIRCULAR 2021-22

COUNCIL FOR THE INDIAN SCHOOL CERTIFICATE EXAMINATIONS
Pragati House, 3rd Floor, 47-48, Nehru Place, New Delhi-110019

Chief Executive & Secretary
GERRY ARATHOON
M.A., B.Ed.

August 6, 2021

Dear Principal,

Subject : CISCE's Modified Plan for Assessment at the ICSE (Class X) and ISC (Class XII) Levels for the Academic Year 2021-22.

In view of the continuing pandemic situation in the country and the disruption in educational activities brought about due to extended lockdowns, and the various alternate modes of syllabus transaction that need to be adopted, due to closure of schools, the CISCE had carried out an extensive exercise of Syllabus review.

As a part of this exercise, syllabi **for various subjects at the ICSE and ISC levels specifically for Classes X and XII, for the Examination Year 2022 were examined by subject experts** to identify portions which may be reduced, without compromising on the quality of content. This **Reduced Syllabus** for the ICSE (Class X) and ISC (Class XII) Year 2022 Examinations is available on the CISCE website under the PUBLICATIONS section.

In addition to reduction of Syllabus at the ICSE (Class X) and ISC (Class XII) levels, the CISCE will follow a different method of conducting Examinations for the Academic Year 2021-22. The details of this modified Assessment Plan for ICSE (Class X) and ISC (Class XII) levels for the Academic Year 2021-22 are given below:

DIVISION OF THE ACADEMIC SESSION 2021-22 INTO TWO SEMESTERS

- The Academic Session 2021-22 will be divided into TWO Semesters, with approximately 50% of the syllabus being covered in each Semester.
- The Reduced Syllabus for ICSE (Class X) and ISC (Class XII) for the Examination Year 2022 has accordingly been bifurcated, and Units/subunits to be covered in each Semester specified clearly.
- The **Semester-wise Bifurcated Theory Syllabus for Classes X and XII** is available on the CISCE website under PUBLICATIONS.

CISCE CIRCULAR 2021-22

CONDUCT OF EXAMINATIONS BY CISCE AT THE END OF EACH SEMESTER

- The CISCE will conduct **Examinations** at the end of each Semester.

FIRST SEMESTER EXAMINATION

- The first Semester Examination will be conducted in **November 2021** and will be based **ONLY** on the portion of Syllabus (Reduced Syllabus for ICSE/ISC Examination Year 2022) specified for the **First Semester.**
- This will be an MCQ based examination, which will be conducted online.

SECOND SEMESTER EXAMINATION

- The Second Semester Examination will be conducted in **March/April 2022** and will be based **ONLY** on the portion of Syllabus (Reduced Syllabus for ICSE/ISC Examination Year 2022) specified for the **Second Semester.**
- This Examination will be conducted in online/offline mode, depending upon the pandemic situation in the country.

- The question papers for each Semester Examination will be of 80/100 marks for ICSE and 70/80 marks for ISC, as per the maximum marks currently allocated for the Theory component of the subjects. However, the weightage of marks (for each of the Semesters) to be finally used for computation of the Board results would be brought down to half.

DETAILS PERTAINING TO THE CONDUCT OF THE SEMESTER-WISE EXAMINATIONS WILL BE SHARED WITH THE SCHOOLS IN DUE COURSE.

PRACTICAL/PROJECT WORK AT THE ISC LEVEL AND INTERNAL ASSESSMENT AT THE ICSE LEVEL

- In addition to the Examinations conducted at the end of each of the two Semesters during the academic year 2021-22, candidates will also be assessed on Practical/Project Work at the ISC level. The Mark weightage of the same remains unchanged (Refer to ISC Reduced Syllabus for the Year 2022 Examination)
- If the situation permits, the ISC Practicals will be conducted as per Option 1 (Visiting Examiners set the Practical Question Papers based on detailed guidelines and instructions from the CISCE). In case the situation is not conducive due to the pandemic, and candidates are unable to come to their respective schools to take the Practical Examination, Option 2 (Online/Virtual mode) will be exercised.
- Similarly, in addition to the Semester Examinations conducted by the CISCE during the academic year, candidates will also be assessed on Internal Assessment at the ICSE level. The Mark weightage of the same remains unchanged (Refer to ICSE Reduced Syllabus for the Year 2022 Examination).

CISCE CIRCULAR 2021-22

UPLOADING OF MARKS FOR PRACTICAL/PROJECT WORK/INTERNAL ASSESSMENTS/ SUPW GRADES

- School will be required to ensure that all candidates finish the stipulated Practical/Project Work/Internal Assessment, as specified in the ICSE and ISC Reduced Syllabi. The same may be evaluated and marked by the Visiting Examiners (for ISC)/Internal Examiners (For ICSE), as per the existing practice.
- Schools will be required to upload marks for Practical/Project Work/Internal Assessment/ SUPW grades on the CAREERS portal at the end of the second Semester, by a specified date.
- School must maintain a record of all work done by candidates for Practical/Project Work/ Internal Assessment. The CISCE may ask schools to send sample/s of work done by the candidates, should the need arise.

Classes IX and XI

There is **NO CHANGE** in the syllabus for Classes IX and XI. For ICSE (Class IX) and ISC (Class XI), schools are required to follow the ICSE and ISC Regulations and Syllabuses for the Year 2023, respectively, as available on the CISCE's website.

Please note that the CISCE will not be conducting the Class IX and XI Examinations during the academic year 2021-22.

You are requested to ensure that all concerned, including the candidates and teachers are apprised of the above-mentioned changes.

I look forward to your cooperation in this regards.

With warm regards,

Yours sincerely,

Gerry Arathoon

Chief Executive & Secretary

SYLLABUS

PHYSICS (52)

CLASS 10

BIFURCATED SYLLABUS

SCIENCE Paper - 1

(As per the Reduced Syllabus for ICSE - Class X Year 2022 Examination)

SEMESTER 1 (Marks: 40)			SEMESTER 2 (Marks: 40)		
Unit No.	**Name Of The Unit**	**Name Of The Sub-Unit**	**Unit No.**	**Name Of The Unit**	**Name Of The Sub-Unit**
1.	**Force, Work, Power and Energy** (Complete Unit)		**3.**	**Sound**	(ii) Natural vibrations, Damped vibrations, Forced vibrations and Resonance - a special case of forced vibrations. (iii) Loudness, pitch and quality of sound.
2.	**Light** (Complete Unit)		**4.**	**Electricity and Magnetism** (Complete Unit)	
3.	**Sound**	(i) Reflection of Sound Waves; echoes: their use; simple numerical problems on echoes.	**5.**	**Heat** (Complete Unit)	
			6.	**Modern Physics** (Complete Unit)	

SYLLABUS

PHYSICS CLASS 10

Latest Reduced Syllabus issued by CISCE for Academic Year 2021-2022

There will be one paper of two hours duration carrying 80 marks and Internal Assessment of practical work carrying 20 marks.
The paper will be divided into two sections, Section I (40 marks) and Section II (40 marks).
***Section I** (compulsory) will contain short answer questions on the entire syllabus.*
***Section II** will contain six questions. Candidates will be required to answer any four of these six questions.*
***Note:** Unless otherwise specified, only SI Units are to be used while teaching and learning, as well as for answering questions.*

1. Force, Work, Power and Energy

(i) Turning forces concept; moment of a force; forces in equilibrium; centre of gravity; [discussions using simple examples and simple numerical problems].

Elementary introduction of translational and rotational motions; moment (turning effect) of a force, also called torque and its cgs and SI units; common examples - door, steering wheel, bicycle pedal, etc.; clockwise and anti-clockwise moments; conditions for a body to be in equilibrium (translational and rotational); principle of moment and its verification using a metre rule suspended by two spring balances with slotted weights hanging from it; simple numerical problems; Centre of gravity (qualitative only) with examples of some regular bodies and irregular lamina.

(ii) Uniform circular motion.

As an example of constant speed, though acceleration (force) is present. Differences between centrifugal and centripetal force.

(iii) Work, energy, power and their relation with force.

Definition of work. WFS=cosθ; special cases of θ = 0°, 90°. W= mgh. Definition of energy, energy as work done. Various units of work and energy and their relation with SI units. [erg, calorie, kW h and eV].

Definition of Power, P=W/t; SI and cgs units; other units, kilowatt (kW), megawatt (MW) and gigawatt (GW); and horsepower (1hp=746W) [Simple numerical problems on work, power and energy].

(iv) Different types of energy (e.g., chemical energy, Mechanical energy, heat energy, electrical energy, nuclear energy, sound energy, light energy).

Mechanical energy: potential energy U = mgh (derivation included) gravitational PE, examples; kinetic energy K= ½ mv^2 (derivation included); forms of kinetic energy: translational, rotational and vibrational - only simple examples. [Numerical problems on K and U only in case of translational motion]; qualitative discussions of electrical, chemical, heat, nuclear, light and sound energy, conversion from one form to another; common examples.

(v) Machines as force multipliers; load, effort, mechanical advantage, velocity ratio and efficiency; pulley systems showing the utility of each type of machine.

Functions and uses of simple machines: Terms- effort E, load L, mechanical advantage MA = L/E, velocity ratio VR = V_E/V_L = d_E / d_L, input (W_i), output (W_o), efficiency (η), relation between η and MA, VR (derivation included); for all practical machines η <1; MA < VR.

Pulley system: single fixed, single movable, block and tackle(Pulleys using single tackle); MA, VR and η in each case.

(vi) Principle of Conservation of energy.

Statement of the principle of conservation of energy; theoretical verification that U + K = constant for a freely falling body. Application of this law to simple pendulum (qualitative only); [simple numerical problems].

2. Light

(i) Refraction of light through a glass block and a triangular prism - qualitative treatment of simple applications such as real and apparent depth of objects in water and apparent bending of sticks in water. Applications of refraction of light.

Partial reflection and refraction due to change in medium. Laws of refraction; the effect on speed (V), wavelength (λ) and frequency (f) due to refraction of light; conditions for a light ray to pass undeviated. Values of speed of light (c) in vacuum, air, water and glass; refractive index μ = c/V, V = fλ. Values of μ for common substances such as water, glass and diamond; experimental verification; refraction through glass block; lateral displacement; refraction through a glass

prism, simple applications: real and apparent depth of objects in water; apparent bending of a stick under water. Simple numerical problems and approximate ray diagrams required.

(ii) Total internal reflection: Critical angle; examples in triangular glass prisms; comparison with reflection from a plane mirror (qualitative only). Applications of total internal reflection.

Transmission of light from a denser medium (glass/ water) to a rarer medium (air) at different angles of incidence; critical angle (C) $\mu = 1/\sin C$. Essential conditions for total internal reflection. Total internal reflection in a triangular glass prism; ray diagram, different cases - angles of prism (60°,60°,60°), (60°,30°,90°), (45°,45°,90°); use of right-angle prism to obtain $\delta = 90°$ and 180° (ray diagram); comparison of total internal reflection from a prism and reflection from a plane mirror.

(iii) Lenses (converging and diverging) including characteristics of the images formed (using ray diagrams only); magnifying glass; location of images using ray diagrams and thereby determining magnification.

Types of lenses (converging and diverging), convex and concave, action of a lens as a set of prisms; technical terms; centre of curvature, radii of curvature, principal axis, foci, focal plane and focal length; detailed study of refraction of light in spherical lenses through ray diagrams; formation of images - principal rays or construction rays; location of images from ray diagram for various positions of a small linear object on the principal axis; characteristics of images. Sign convention and direct numerical problems using the lens formula are included (derivation of formula not required).

Scale drawing or graphical representation of ray diagrams not required.

Power of a lens (concave and convex) – only definition and basic understanding based on the curvature or thickness of lens. Applications of lenses.

(iv) Using a triangular prism to produce a visible spectrum from white light, Electromagnetic spectrum.

Deviation produced by a triangular prism; dependence on colour (wavelength) of light; dispersion and spectrum; electromagnetic spectrum: broad classification (names only arranged in order of increasing wavelength); properties common to all electromagnetic radiations; properties and uses of infrared and ultraviolet radiation.

3. Sound

(i) Reflection of Sound Waves; echoes: their use; simple numerical problems on echoes.

Production of echoes, condition for formation of echoes; simple numerical problems; use of echoes by bats, dolphins, fishermen, medical field. SONAR.

(ii) Natural vibrations, Damped vibrations, Forced vibrations and Resonance - a special case of forced vibrations. *Meaning and simple applications of natural, damped, forced vibrations and resonance.*

(iii) Loudness, pitch and quality of sound

Definition of each of the characteristics and factors affecting them.

4. Electricity and Magnetism

(i) Ohm's Law; concepts of emf, potential difference, resistance; resistances in series and parallel, internal resistance.

Concepts of pd (V), current (I), resistance (R) and charge (Q). Ohm's law: statement, V=IR; SI units; graph of V vs I and resistance from slope; ohmic and non-ohmic resistors, factors affecting resistance (including specific resistance) and internal resistance; super conductors, electromotive force (emf); combination of resistances in series and parallel. Simple numerical problems using the above relations. (Simple network of resistors including not more than four external resistors. Internal resistance may be included).

(ii) Electrical power and energy.

Electrical energy; examples of heater, motor, lamp, loudspeaker, etc. Electrical power; measurement of electrical energy, $W = QV = VIt$ from the definition of pd. Combining with ohm's law $W = VIt = I^2 Rt = (V^2/R)t$ and electrical power $P = (W/t) = VI = I^2R = V^2/R$. Units: SI and commercial; Power rating of common appliances, household consumption of electric energy; calculation of total energy consumed by electrical appliances; $W = Pt$ (kilowatt × hour = kW h) - simple numerical problems.

(iii) Household circuits – main circuit; switches; fuses; earthing; safety precautions; three-pin plugs; colour coding of wires.

House wiring (ring system) (diagrammatic representation excluded), main circuit (3 wires-live,

neutral, earth) with fuse / MCB, main switch and its advantages, need for earthing, fuse, 3-pin plug and socket; Conventional location of live, neutral and earth points in 3 pin plugs and sockets. Safety precautions, colour coding of wires.

(iv) Magnetic effect of a current (principles only, laws not required); electromagnetic induction (elementary).

Oersted's experiment on the magnetic effect of electric current; magnetic field (B) and field lines due to current in a straight wire (qualitative only), right hand thumb rule – magnetic field due to a current in a loop; Electromagnets: their uses; comparisons with a permanent magnet; conductor carrying current in a magnetic field experiences a force, Fleming's Left Hand Rule and its understanding, Simple introduction to electromagnetic induction; a magnet moved along the axis of a solenoid induces current, Fleming's Right Hand Rule and its application in understanding the direction of current in a coil and Lenz's law, Comparison of AC and DC.

5. Heat

(i) Calorimetry: meaning, specific heat capacity; principle of method of mixtures; Numerical Problems on specific heat capacity using heat loss and gain and the method of mixtures.

Heat and its units (calorie, joule), temperature and its units (^0C,, K); thermal (heat) capacity $C' = Q/\Delta T$... (SI unit of C'): Specific heat Capacity $C = Q/m\Delta T$ (SI unit of C) Mutual relation between Heat Capacity and Specific Heat capacity, values of C for some common substances (ice, water and copper). Principle of method of mixtures including mathematical statement. Natural phenomenon involving specific heat. Consequences of high specific heat of water. [Simple numerical problems].

(ii) Latent heat; loss and gain of heat involving change of state for fusion only.

Change of phase (state); heating curve for water; latent heat; specific latent heat of fusion (SI unit). Simple numerical problems. Common physical phenomena involving latent heat of fusion.

6. Modern Physics

Radioactivity and changes in the nucleus; background radiation and safety precautions.

Brief introduction (qualitative only) of the nucleus, nuclear structure, atomic number (Z), mass number (A). Radioactivity as spontaneous disintegration. α, β and γ - their nature and properties; changes within the nucleus. One example each of α and β decay with equations showing changes in Z and A. Uses of radioactivity - radio isotopes. Harmful effects. Safety precautions. Background radiation. Radiation: X-rays; radioactive fallout from nuclear plants and other sources.

Nuclear Energy: working on safe disposal of waste. Safety measures to be strictly reinforced.

A NOTE ON SI UNITS

SI units (Systeme International d'Unites) were adopted internationally in 1968.

Fundamental units :

The system has seven fundamental (or basic) units, one for each of the fundamental quantities.

Fundamental quantity	Unit	
	Name	Symbol
Mass	Kilogram	kg
Length	Metre	m
Time	Second	s
Electric current	Ampere	A
Temperature	Kelvin	K
Luminous intensity	Candela	cd
Amount of substance	Mole	mol

Derived units :

These are obtained from the fundamental units by multiplication or division; no numerical factors are involved. Some derived units with complex names are:

Derived quantity	Unit	
	Name	Symbol
Volume	cubic metre	m^3
Density	kilogram per cubic metre	$kg\ m^{-3}$
Velocity	metre per second	$m\ s^{-1}$
Acceleration	metre per second square	$m\ s^{-2}$
Momentum	kilogram metre per second	$kg\ m\ s^{-1}$

Some derived units are given special names due to their complexity when expressed in terms of the fundamental units, as below:

Derived quantity	Unit	
	Name	Symbol
Force	newton	N
Pressure	pascal	Pa
Energy, Work	joule	J
Power	watt	W
Frequency	hertz	Hz
Electric charge	coulomb	C
Electric resistance	ohm	Ω
Electromotive force	volt	V

When the unit is named after a person, the symbol has a capital letter.

Standard prefixes

Decimal multiples and submultiples are attached to units when appropriate, as below:

Multiple	Prefix	Symbol
10^{9}	giga	G
10^{6}	mega	M
10^{3}	kilo	k
10^{-1}	deci	d
10^{-2}	centi	c
10^{-3}	milli	m
10^{-6}	micro	μ
10^{-9}	nano	n
10^{-12}	pico	p
10^{-15}	femto	f

INTERNAL ASSESSMENT OF PRACTICAL WORK

Candidates will be asked to carry out experiments for which instructions will be given. The experiments may be based on topics that are not included in the syllabus, but theoretical knowledge will not be required. A candidate will be expected to be able to follow simple instructions, to take suitable readings and to present these readings in a systematic form. He/she may be required to exhibit his/her data graphically. Candidates will be expected to appreciate and use the concepts of least count, significant figures and elementary error handling.

Note : Teachers may design their own set of experiments, preferably related to the theory syllabus. A comprehensive list is suggested below:

1. Lever - There are many possibilities with a meter rule as a lever with a load (known or unknown) suspended from a point near one end (say left), the lever itself pivoted on a knife edge, use slotted weights suspended from the other (right) side for effort.

   Determine the mass of a metre rule using a spring balance or by balancing it on a knife edge at some point away from the middle and a 50g weight on the other side. Next pivot (F) the metre rule at the 40cm, 50cm and 60cm mark, each time suspending a load L or the left end and effort E near the right end. Adjust E and or its position so that the rule is balanced. Tabulate the position of L, F and E and the magnitudes of L and E and the distances of load arm and effort arm. Calculate MA=L/E and VR = effort arm/load arm. It will be found that MA <VR in one case, MA=VR in another and MA>VR in the third case. Try to explain why this is so. Also try to calculate the real load and real effort in these cases.
2. Determine the VR and MA of a given pulley system.
3. Trace the course of different rays of light refracting through a rectangular glass slab at different angles of incidence, measure the angles of incidence, refraction and emergence. Also measure the lateral displacement.
4. Determine the focal length of a convex lens by (a) the distant object method and (b) using a needle and a plane mirror.
5. Determine the focal length of a convex lens by using two pins and formula $f = uv/(u+v)$.
6. For a triangular prism, trace the course of rays passing through it, measure angles i_1, i_2, A and δ. Repeat for four different angles of incidence (say i_1=400 , 500, 600 and 700). Verify $i_1 + i_2 = A + \delta$ and $A = r_1 + r_2$.
7. For a ray of light incident normally (i_1=0) on one face of a prism, trace course of the ray. Measure the angle δ. Explain briefly. Do this for prisms with A=60^0, 45^0 and 90^0.

8. Calculate the sp. heat of the material of the given calorimeter, from the temperature readings and masses of cold water, warm water and its mixture taken in the calorimeter.
9. Determination of sp. heat of a metal by method of mixtures.
10. Determination of specific latent heat of ice.
11. Using as simple electric circuit, verify Ohm's law. Draw a graph and obtain the slope.
12. Set up model of household wiring including ring main circuit. Study the function of switches and fuses.

Note: Teachers may feel free to alter or add to the above list. The students may perform about 3 to 5 experiments.

EVALUATION

The practical work/project work are to be evaluated by the subject teacher and by an External Examiner. (The External Examiner may be a teacher nominated by the Head of the school, who could be from the faculty, **but not teaching the subject in the relevant section/class.** For example, a teacher of Physics of Class VIII may be deputed to be an External Examiner for Class X, Physics projects.)

The Internal Examiner and the External Examiner will assess the practical work/project work independently.

Award of marks	**(20 Marks)**
Subject Teacher (Internal Examiner)	10 marks
External Examiner	10 marks

The total marks obtained out of 20 are to be sent to the Council by the Head of the school.

The Head of the school will be responsible for the online entry of marks on the Council's CAREERS portal by the due date.

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Topics Found Difficult / Confusing By candidates

Examination Paper 2020

- Work done when a body moves in a circular path.
- Diagram of refraction from denser to rarer medium to show the formation of an image.
- Completing the path of a ray through 30°,60° and 90° prism.
- Scattering of light
- Refraction through any refracting medium when opposite faces are parallel and when they are not parallel.
- Numerical problems based on light using sign convention.
- Graphs on calorimetry.
- Numerical problems based on Heat.
- Numerical problems based on Electricity, especially in finding the current in parallel branches.
- Completing the nuclear reactions in reverse order.

Examination Paper 2019

- Understanding of lever of class 1 with M.A. greater than 1 and class 2 lever.
- Physical quantity and unit.
- Specific heat capacity and Specific resistance
- Ratio concept in solving numerical.
- Factors affecting critical angle and conditions for total internal reflection.
- Correlation between the holes present on the flute and the frequency of sound produced.
- Connection of live, neutral and earth wire with the appliance.
- Nuclear fusion reaction is called as thermonuclear reaction?
- Identification of lenses when virtual images are formed.
- Change in the focal length when the refractive index of the outside medium changes.
- The diagram of AC generator and DC motor.
- Difference between the number of turns of the coil and just coils.

Examination Paper 2018

- Change in mechanical advantage when the load is shifted towards fulcrum in class II lever.
- Speed of light for all wavelengths in vacuum is the same.
- Problems on calorimetry.
- Conversion of units.
- Heat capacity and specific heat capacity.
- Ray diagrams of lenses.

Topics Found Difficult / Confusing By candidates

- Numerical problem on lens formula.
- Total internal reflection through right angled isosceles prism.
- Specific resistance and its unit.
- Differentiation between resistance and specific resistance.
- Difference between the use of a fuse in a normal circuit and a power circuit.
- Numerical on reflection of sound.
- Confusion between the use of $V = \frac{d}{t}$ and $V = \frac{2d}{t}$
- Beta emission during carbon dating.
- Nuclear fusion.
- Concept of isobar.
- Identification of magnetic poles in electromagnets.
- Substitution in a numerical which required some conversion.

Examination Paper 2017

- Conversion of units.
- Numerical on moment of force.
- Advantages of movable and fixed pulley.
- Problems on calorimetry.
- Ray diagrams for lenses and prism.
- Reason for stepping up voltage during power transmission.
- Dual control switch.
- Numerical based on sound.
- Specific resistance and its unit.
- Causes of energy losses in the transformer.

Examination Paper 2016

- Students were confused in Q 4 a) and d) part as the nature of question was the same.
- Clarity was lacking in Q 6 a) i, ii, iii.
- It is also observed that in ray diagrams in spite of knowing diagrams students loose marks as they don't draw arrows on rays before and after refraction and don't draw dotted line for virtual intersection or image.
- Most of the students are confused between the concept of dispersion and scattering.
- In electricity the difference between P.D. and terminal voltage is not clear. In some cases P.D. is misunderstood as only potential drop.
- Students were also confused about the working and the characteristics of transformers.

Topics Found Difficult / Confusing By candidates

- Due to the lack of necessary information Q 2 (e) was confusing.
- Q 5 (a) ii, iii was asked beyond the depth of the topic which is covered in std. 10.
- In Q10 (c) students were not aware about two conditions required for a nucleus to be radioactive.
- Calorimetry numerical were found difficult.
- Q6 (b) was beyond the scope of syllabus as it does not include latent heat of vaporization.
- Students were not comfortable in stating the factors affecting the frequency of stretched string.

Examination Paper 2015

- Cases of inter conversion of energy.
- Concept of work. Work done for different angles between force and displacement.
- Numerical problems based on p = f.v and machines.
- Interpretation of graphs and slopes.
- Vibration in a stretched string.
- Cases of resonance, forced vibrations, free vibrations, etc.
- Safe limit of sound level for humans.
- Numerical problems on "Heat"
- Difference between heat capacity, SHC and SLHC.
- Similarities between A.C generator and D.C motor.
- Cathode ray tube.
- Mass number and atomic number.

Suggestions for Students

- ⇨ Try to understand the concept and try to apply it to the immediate surrounding.
- ⇨ Try to relate the concepts from Mathematics with Physics and vice-versa.
- ⇨ Avoid rote learning. Answer in your own words and then verify whether you have covered all points.
- ⇨ Watch related videos on YouTube and try to make some projects/models which work on the principles which you have learnt.
- ⇨ Pay equal attention to all chapters.
- ⇨ Take out time for self-study.
- ⇨ Periodic revision of the topics completed should be done.
- ⇨ Practice previous years' question papers.
- ⇨ Analyse your errors during practice papers and work accordingly.
- ⇨ Use the reading time of 15 minutes judiciously to decide the questions that you are going to attempt.
- ⇨ Keep your answer paper presentable by keeping your handwriting legible and by avoiding unnecessary scratching and striking off
- ⇨ Write the formula in the beginning while solving numerical.
- ⇨ Definitions along with key words must be practiced.
- ⇨ Practice conversion of CGS units to SI units and vice-versa.
- ⇨ Practice drawing block and tackle system of pulleys, by drawing string straight, showing rigid support and tension in the string opposite to the direction of load.
- ⇨ Practice ray diagrams with arrows marked.
- ⇨ Show virtual images by dotted lines.
- ⇨ Do not leave the answer in fractional form. Express it in decimal form.
- ⇨ Express the answer only in SI units unless otherwise asked.
- ⇨ Comprehend the key terms/technical terms/ keywords, laws and principles before memorisation.
- ⇨ Practise concept based and application-based questions regularly.
- ⇨ Practise numerical problems starting from simple to complex that is from direct formula based to application/understanding based.
- ⇨ Give more emphasis on solving numerical problems with understanding.
- ⇨ Emphasise on practice by writing rather than just reading.
- ⇨ Practise diagrams regularly.
- ⇨ Think logically before drawing ray diagrams.
- ⇨ Discourage yourself from drawing rough hand sketches when diagram is asked in the question.
- ⇨ Use first 15 minutes of reading time judiciously to understand what is asked in the question. Keep in mind or note every bit of information given in the question.
- ⇨ Write to the point rather than beating around the bush.
- ⇨ Do not change the numbering system given in the question paper while writing the answers on the answer sheet.

Suggestions for Students

- ⇨ Practise beginning a new question on a fresh page, or after leaving 8 to 10 lines.
- ⇨ Practise solving previous years' ICSE question papers.
- ⇨ Avoid selective study.
- ⇨ Learn tables and squares up to 30.
- ⇨ Read the questions heedfully and write answer in brief and to the point.
- ⇨ Express the answer only in SI units unless otherwise asked.
- ⇨ State the meaning of the symbols if the answer is given in terms of any formula/ mathematical equation.
- ⇨ Use abbreviations/symbols which are standard/acceptable.
- ⇨ Solve at least the last five years' I.C.S.E. question papers.
- ⇨ Write in a neat and legible handwriting.
- ⇨ Avoid changing the order of sequence of questions and numbering system while attempting the paper.
- ⇨ Express final answer with proper unit as per the requirement of the question.
- ⇨ Focus more on conceptual learning rather than rote learning.
- ⇨ Make observations and try to relate your learning with it.
- ⇨ Always participate in class discussion.
- ⇨ Learn to write answers precisely and to the point.
- ⇨ It is advisable to learn tables and squares up to 30. This will save a lot of time spent on calculation.
- ⇨ Avoid writing answers which are simply a repetition of the question. Instead be specific about the key word in that statement.
- ⇨ Do not leave any topic for option. All topics are covered in section I which is compulsory.
- ⇨ Avoid changing the order of sequence of questions and numbering system.
- ⇨ Handwriting should be neat and legible.
- ⇨ Learn the principles, laws and definitions accurately.
- ⇨ Ray diagrams and the other diagrams need to be practiced periodically. While drawing them, draw arrows on the rays before and after the refraction and virtual rays or image should be drawn by dotted lines. No arrows to be drawn on virtual ray.
- ⇨ While writing answers it is not only important to cover all points but also to present them in a proper sequence.
- ⇨ While solving a numerical it is advisable that the formula be written in the beginning. Essential steps need to be shown and the final answer be expressed along with a proper unit.
- ⇨ Avoid computation at the first step; let it be plain substitution as the marks are awarded for the correct substitution.
- ⇨ It is advisable to state the meaning of the symbols if the answer is given in terms of any formula. Do not use any abbreviations which are not standard.
- ⇨ The answer need to be given in SI units unless it is asked otherwise.

Suggestions for Students

- ⇨ In numerical as far as possible avoid mental calculation at the first stage, let it be direct substitution.
- ⇨ Advisable to present the final answer in the decimal form. Answer in fraction is treated as incomplete calculation.
- ⇨ It is advisable to solve previous year's papers in writing.
- ⇨ More emphasis should be given on writing rather than memorising.
- ⇨ Units should be written without spelling errors.
- ⇨ Use the reading time of 15 minutes judiciously to make a proper choice of questions from section II by reading the requirements of the question carefully supported with a high degree of concentration.
- ⇨ A thorough revision of all topics is all time important.
- ⇨ More emphasis should be given on writing rather than memorizing.
- ⇨ It is better to inculcate the habit of underlining the important points or key words in the answer.
- ⇨ Be regular in your study habits. Complete your syllabus well in time. A thorough revision of all topics is all time important.
- ⇨ More emphasis should be given on writing rather than memorizing.
- ⇨ For speed in mathematical calculations; it is advisable to learn tables up to 30, know squares up to 30, cubes up to 15 and basics of fractions and decimal.
- ⇨ It is better to inculcate the habit of underlining the important points or key words in the answer.

POSITIVE AFFIRMATIONS

"Affirmations are like a seed planted in soil. Poor soil, poor growth. Rich soil, abundant growth. The more you choose to think thoughts that make you feel good, the quicker the affirmations work."

- Louise Hay

- I am confident.
- I love who I am.
- I am compassionate.
- I am responsible.
- I am a leader.
- I believe in my dreams.
- I am brave.
- I choose a positive attitude.
- I am enough.
- I am great just the way I am.
- I work hard.
- I radiate joy and love.
- I am honest.
- I am patient.
- I help my family.
- I am strong.
- I can achieve my goals.
- I make good decisions.
- I am diligent.
- I am thoughtful.
- I am talented.
- I am loved.
- I am generous.
- I accept and love myself.
- I am unique.
- I am wonderfully made.
- I am creative.
- Good things happen to me.
- I am loving.
- I am kind.
- I am joyful.
- I care about others.
- I am important.
- I like myself.
- It's going to be a great day.
- I learn from my mistakes.
- I make friends easily.
- I am worthy.
- I am open to new experiences.
- I am beautiful.
- I am deserving of good things.
- I am grateful.
- I believe in me.
- I respect myself and I respect others.

Our mind starts believing what we repeatedly think or say. We, at Oswaal Books, resonate with this belief. So, we want all our readers to create their own positive affirmations! A positive affirmation is something spoken aloud that you want to believe or want to be true. Repeating positive affirmations daily can help shift your internal dialogue from negative to positive.

So let's get started!

WRITING NOTES

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ICSE SEMESTER 1 EXAMINATION
SPECIMEN QUESTION PAPER
PHYSICS
SCIENCE Paper – 1

Maximum Marks: 40

Time allowed: One hour (inclusive of reading time)

ALL QUESTIONS ARE COMPULSORY

The intended marks for questions or parts of questions are given in brackets [ ].

Select the correct option for each of the following questions.

Question 1

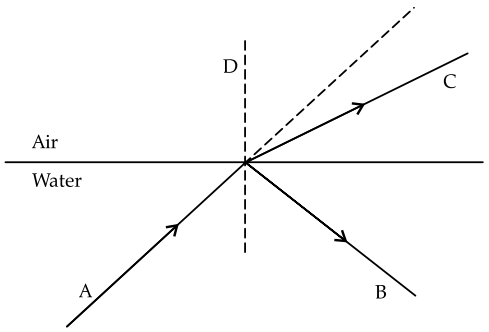
(a) Choose the correct statement with respect to Refraction of light **[1]**

1. The colour always changes when light enters from one optical medium to another.
2. Absorption of light when it strikes the surface of a medium is refraction.
3. Speed of light changes when it enters from one optical medium to another of different optical density.
4. Speed of light does not change when it enters from one optical medium to another of different optical density.

(b) When a light ray enters from a denser medium to a rarer medium **[1]**

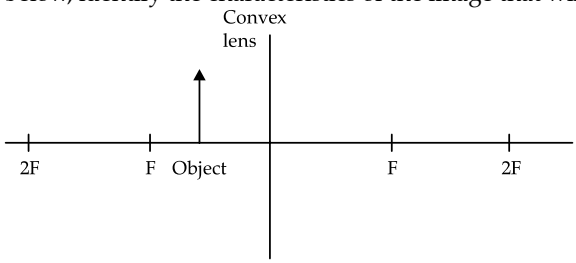
1. The light ray bends towards the normal.
2. Angle of incidence is less than angle of refraction.
3. Speed of light decreases.
4. Speed of light remains unchanged.

(c) In the diagram shown below: **[1]**



1. B is incident ray and C is refracted ray.
2. A is incident ray and B is refracted ray.
3. C is incident ray and B is refracted ray.
4. A is incident ray and C is refracted ray.

(d) From the diagram shown below, identify the characteristics of the image that will be formed. **[1]**



1. Real.
2. Diminished.
3. Formed within the focal length.
4. Virtual.

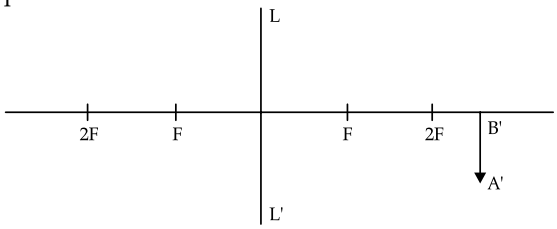
(e) The wavelength of light in a medium A is 600 nm. The wave enters medium B of refractive index 1.5
Steps to find the wavelength of light in medium B are given below. Choose an option which has the correct sequence of steps, to find the wavelength. **[2]**

(i) $\lambda = 1.5 \times 600$ (ii) $\lambda = \frac{600}{1.5}$ (iii) $\lambda = 400$ nm

(iv) $\lambda = 900$ nm (v) $1.5 = \frac{\lambda}{600}$

1. (i) then (iii)
2. (ii) then (iii)
3. (i) then (iv)
4. (ii), (i) then (iv)
5. (v) then (iv)

(f) The diagram below shows an image formed at a distance 36 cm from the lens LL′ of focal length 12 cm. With respect to this answer the questions that follow. **[4]**



(i) The position of the object on the left-hand side should be
1. between 12 cm to 30 cm from the lens.
2. beyond 24 cm from the lens.
3. between 12 cm to 24 cm from the lens.
4. within 12 cm from the lens.

(ii) Power of this lens is
1. – 8.33 D
2. + 8.4 D
3. + 8.33 D
4. – 8.4 D

(iii) The object distance with sign convention is
1. – 18 cm
2. – 15 cm
3. – 9 cm
4. + 18 cm

(iv) If the lens LL′ is replaced by another lens of same type but focal length 15 cm, then for the same object distance
1. the size of the image decreases.
2. the size of the image increases.
3. the size of the image remains the same.
4. information is insufficient to conclude.

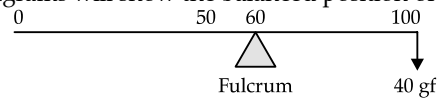
Question 2

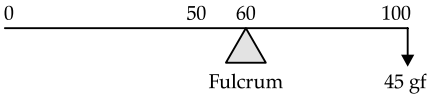
(a) The usable form of mechanical energy is **[1]**
1. Elastic potential energy
2. Kinetic energy
3. Gravitational potential energy
4. None of the given options.

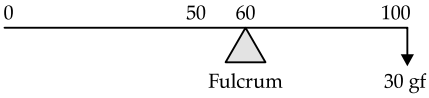
(b) One horsepower is equal to **[1]**
1. 100 W
2. 735 W
3. 764 W
4. 746 W

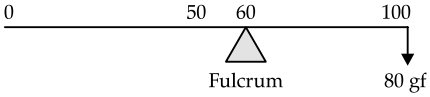
(c) If A and B of the same mass can climb the third floor of the same building in 3 minutes and 5 minutes respectively, then the ratio of their powers of A is to B in an ideal situation is **[1]**
1. 1 : 1
2. 3 : 5
3. The information is insufficient to form a conclusion.
4. 5 : 3

(d) If the centre of gravity of a metre scale of mass 80 g lies at the 45 cm mark, then which one of the following diagrams will show the balanced position of the scale. **[1]**

1.


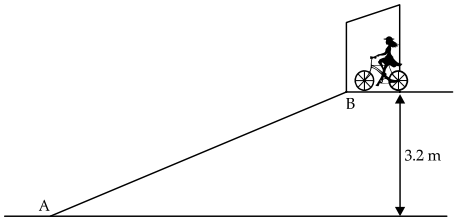
2.


3.


4.


(e) A body has kinetic energy 250 J. If the mass of the body is 5 kg, then choose its velocity and momentum from the following options. **[2]**
1. 50 m/s
2. 50 kg.m/s
3. 20 kg.m/s
4. 15 m/s
5. 10 m/s
6. 100 kg.m/s

(f) A girl at rest at gate of her society which is 3.2 m above the road comes down the slope AB on a cycle without paddling. [g = 10 N/kg] **[4]**



(i) The mechanical energy possessed by the girl at B is
1. Vibrational kinetic energy.
2. Translational kinetic energy
3. Elastic potential energy.
4. Gravitational potential energy.

(ii) The velocity with which girl reaches point A is
1. 32 m/s
2. 10 m/s
3. 8 m/s
4. Insufficient information to calculate velocity.

(iii) If the mass of the girl is 40 kg then the kinetic energy of the girl at A is [Assuming no loss of energy.]
1. 1280 J
2. 1600 J
3. 400 J
4. 3200J

(iv) The potential energy of the girl (of mass 40 kg) when she reaches the midpoint of the slope of AB
1. 800 J
2. 200 J
3. 1600 J
4. 640 J

Question 3

(a) Mechanical advantage (M.A.), load(L), and effort(E) are related as **[1]**
1. M.A. = L × E
2. M.A. = E/L
3. M.A. × E = L
4. M.A. × L = E

(b) Which one of the following statements is correct? **[1]**
1. A machine is used to have more output energy as compared to input energy.
2. Mechanical advantage of a machine can never be greater than 1.
3. If a machine gives convenience of direction, then its mechanical advantage should be greater than 1.
4. For a given design of a machine, even if the mechanical advantage increases, the velocity ratio remains the same.

(c) If a block and tackle system with convenient direction has 3 movable pulleys, then its velocity ratio **[1]**
1. is either 6 or 7
2. should be 6
3. should be 7
4. is 3

(d) Work done by a body moving on a circular track is zero at every instant because **[1]**
1. displacement is zero.
2. displacement is perpendicular to the centripetal force.
3. there is no force acting.
4. reason is not mentioned in the other options.

(e) Identify the conditions required to hear a clear and distinct echo by humans, in air **[2]**
1. The reflecting surface should be rough.
2. The size of the reflecting surface should be smaller than the wavelength of sound.
3. Sound should not be reflected back within 0.1 s.
4. The incident sound should have frequency more than 25000 Hz.
5. The size of the reflecting surface should be larger than the wavelength of sound.

(f) A person standing in front of a vertical cliff fires a gun and hears its echo in 3 s. The speed of sound in air is 340 m/s **[4]**

(I) Calculate distance at which the person is standing in front of the cliff? Steps are given to calculate the distance. Select the correct sequence of the steps from the given options:

(i) $340 = \frac{2d}{3}$ (ii) $340 = \frac{d}{3}$

(iii) $d = 170 \times 2 = 510$ m (iv) $d = 340 \times 3 = 1020$ m

1. (ii) then (iv)
2. (iii) then (ii)
3. (i) then (iii)
4. (iii) then (i)
5. (i) then (iv)

(II) If the speed of sound changes to 350 m/s then how much distance should the person move towards or away from the cliff in order to hear the echo in the same time. Steps are given to calculate the distance. Select the correct sequence of the steps from the given option. **[4]**

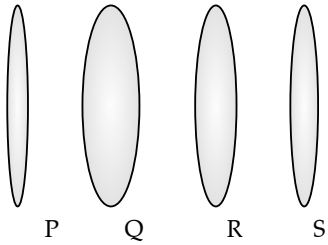
(i) $\frac{340 + 350}{2} = \frac{2d}{3}$ (ii) $350 - 340 = \frac{2d}{3}$

(iii) $\frac{345 \times 3}{2} = 517.5$ m (iv) $d = \frac{30}{3} = 15$ m (v) 7.5 m

1. (ii), (iii) then (v)
2. (iv) then (ii)
3. (iv) then (v)
4. (ii) then (iv)
5. (i), (iv) and (v)

Question 4

(a) Assuming all lenses shown below are of the same material, state which lens has the maximum power. **[1]**

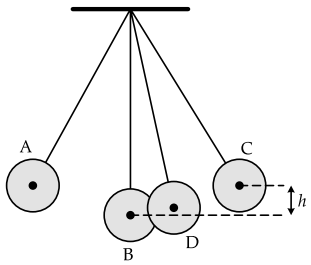


1. R 2. P 3. Q 4. S

(b) In an electric cell while in use, the change in energy is from: **[1]**

1. Chemical to mechanical
2. Chemical to electrical
3. Electrical to mechanical
4. Electrical to chemical

(c) The diagram below shows a pendulum having a bob of mass 80 g. A and C are extreme positions and B is the mean position. The bob has velocity 5 m/s at position B. Assuming there is no loss of energy, select the correct statements from the options given below: [g = 10 N/kg] **[2]**

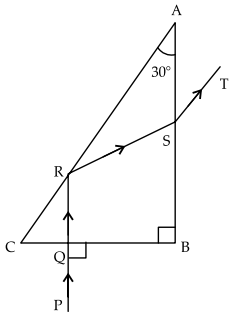


1. At point A, the bob will have only kinetic energy.
2. The maximum potential energy gained by the bob will be 1000 J.
3. The maximum height '*h*' reached by the bob will be 125 cm.
4. At point D, the bob will have maximum kinetic energy.
5. The maximum potential energy gained by the bob will be 1 J
6. At point B, the energy possessed by the bob is 1000 J.

(d) Select correct options for Total internal reflection in a medium. **[2]**

1. Can take place in an optically denser medium as compared to an optically rarer medium.
2. Takes place for any angle of incidence greater than 42 degree.
3. This reflection does not obey the laws of reflection.
4. Can take place if the angle of incidence in a denser medium is more than the critical angle.

(e) The diagram shows the path of light through a right-angled prism of critical angle 42°.
Observe the diagram and answer the questions that follow. **[4]**



(i) The phenomenon at the surface AC is
1. Refraction
2. Partial reflection
3. Total internal reflection
4. Scattering.

(ii) The angle of incidence at the surface AC is
1. 30° 2. 45° 3. 0° 4. 60° 5. 90°

(iii) The angle of incidence at the surface AB is
1. 30° 2. 0° 3. 45° 4. 60° 5. 90°

(iv) Which of the following statement is wrong?
1. Speed of light ray PQ is equal to the speed of light ray ST.
2. Speed of light ray QR is equal to the speed of light ray RS.
3. Speed of light ray PQ is greater than the speed of light ray RS.
4. Speed of light ray RQ is greater than the speed of light ray ST.

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ICSE - Specimen Question Paper
Semester – 1

OMR SHEET

Booklet Series: A

Use English Numbers / Letters only. Use Blue / Black Ball Point Pen to write in box.

Booklet Series: Ⓐ Ⓑ Ⓒ Ⓓ

Roll Number: 0 1 2 3 4 5 6 7 8 9

Subject

Name

Test Date

Student's Signature

Invigilator's Signature

Certified that all the entries In this section have been properly filled by the student

Proper Marking

The OMR Sheet will be computer checked Fill the circles completely and dark enough for proper detection, Use ballpen (black or blue) for marking.

Ⓐ Ⓑ ● Ⓓ

Avoid Improper Marking

Partially Filled

Lightly Filled

Test Center Code: 0 1 2 3 4 5 6 7 8 9

IMPORTANT

The candidate should check that the Test Book Series printed on the OMR Sheet is the same as printed on the Test Booklet. In case of discrepancy, the candidate should immediately report the matter to the invigilator for replacement of both the Test Booklet and the Answer Sheet.

Darken the circle for each question.

Q.No.	Response
1.	
(a)	① ② ③ ④
(b)	① ② ③ ④
(c)	① ② ③ ④
(d)	① ② ③ ④
(e)	① ② ③ ④ ⑤
1(f)	
(i)	① ② ③ ④
(ii)	① ② ③ ④
(iii)	① ② ③ ④
(iv)	① ② ③ ④
2.	
(a)	① ② ③ ④
(b)	① ② ③ ④
(c)	① ② ③ ④
(d)	① ② ③ ④
(e)	① ② ③ ④ ⑤ ⑥
2(f)	
(i)	① ② ③ ④
(ii)	① ② ③ ④
(iii)	① ② ③ ④

Q.No.	Response
(iv)	① ② ③ ④
3.	
(a)	① ② ③ ④
(b)	① ② ③ ④
(c)	① ② ③ ④
(d)	① ② ③ ④
(e)	① ② ③ ④ ⑤
3(f)	
(I)	① ② ③ ④ ⑤
(II)	① ② ③ ④ ⑤
4.	
(a)	① ② ③ ④
(b)	① ② ③ ④
(c)	① ② ③ ④ ⑤ ⑥
(d)	① ② ③ ④
(e)	
(i)	① ② ③ ④
(ii)	① ② ③ ④ ⑤
(iii)	① ② ③ ④ ⑤
(iv)	① ② ③ ④

ICSE Specimen Question Paper
Semester-1

SOLUTIONS

1. (a) Ans. Option (3) is correct.

Explanation: Speed of light in vacuum is 3×10^8 ms^{-1}. But its speed reduces as it enters in an optically denser medium.

(b) Ans. Option (2) is correct.

Explanation: As light enters from denser to rarer medium, its speed increases and hence it bends away from normal. So, the angle of incidence becomes less than the angle of refraction.

(c) Ans. Option (4) is correct.

Explanation: A is the incident ray in water. C is the refracted ray in air. B cannot be a refracted ray since it lies in the same medium (water).

(d) Ans. Option (4) is correct.

Explanation: Since the object lies between focus and optical center, so the the image will be formed on the same side of the lens. The image is magnified, erect and virtual.

(e) Ans. Option (2) is correct.

Explanation: $\lambda_B = \frac{\lambda_A}{\mu}$

$= \frac{600}{1.5}$

$= 400$ nm

(f) (i) Ans. Option (3) is correct.

Explanation: Image distance = 36 cm,
i.e. beyond $2F_2$
So, the object should be between F_1 and $2F_1$.
Since the focal length is 12 cm, so the object should be between 12 cm and 24 cm from the lens.

(ii) Ans. Option (3) is correct.

Explanation: Power of a lens = $1/f$, where f is in metre.

Here $f = +12$ cm $= \frac{12}{100}$ m

$\therefore \quad P = +\frac{100}{12} = +8.33$ D

(iii) Ans. Option (1) is correct.

Explanation: $v = 36$ cm

$f = -12$ cm

Applying lens formula,

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$

or, $\frac{1}{36} - \frac{1}{u} = \frac{1}{12}$

or, $\frac{1}{36} - \frac{1}{12} = \frac{1}{u}$

$\therefore \quad u = -18$ cm

(iv) Ans. Option (2) is correct.

Explanation: Applying lens formula,

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$

or, $\frac{1}{v} + \frac{1}{18} = \frac{1}{15}$

or, $\frac{1}{15} - \frac{1}{18} = \frac{1}{v}$

$\therefore \quad v = 90$ cm

So, v/u ratio increases. So, the magnification increases.

2. (a) Ans. Option (2) is correct.

Explanation: Kinetic energy is a form of mechanical energy which is used for doing work.

(b) Ans. Option (4) is correct.

(c) Ans. Option (4) is correct.

Explanation: power of A $= \frac{mgh}{3}$

Power of B $= \frac{mgh}{5}$

$\therefore \frac{\text{Power of A}}{\text{Power of B}} = \frac{5}{3}$

(d) Ans. Option (3) is correct.

Explanation:
Anticlockwise moment = 80 × (60 – 45)
= 1200
Only for option (3), clockwise moment
= 30 × (100 – 60) = 1200
i.e. Anticlockwise moment = clockwise moment. So, the scale will be balanced.

(e) Ans. Options (5) and (2) are correct.

Explanation: Kinetic energy = 250 J

or, $\frac{1}{2} = 250$

or, $\frac{1}{2} \times 5 \times v^2 = 250$

or, $v^2 = 100$

$\therefore$ $v = 10\ ms^{-1}$.

So, option (5) is correct.

Momentum = mass × velocity

or, Momentum = 5 × 10

$\therefore$ Momentum = 50 $kgms^{-1}$.

So, option (2) is correct.

(f) (i) Ans. Option (4) is correct.

Explanation: Gravitational potential energy is the energy possessed by an object due to its position in a gravitational field.

(ii) Ans. Option (4) is correct.

Explanation: $V_f = 2 \times g\sin\theta \times s$
θ is not known. So, velocity at A cannot be calculated.

(iii) Ans. Option (1) is correct.

Explanation: At B, energy is totally potential
$= mgh = 40 \times 10 \times 3.2 = 1280$ J
At A, the total potential energy will be converted into kinetic energy.
So, at A, kinetic energy = 1280 J

(iv) Ans. Option (4) is correct.

Explanation: When the girl reaches the mid-point of the slope then she is at a height 1.6 m from ground. So, her potential energy
$= mgh' = 40 \times 10 \times 1.6 = 640$ J

3. (a) Ans. Option (3) is correct.

Explanation: Mechanical advantage = Load / Effort
$\therefore$ M.A. × E = L

(b) Ans. Option (4) is correct.

Explanation: For a machine of given design, the velocity ratio does not change. Mechanical advantage may change with the change of efficiency.

(c) Ans. Option (1) is correct.

Explanation: Block and tackle system with convenient direction having 3 movable pulleys should have 3 or 4 fixed pulleys.
If it has 3 fixed pulleys, then velocity ratio
= 3 + 3 = 6
If it has 4 fixed pulleys, then velocity ratio
= 3 + 4 = 7

(d) Ans. Option (2) is correct.

Explanation: When a body moves in a circular path, the force (centripetal force) on the body is directed towards the centre and the displacement at all instant is tangent to the circular path i.e. perpendicular to the direction of force.
Work done = F s cosθ
$\theta = 90^0$
Hence the work done is zero.

(e) Ans. Options (3) and (5) are correct.

Explanation: For proper reflection of sound, the reflector should be larger than the wavelength of sound wave.
Sensation of sound remains in human brain for 0.1 s. So, to hear distinct echo, the time interval between original sound and reflected sound should be more than 0.1 s.

(f) I. Ans. Option (3) is correct.

Explanation: Velocity of sound = Total distance covered / time
If d = distance of the cliff, then $340 = \frac{2d}{3}$
$\therefore$ $d = \frac{340 \times 3}{2} = 510$ m

II. Ans. Option (4) is correct.

Explanation:
Speed difference = $\frac{2 \times (\text{distance difference})}{3}$

or, $350 - 340 = \frac{2d}{3}$

or, $10 = \frac{2d}{3}$

or, $d = \frac{10 \times 3}{2}$

$\therefore$ $d = 15$ m

4. (a) Ans. Option (3) is correct.

Explanation: As the thickness of the lens increases, its focal length decreases and hence its power increases.

(b) Ans. Option (2) is true.

(c) Ans. Options (2) and (6) are correct.

Explanation: Energy at position B is totally kinetic.

$$\text{K.E.} = \frac{1}{2}mv^2 = \frac{1}{2} \times 80 \times 5^2 = 1000 \text{ J}.$$

So, option (6) is correct.

Potential energy at A = Potential energy at C = Kinetic energy at B = 1000 J .

So, option (2) is correct.

(d) Ans. Options (1) and (2) are correct.

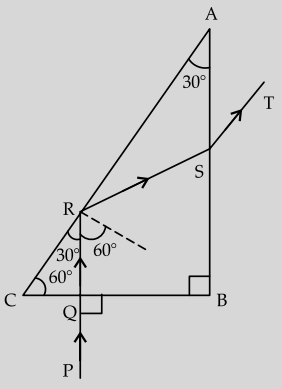
Explanation: When light travels from a denser to a rarer medium, then total internal reflection may occur in denser medium if the angle of incidence is greater than the critical angle.

(e) (i) **Ans. Option (3) is correct.**

Explanation: AC is the surface of separation of denser and rarer medium. No light has refracted from denser to rarer medium. Hence it is total internal reflection.

(ii) **Ans. Option (4) is correct.**

Explanation:



In ΔABC,

$\angle CAB = 30^0$

$\angle ABC = 90^0$

$\therefore \angle ACB = 60^0$

Now in ΔRCQ,

$\angle RCQ = 60^0$

$\angle RQC = 90^0$

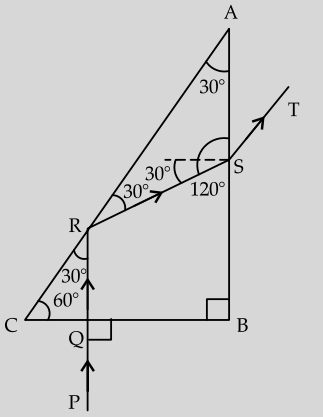
$\therefore \angle CRQ = 30^0$

Angle of incidence = $90^0 - \angle CRQ$

$= 90^0 - 30^0 = 60^0$

(iii) Ans. Option (1) is correct.

Explanation:



In ΔRSA,

$\angle RAS = 30^0$

$\angle ARS = \angle CRQ = 30^0$

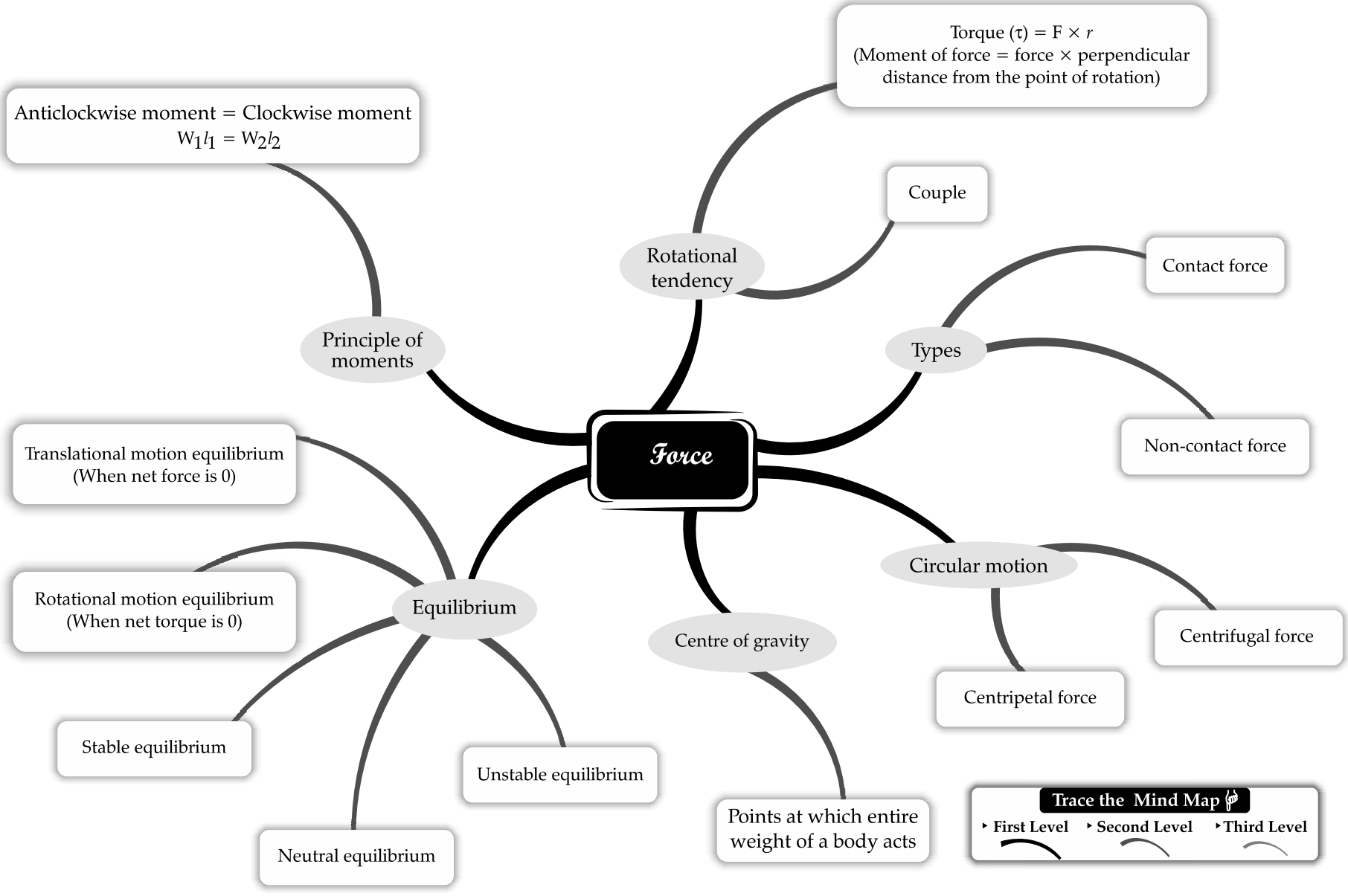
$\therefore \angle RSA = 120^0$

Angle of incidence = $120^0 - 90^0 = 30^0$

(iv) Ans. Option (4) is correct.

Explanation: Ray RQ is in denser medium and ST is in rarer medium.

Hence speed of ray ST is greater than the speed of RQ.


Force
Rotational tendency
Torque (τ) = F × r
(Moment of force = force × perpendicular distance from the point of rotation)
Couple
Principle of moments
Anticlockwise moment = Clockwise moment
$W_1 l_1 = W_2 l_2$
Types
Contact force
Non-contact force
Equilibrium
Translational motion equilibrium
(When net force is 0)
Rotational motion equilibrium
(When net torque is 0)
Stable equilibrium
Unstable equilibrium
Neutral equilibrium
Centre of gravity
Points at which entire weight of a body acts
Circular motion
Centrifugal force
Centripetal force
Trace the Mind Map
First Level
Second Level
Third Level

CHAPTER

1 FORCE

Syllabus

- *Turning forces concept; moment of a force; forces in equilibrium; centre of gravity; [discussions using simple examples and simple numerical problems].*
- *Elementary introduction of translational and rotational motions; moment (turning effect) of a force, also called torque and its C.G.S and S.I. units; common examples – door, steering wheel, bicycle pedal, etc.; clockwise and anti-clockwise moments; conditions for a body to be in equilibrium (translational and rotational); principle of moment and its verification using a metre rule suspended by two spring balances with slotted weights hanging from it; simple numerical problems; Centre of gravity (qualitative only) with examples of some regular bodies and irregular lamina.*
- *Uniform circular motion.*
- *As an example of constant speed, though acceleration (force) is present. Differences between centrifugal and centripetal forces.*

REVISION NOTES

Turning Forces, Equilibrium

Translational Motion

- It is basically the motion of the object where in object shifts from one point to another point in the space.
  - Examples of translational motion include motion of a rectangular wooden block down an inclined plane.
  - Rectilinear motion, object moves in straight line.

Rotational Motion

- When a rigid body rotates about its centre of mass, it is called rotational motion.
  - An object spinning about a fixed axis is said to be in rotational motion.
  - Examples of rotational motion include a spinning top.

Scan to know more about this topic

Principle of Moments

Forces and its Types :

- **Force :** A force is that physical cause which changes or tends to change the state of rest or motion or direction of a body. It can also change the shape or size of a body.
- The S.I. unit of force is newton (N). It is a vector quantity. C.G.S unit is dyne and gravitational unit is gf or kgf, where 1 kgf = 9.8 N.
- Force can be classified into two broad categories: contact forces and non-contact forces.
- **Contact force :** A force that comes into play only when there is a direct contact between two objects, is known as contact force. Pushing a car, kicking a ball, pulling an object etc. are the examples of contact force.

- **Non-Contact force :** A force that comes into play, even when there is no direct (physical) contact between the two objects, is known as non-contact forces.
- Electrical, magnetic, gravitational and nuclear forces are examples of non-contact forces.

Scan to know more about this topic
Non-Contact force

Torque :

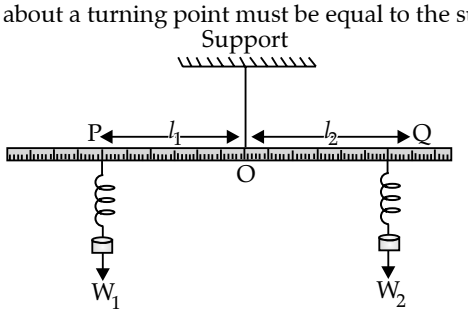
- Torque is the measure of rotational tendency of a force. It is also called moment of force.
- Torque is the product of force with the perpendicular distance of force from the point of rotation.
- Mathematically,
- Torque = Force × perpendicular distance from the axis of rotation.
- Torque is a vector quantity. Its S.I. unit is newton metre (N-m).
- **Couple :** Two equal and opposite forces acting along parallel lines at different points of the body form a couple.

Scan to know more about this topic
Contact force

Principle of Moments :

- **Principle of Moments :** When an object is in equilibrium, the sum of the anti-clockwise moments about a turning point must be equal to the sum of the clockwise moments.

Scan to know more about this topic
Types of equilibrium



Let the distance of the weight W_1 from the support be l_1 and the distance of weight W_2 from the support be l_2. Let the weight W_1 tries to rotate the scale in anti-clockwise direction so,

Anti-clockwise moment = $W_1 \times l_1$

And the weight W_2 tries to rotate the scale in clockwise direction so,

Clockwise moment = $W_2 \times l_2$

As the scale is in equilibrium so,

Anti-clockwise moment = Clockwise moment

$W_1 \times l_1 = W_2 \times l_2$

Forces in Equilibrium :

- When a number of forces acting on a body produces no change in its state of rest or of motion, the body is said to be in equilibrium.
- The condition for a body to be in translatory motion equilibrium is that net force acting on the body is zero.
- The condition for a body to be in rotational motion equilibrium is that net torque acting on the body is zero.
- The equilibrium of a body is of three types :
  - **(i)** Stable equilibrium
  - **(ii)** Neutral equilibrium.
  - **(iii)** Unstable equilibrium.
- A body is said to be in stable equilibrium, if it has a tendency to return to its original position, after being slightly disturbed.
- A body is said to be in neutral equilibrium if on being slightly disturbed, it continues to stay in equilibrium in its new position, in the same way as it was in its original position.
- A body is said to be in unstable equilibrium, if it has no tendency to come to its original position, after being slightly disturbed from that position.

The necessary conditions for a body to be in equilibrium are :

- **(i)** The sum of all the forces acting on the body is zero.
- **(ii)** The algebraic sum of the moments of all the forces acting on the body about any arbitrary point is zero.

Centre of Gravity and Uniform Circular Motion

Centre of Gravity :

- Centre of gravity of a rigid body is a point at which the entire weight of the body acts and algebraic sum of moments of weights of particles constituting the body is zero about this point.
- Centre of gravity of an irregular lamina is found by taking three points at the edges of the lamina. Then the object is suspended from any of the chosen points, and a weighted string is dropped from the same point and a line is drawn on the lamina along the string. This procedure is repeated from other two points on the lamina. These three lines will intersect at a point on the lamina which is basically the centre of gravity.

Circular Motion :

- A body which traces the trajectory of a circle during its motion is said to be in circular motion.
- If during circular motion the speed of body remains same, it is said to be in uniform circular motion.
- During circular motion, the direction of motion of the body changes continuously. Hence, velocity changes and the motion is said to be accelerated.
- The acceleration is always directed towards the centre of the circular path.
- The acceleration is deemed as centripetal acceleration.
- The direction of centripetal force is always towards the centre of the circular path.

Centripetal and Centrifugal Force :

- Centripetal force acts on a body moving in a circular path and is directed inwards.
- Centrifugal force appears to act on a body moving in a circular path and is directed outwards.
- Centripetal is a real (or inward) force.
- Centrifugal is an imaginary (or outward) force.
- Example of centripetal force includes satellite orbiting the planet.
- Example of centrifugal force includes a bike making a turn.

MNEMONICS

Concept : Centripetal and Centrifugal Force

Mnemonics : Corona **I**nfected **C**ountries need more **O**xygen

Interpretation :

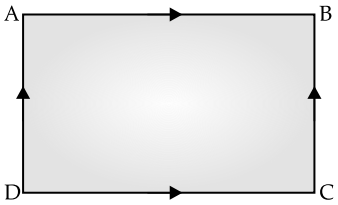
C : Centripetal force
I : Inward direction
C : Centrifugal force
O : Outward direction

In a circular motion, centripetal force acts inwards *i.e.* towards the center of rotation and centrifugal force acts in the outward direction.

MULTIPLE CHOICE QUESTIONS

STAND ALONE MCQs

AI **Q. 1.** An athlete runs at uniform speed on the track shown below. How many times will the athlete have to change his direction of motion, while he completes one round?

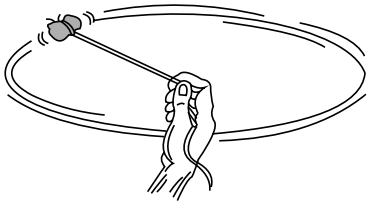


(A) 4
(B) 3
(C) 2
(D) 1

Ans. Option (A) is correct.

Explanation: The athlete runs at a uniform speed on the straight parts AB, BC, CD and DA of the track. In order to keep himself on track, he quickly changes his speed at the corners. So, it is clear that to move in the given track once, he has to change his direction of motion four times.

Q. 2. A stone is moved in a circular path with constant speed by tying a thread with it, as shown in the figure. If the thread is released the stone will move



(A) In the circular path due to inertia
(B) Along a straight line tangential to the circular path.
(C) In any arbitrary direction
(D) In a direction along the radius of the circular path.

Ans. Option (B) is correct.

Explanation: On being released the stone moves along a straight line tangential to the circular path. This is because once the stone is released, it continues to move along the direction it has been moving at that instant.

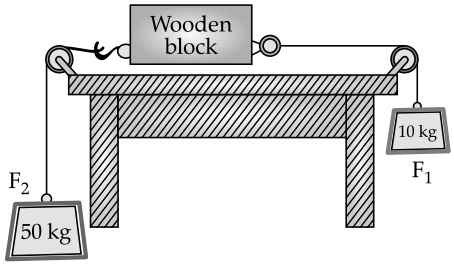
AI **Q. 3.** Which type of force acting on a body brings it into motion?
(A) Balanced
(B) Unbalanced
(C) Both balanced and unbalanced
(D) Force does not create motion.

Ans. Option (B) is correct.

Explanation: When two forces are acting on an object balance each other, then those forces are called balanced forces. There is no resultant force acting on the object. If no force act on a body according to Newton's 1st law, there cannot be any motion created.

When two forces are acting on an object cannot balance each other, then those forces are called unbalanced forces. So, there is no resultant force acting on the object. Now according to Newton's 1st law there will be a motion created. A stationary object will move in the direction of the force.

Q. 4. In the following figure, the force acting on the wooden block is



(A) Balance
(B) Unbalanced
(C) May be balanced or unbalanced. It depends on the mass of the wooden block.
(D) Zero

Ans. Option (B) is correct.

Explanation:

$F_2 = 50 \times 9.8$ N

$F_1 = 10 \times 9.8$ N

$F_2 > F_1$

Hence the force acting is unbalanced.

AI **Q. 5.** When a marble rolls down an inclined plane, its velocity increases. The unbalanced force acting on the marble is
(A) Frictional force
(B) Force of gravity
(C) Gravitational force
(D) None of the above

Ans. Option (B) is correct.

Explanation: When a marble rolls down an inclined plane, then two forces are acting on it – frictional force and force of gravity. There two forces that cannot balance each other and hence develop a net unbalanced force. Force of gravity being more than the force of friction, the marble moves downward.

AI **Q. 6.** Law of inertia is

(A) Newton's 1st law of motion
(B) Newton's 2nd law of motion
(C) Newton's 3rd law of motion
(D) Newton's law of gravitation

Ans. Option (A) is correct.

Explanation: Newton's 1st law says - an object remains in a state of rest or of uniform motion in a straight line unless compelled to change that state by an applied force. In other words, all objects resist a change in their state of motion. In a qualitative way, the tendency of undisturbed objects to stay at rest or to keep moving with the same velocity is called inertia. This is why, the first law of motion is also known as the law of inertia.

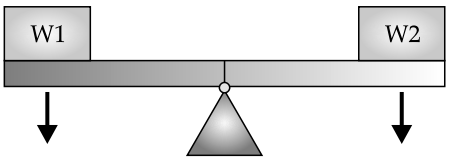
Q. 7. Which of the following is a contact force?

(A) Magnetic force
(B) Electrostatic force
(C) Gravitational force
(D) None of the above

Ans. Option (D) is correct.

Explanation: All the three forces are non-contact force.
A non-contact force is a force which acts on an object without coming physically in contact with it.
A magnetic substance is attracted by a magnet, even if the magnetic substance is not in contact with the magnet. So, magnetic force is a non-contact force.
Two charged particles attract or repel each other even if those are not in contact. So, electrostatic force is a non-contact force.
Between two bodies there is a gravitational attraction, even if there is no contact between them. So, gravitational force is a non-contact force.

AI **Q. 8.** Which weight creates a clock-wise moment? Which weight creates an anti-clock wise moment?



(A) W2 creates clock-wise moment. W1 creates anti-clockwise moment.
(B) W1 creates clock-wise moment. W2 creates anti-clockwise moment.
(C) Both W1 and W2 create clockwise moments.
(D) Both W1 and W2 create anti-clockwise moments.

Ans. Option (A) is correct.

Explanation: The moment of a force is a measure of its tendency to cause a body to rotate about a specific point or axis.
If W1 is more than W2, left side of the see-saw tries to go down and thus an anticlockwise movement is created. So, W1 creates an anticlockwise moment.
If W2 is more than W1, right side of the see-saw tries to go down and thus a clockwise movement is created. So, W2 creates a clockwise moment.

Q. 9. The condition for a body to be in translatory motion equilibrium is that net ____ acting on the body is zero and the condition for a body to be in rotational motion equilibrium is that net ____ acting on the body is zero.

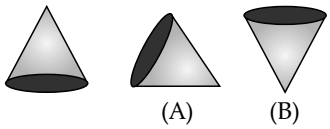
(A) Torque, force
(B) Force, Torque
(C) Force, Force
(D) Torque, Torque

Ans. Option (B) is correct.

Explanation: For translatory motion, there should be a force acting on a body. So, if net force acting on the body is zero, the body will be in translatory equilibrium. Translatory equilibrium means either the body is at rest or moves in a straight line with a constant velocity.
For rotational motion, there should be a torque acting on the body. So, if net torque acting on the body is zero, the body will be in rotational motion equilibrium. Rotational motion equilibrium means the body is either not moving or moving with constant angular velocity.

Q. 10. A cone is placed in position (A) and (B) as shown in the figure.

(A) Position (A) is the stable equilibrium position of the cone and position (B) is unstable equilibrium position of the cone.
(B) Position (B) is the stable equilibrium position of the cone and position (a) is unstable equilibrium position of the cone.
(C) Position (A) is the stable equilibrium position of the cone and position (B) is unstable equilibrium position of the cone.
(D) Position (A) is the neutral equilibrium position of the cone and position (B) is unstable equilibrium position of the cone.



Ans. Option (D) is correct.

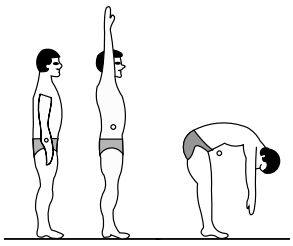
Explanation: A body is said to be in neutral equilibrium if on being slightly disturbed, it continues to stay in equilibrium in its new position, in the same way as it was in its original position. Hence in position (A) the cone is in neutral equilibrium.
A body is said to be in unstable equilibrium, if it has a tendency to accelerate away from its original position, after being slightly disturbed. Hence in position (B) the cone is in unstable equilibrium.

AI **Q. 11.** Centripetal force is a ____ force and centrifugal force is a _____ force.
(A) Real, imaginary
(B) Imaginary, real
(C) Real, real
(D) Imaginary, imaginary

Ans. Option (A) is correct.

Explanation: The centripetal force is a real force that acts whenever there is a circular motion. If an object is moving in circles at a constant velocity, it means that the only force that is acting on it is directed towards the center of the circle. It is a real force since it develops due to gravitational interaction.
Centrifugal force is an imaginary force acting on the object in a direction away from the centre along the radius of the circular path. It has the same magnitude and opposite direction to that of centripetal force. Centrifugal force is not a real force since it does not arise due to gravitational or electrostatic or nuclear interaction. It has no independent existence.

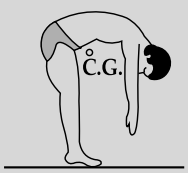
AI **Q. 12.** In which of the following postures the centre of gravity will be outside the human body?



(A) Posture (A)
(B) Posture (B)
(C) Posture (C)
(D) In all posture, centre of gravity will be inside the human body.

Ans. Option (C) is correct.

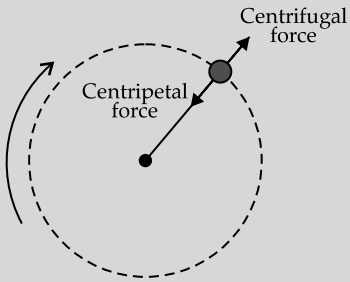
Explanation: While doing Yogasanas, if we bend our body in inverted V or U shape, then the centre of gravity of the body may lie outside of the body.



AI **Q. 13.** Directions of Centripetal force and Centrifugal force are
(A) Radially inwards towards the centre, Radially outwards away from the centre.
(B) Radially outwards away from the centre, Radially inwards towards the centre.
(C) Both radially outwards away from the centre
(D) Both radially inwards towards the centre

Ans. Option (A) is correct.

Explanation: The centripetal force acts whenever there is a circular motion. If an object is moving in circles at a constant velocity it means that the only force that is acting on it is directed towards the centre of the circle. Its magnitude is mv^2/R.



Centrifugal force is an imaginary force acting on the object in a direction away from the centre along the radius of the circular path. It has the same magnitude and opposite direction to that of centripetal force.

Q. 14. S.I. unit of force is _____ and it is a _____ quantity.
(A) Dyne, vector
(B) Newton, vector
(C) Newton, scalar
(D) kgf, vector

Ans. Option (B) is correct.

Explanation: Force is a vector quantity since it has both magnitude and direction.
1 N force is that force which when applied to a body of mass 1 kg, an acceleration 1 ms^{-2} is produced.
Kg is the S.I. unit of mass and ms^{-2} is the S.I. unit of acceleration. Hence, Newton is the S.I. unit of force.

Q. 15. A batsman hits a cricket ball which then rolls on a level ground. After covering a short distance, the ball comes to rest. The ball slows to a stop because
(A) the batsman did not hit the ball hard enough.
(B) velocity is proportional to the force exerted on the ball.
(C) there is a force on the ball opposing the motion.
(D) there is no unbalanced force on the ball, so the ball would want to come to rest.

Ans. Option (C) is correct.

Explanation: When the ball rolls on the ground, the ground exerts a frictional force on the ball in the opposite direction of its motion which retards the ball and finally stops.

Q. 16. The magnitude of non-contact force between two bodies varies

(A) Directly with the distance between the two bodies
(B) Inversely with the distance between the two bodies
(C) Directly with the square of the distance between the two bodies
(D) Inversely with the square of the distance between the two bodies
(E) Inversely with the cube of the distance between the two bodies

Ans. Option (D) is correct.

Explanation: The magnitude of non-contact between two bodies varies inversely with the square of the distance between the two bodies.

As for example: Gravitational force is a non-contact force. From Newton's laws of gravitation, the force between two bodies is given by $F = G\frac{m_1 m_2}{r^2}$

Electrostatic force is a non-contact force. From Coulomb's law, the force acting between two charged particles is given by $F = K\frac{q_1 q_2}{r^2}$

Q. 17. Turning effect of a force acting on a body about an axis is called

(A) The moment of the force
(B) Torque
(C) Momentum
(D) Couple
(E) Both (A) and (B)

Ans. Option (E) is correct.

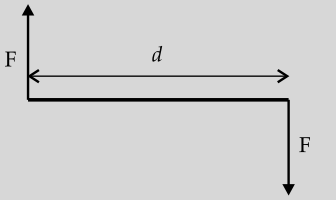
Explanation: Turning effect of a force acting on a body about an axis is called the moment of the force or torque and it is equal to the product of the magnitude of the force and the perpendicular distance of the line of action of the force from the axis of rotation.

Q. 18. Which of the following statements is true?

(A) Two equal and opposite parallel forces not acting along the same line form a couple.
(B) Two equal and opposite parallel forces acting along the same line form a couple.
(C) Two equal and parallel forces not acting along the same line form a couple.
(D) Two unequal and opposite parallel forces not acting along the same line form a couple.
(E) Any two forces acting along a line form a couple.

Ans. Option (A) is correct.

Explanation: Couple is a pair of equal parallel forces that are opposite in direction. The only effect of a couple is to produce or prevent the turning of a body. The turning effect, or moment of a couple is measured by the product of the magnitude of either force and the perpendicular distance between the action lines of the forces.



Q. 19. A window pane is 2 m wide. It can be opened by applying a 50 N force normally at the mid-point of the window pane. Select the correct answer for the moment of the force required to open the window pane and minimum force required to open it.

(A) 25 N
(B) 50 Nm
(C) 25 Nm
(D) 50 Nm
(E) 100 Nm
(F) 50 N

Ans. Option (B) and (A) are correct.

Explanation: Moment of force required

$= 50 \times \frac{2}{2}$

$= 50$ Nm

Minimum force × breadth of the pane = 50

or, Minimum Force × 2 = 50

∴ Minimum force = 25 N

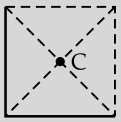
Q. 20. In which of the following figures the centre of gravity will be outside of the body?

(A) Figure A
(B) Figure B
(C) Figure C
(D) Figure D
(E) Figure E
(F) Figure F

Ans. Options (A) and (D) are correct.

Explanation: For rings, the centre of gravity is at the centre. The centre is outside the body.

For L-shaped bodies, if a rectangle is completed, the centre of centre of gravity will be at the point of cross-section of the diagonals. This point is outside the body.



ASSERTION AND REASON MCQs

Directions: In the following questions, A statement of Assertion (A) is followed by a statement of **Reason (R).** Mark the correct choice as:

(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is NOT the correct explanation of A.
(C) A is true but R is false.
(D) A is false and R is true.

Q. 1. Assertion (A): In a beam balance when the beam is balanced in horizontal position, it is in static equilibrium.

Reason (R): A system is in static equilibrium when the net forces and net torque on every particle is zero.

Ans. Option (A) is correct.

Explanation: When beam is balanced in horizontal position, the net forces and net torque on every particle is zero. So, the system is in static equilibrium.
Hence assertion and reason both are true and the reason explains the assertion.

Q. 2. Assertion (A): It is disadvantageous to use lever handle of longer length.

Reason (R): Moment of force increase using lever handle of longer length.

Ans. Option (D) is correct.

Explanation:
Moment of force = Force applied × length of the lever handle
If moment of force is fixed, then with reduced force, same moment can be achieved by using lever handle of longer length. Thus it is advantageous to use lever handle of longer length.
So, the reason is true but the assertion is false.

Q. 3. Assertion (A): Moment of couple is independent of the reference point (point of rotation).

Reason (R): Moment of couple = Force × distance between forces.

Ans. Option (B) is correct.

Explanation: Moment of couple = Force × distance between forces.
If the reference point (point of rotation) shifts, then also the distance between the forces does not change and hence there is no change in moment of couple. So, the moment of couple is independent of the reference point.
So, the assertion and reason both are true but the reason does not properly explain the assertion.

Q. 4. Assertion (A): Algebraic sum of moments of weights of particles constituting a body is zero about the centre of gravity of the body.

Reason (R): Centre of gravity of a body may be outside the body.

Ans. Option (B) is correct.

Explanation: Centre of gravity of a body is the point where algebraic sum of moments of weights of the particles constituting the body is zero. So, the assertion is true.
In case of rings or U-shaped body, the centre of gravity of may be outside the body. Hence the reason is also true. But the reason does not explain the assertion.

Q. 5. Assertion (A): Two uniform scales are pivoted at the respective centres. The heavier scale turns around.

Reason (R): Both the scales have their centres of gravity at the respective centres of the scales.

Ans. Option (D) is correct.

Explanation: Since both the scales are uniform, their centres of gravity are at the centres of the scales, irrespective of their weights. The weights of the scales are concentrated at the centre of gravity. Hence there is no chance to turn around.
So, the assertion is false but the reason is true.

Q. 6. Assertion (A): Centrifugal force is the force of reaction of centripetal force.

Reason (R): Action-reaction pair of forces acts on two bodies.

Ans. Option (D) is correct.

Explanation: From Newton's third law of motion, action-reaction pair of forces acts on two bodies.
But the centrifugal force and the centripetal force act on the same body. Hence centrifugal force is the force of reaction of centripetal force.
So, the assertion is false but the reason is true.

Q. 7. Assertion (A): To accelerate the motion of an object, an unbalanced force is required.

Reason (R): If an unbalanced force is applied on the object, there will be a change either in its speed or in the direction of its motion.

Ans. Option (A) is correct.

Explanation: Acceleration is change in velocity with time. Since unbalanced force produces change in velocity, hence unbalanced force is required to accelerate the motion of a body.

Q. 8. Assertion (A): kgf is a unit of force.

Reason (R): 1 kgf = 9.8 N.

Ans. Option (B) is correct.

> ***Explanation:*** kgf is the gravitational unit of force. So, assertion is true.
> 1 kgf = mass (1 kg) × acceleration due to gravity in m/s^2 = 1 × 9.8 = 9.8 N. So, the reason is true. But it does not explain the assertion.

Q. 9. Assertion (A): Force is required for uniform circular motion of a body.

Reason (R): For uniform motion in a straight line, the acceleration is zero.

Ans. Option (B) is correct.

> ***Explanation:*** For uniform circular motion, the speed is constant but the velocity is not constant since object is continuously changing the direction of its motion. So, force is required. So, the assertion is true.
> For uniform motion in a straight light, the magnitude and direction of velocity are constant. So, there is no acceleration. Hence the reason is also true. But the reason is not the explanation of the assertion.

Q. 10. Assertion (A): When an object is said to be in equilibrium, then it should be at rest only.

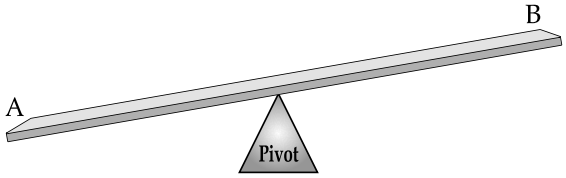
Reason (R): An object may be in equilibrium when it is moving with a constant velocity along a straight line.

Ans. Option (D) is correct.

> ***Explanation:*** It is not necessary that to be in equilibrium. An object has to be at rest. If net force and net torque acting on it are zero, then it is in equilibrium.
> When an object moves in a straight line with constant velocity, then net force and net torque acting on it are zero. So, it is in equilibrium.
> Hence, the assertion is false but the reason is true.

CASE-BASED MCQs

I. Nina and Raju were playing in a park. There was a 4 meter long see-saw.
Raju weights 40 kg and Nina weights 30 kg. When they sat at the edges i.e. at points A and B, the balance was not achieved. They placed themselves in different positions to achieve the balance.



Q. 1. In which direction a rotational motion is created in the see-saw when Raju and Nina sit at point A and B?
(A) Clock-wise
(B) Anti-clockwise
(C) No rotational motion
(D) It depends on the force by Raju and Nina

Ans. Option (B) is correct.

> ***Explanation:*** Net unbalanced force acts at point A hence this force rotates the see-saw anti-clockwise.

Q. 2. Who should move towards the pivot to achieve a balance?
(A) Raju
(B) Nina
(C) Any one
(D) balance cannot be achieved

Ans. Option (A) is correct.

> ***Explanation:*** Raju should move towards the pivot so that moment of the two forces becomes equal.

Q. 3. Raju and Nina both advance towards the pivot by 0.2 m. Will balance be achieved now?
(A) Yes
(B) No
(C) The see-saw will have an anti-clockwise rotational motion.
(D) Both (B) and (C)

Ans. Option (D) is correct.

> ***Explanation:*** Raju and Nina both advance towards the pivot by 0.2 m. So, their distances from the pivot are same i.e. 1.8 m. So, it will not be possible to achieve the balance. The see-saw will have an anti-clockwise rotational motion.

Q. 4. Which principle governs this balance?
(A) Principle of moments
(B) Principle of conservation of mass
(C) Principle of conservation of momentum
(D) None of the above

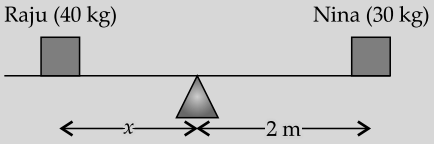
Ans. Option (A) is correct.

> ***Explanation:*** According to this principle, to achieve balance, net anticlockwise moment about the pivot should be equal to the net clockwise moment about the pivot.

Q. 5. What should be the correct positions of Raju and Nina on the see-saw to achieve a balance?
(A) Nina should shift 0.5 m towards the pivot.
(B) Both should shift 0.25 m towards the pivot.
(C) Raju should shift 0.5 m towards the pivot.
(D) It is not possible to achieve the balance.

Ans. Option (C) is correct.

Explanation: Since weight of Raju is more than the weight of Nina, Raju should shift towards the pivot.



Say, now Raju is at a distance x from the pivot.
So, anti-clockwise moment = $40\ x$
Clockwise moment = 30×2
From the principle of moment, for balance,
$40\ x = 30 \times 2$
$\therefore\ x = 60/40 = 1.5$ m
So, Raju should shift 0.5 m towards the pivot.

II. A nut can be opened by applying a force of 150 N by using a lever handle of length 0.4 m. Ramesh failed to open the nut using the same lever. He was then provided with a longer lever handle with which Ramesh was able to open the nut.

Q. 1. What is the moment of force required to open the nut?
(A) Force applied × length of lever handle
(B) Force applied / length of lever handle
(C) Length of lever handle / force applied
(D) None of the above

Ans. Option (A) is correct.

Q. 2. Why did Ramesh fail to open the nut?
(A) He could not hold the lever firmly.
(B) He applied force less than 150 N.
(C) He applied force more than 150 N.
(D) He could not apply the force vertically.

Ans. Option (B) is correct.

Explanation: Moment of the force required to open the nut
= Force applied × length of lever handle
= 150 × 0.4
Length of lever handle remaining same, if the force applied is less, then the required moment will not be achieved and it will not be possible to open the nut.

Q. 3. If the length of the lever handle increases, the required force to open the nut will be
(A) Less
(B) More
(C) same
(D) Depends on the size of the nut

Ans. Option (C) is correct.

Explanation: Moment of the force required to open the nut
= Force applied × length of lever handle
So, if the moment of force is constant, then increase in length of lever handle decreases the force requirement.

Q. 3. If Ramesh is supplied with a lever handle of length 100 cm, what amount of force he should apply now to open the nut?
(A) 60 N
(B) 375 N
(C) 275 N
(D) 35 N

Ans. Option (A) is correct.

Explanation:
$150 \times 0.4 = F \times 1$
$\therefore\ F = 60$ N

Q. 4. S.I. unit of moment of force
(A) dyne cm
(B) N m
(C) N
(D) N m^{-1}

Ans. Option (B) is correct.

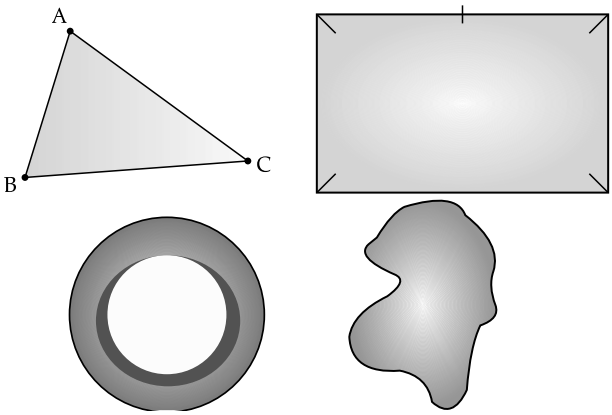
Explanation: Moment = Force × distance
Unit of force in S.I. system is Newton.
Unit of distance in S.I. system is meter.
Hence, the unit of moment of force in S.I. system is N m.

Q 5. A child can provide 10N force. What should be the length of lever handle for the child to open the nut?
(A) 6 m
(B) 1 m
(C) 60 m
(D) 0.5 m

Ans. Option (A) is correct.

Explanation:
150 × 0.4 = 10 × length of lever handle
$\therefore$ Length of lever handle = 150 × 0.4 / 10 = 6 m

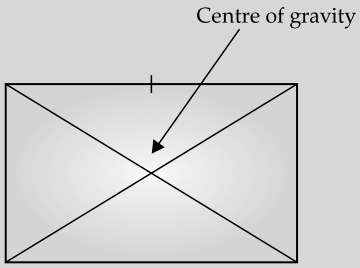
III. Teacher gave 4 objects to Leena to find the centre of gravity of each. The shapes of objects were – ring, rectangular lamina, triangular lamina and irregular shaped lamina. Mass distribution in all the objects was uniform. Lenna could find the centres of gravity of the rectangular and triangular laminas geometrically. But she faced difficulty for the ring and the irregular shaped lamina.



Q. 1. The centre of gravity of the rectangular lamina is
(A) At any corner
(B) At the intersection point of the diagonals
(C) At the mid point of the longer side
(D) At the mid point of the shorter side

Ans. Option (B) is correct.

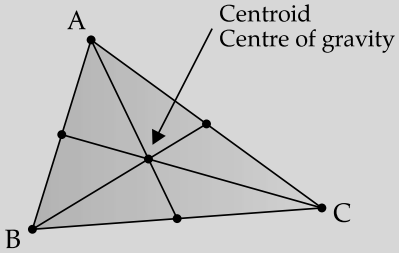
Explanation:



Q. 2. The centre of gravity of the triangular lamina is
(A) At any corner
(B) At the point of intersection of medians
(C) At the point of intersection of bisectors of the angles
(D) At the mid point of the longest side.

Ans. Option (B) is correct.

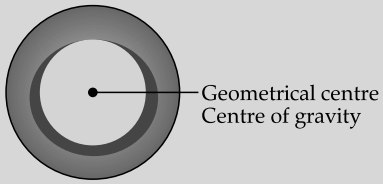
Explanation:



Q. 3. The centre of gravity of the ring
(A) Is on the circumference
(B) Is at the centre of the ring
(C) Does not physically exist
(D) Both (B) and (C)

Ans. Option (D) is correct.

Explanation:

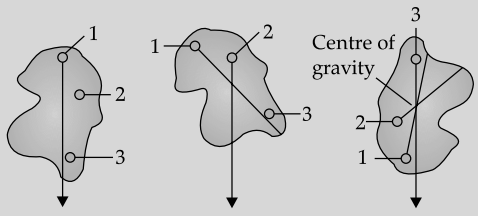


Centre of gravity of a ring is located at the geometric centre though there is no mass at that point.

Q. 4. How Leena can determine the centre of gravity of the irregular lamina?
(A) Three points are to be taken at the edges of the lamina. Then the object is to be suspended from any of the chosen points, and a weighted string is to be dropped from the same point and a line is to be drawn on the lamina along the string. This procedure is to be repeated from other two points on the lamina. These three lines will intersect at a point on the lamina which is the centre of gravity.
(B) Three points are to be taken at the edges of the lamina. The points are then to be joined in all possible ways. These lines will intersect at a point on the lamina which is the centre of gravity.
(C) The lamina is to be hung from different points with the help of a string. The point of hanging for which the lamina will remain horizontal is the centre of gravity.
(D) Determination of centre of gravity of an irregular shaped lamina is a very complex procedure.

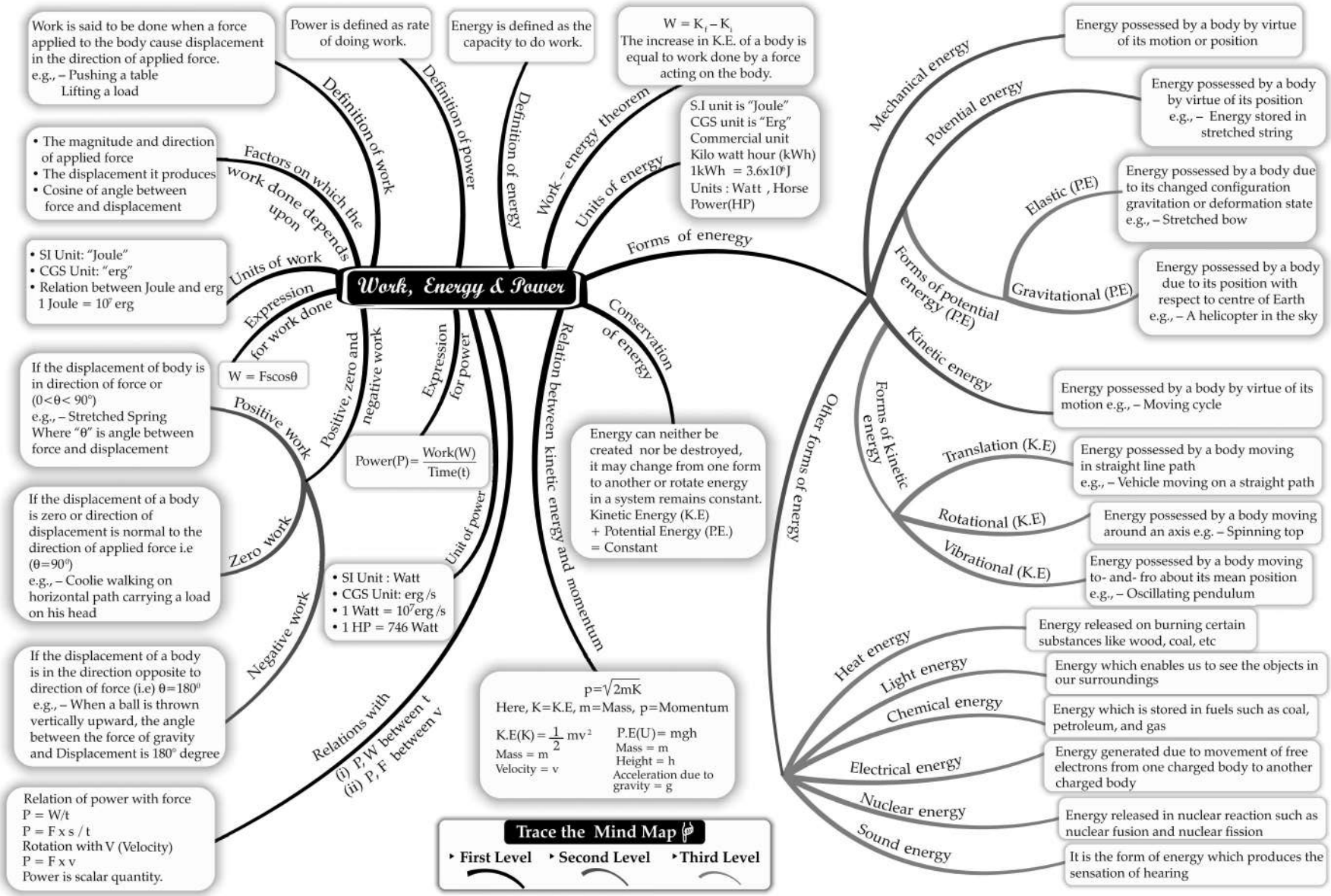
Ans. Option (A) is correct.

Explanation:



Q. 5. The algebraic sum of moments of weights of particles constituting a body about its center of gravity is
(A) 1
(B) 0
(C) Different for different body
(D) Cannot be determined

Ans. Option (B) is correct.


Work, Energy & Power
Definition of work
Work is said to be done when a force applied to the body cause displacement in the direction of applied force.
e.g., – Pushing a table
Lifting a load
Definition of power
Power is defined as rate of doing work.
Definition of energy
Energy is defined as the capacity to do work.
Work – energy theorem
W = K_f – K_i
The increase in K.E. of a body is equal to work done by a force acting on the body.
Units of energy
S.I unit is "Joule"
CGS unit is "Erg"
Commercial unit
Kilo watt hour (kWh)
1kWh = 3.6x10^6 J
Units : Watt , Horse Power(HP)
Factors on which the work done depends upon
• The magnitude and direction of applied force
• The displacement it produces
• Cosine of angle between force and displacement
Units of work
• SI Unit: "Joule"
• CGS Unit: "erg"
• Relation between Joule and erg
1 Joule = 10^7 erg
Expression for work done
W = Fscosθ
Positive, zero and negative work
Positive work
If the displacement of body is in direction of force or (0<θ< 90°)
e.g., – Stretched Spring
Where "θ" is angle between force and displacement
Zero work
If the displacement of a body is zero or direction of displacement is normal to the direction of applied force i.e (θ=90°)
e.g., – Coolie walking on horizontal path carrying a load on his head
Negative work
If the displacement of a body is in the direction opposite to direction of force (i.e) θ=180°
e.g., – When a ball is thrown vertically upward, the angle between the force of gravity and Displacement is 180° degree
Expression for power
Power(P)= Work(W) / Time(t)
Unit of power
• SI Unit : Watt
• CGS Unit: erg /s
• 1 Watt = 10^7 erg /s
• 1 HP = 746 Watt
Relations with
(i) P, W between t
(ii) P, F between v
Relation of power with force
P = W/t
P = F x s / t
Rotation with V (Velocity)
P = F x v
Power is scalar quantity.
Conservation of energy
Energy can neither be created nor be destroyed, it may change from one form to another or rotate energy in a system remains constant.
Kinetic Energy (K.E)
+ Potential Energy (P.E.)
= Constant
Relation between kinetic energy and momentum
p=√2mK
Here, K=K.E, m=Mass, p=Momentum
K.E(K) = 1/2 mv^2
Mass = m
Velocity = v
P.E(U)= mgh
Mass = m
Height = h
Acceleration due to gravity = g
Forms of eneregy
Mechanical energy
Energy possessed by a body by virtue of its motion or position
Potential energy
Energy possessed by a body by virtue of its position
e.g., – Energy stored in stretched string
Forms of potential energy (P.E)
Elastic (P.E)
Energy possessed by a body due to its changed configuration gravitation or deformation state
e.g., – Stretched bow
Gravitational (P.E)
Energy possessed by a body due to its position with respect to centre of Earth
e.g., – A helicopter in the sky
Kinetic energy
Energy possessed by a body by virtue of its motion e.g., – Moving cycle
Forms of kinetic energy
Translation (K.E)
Energy possessed by a body moving in straight line path
e.g., – Vehicle moving on a straight path
Rotational (K.E)
Energy possessed by a body moving around an axis e.g. – Spinning top
Vibrational (K.E)
Energy possessed by a body moving to- and- fro about its mean position
e.g., – Oscillating pendulum
Other forms of energy
Heat energy
Energy released on burning certain substances like wood, coal, etc
Light energy
Energy which enables us to see the objects in our surroundings
Chemical energy
Energy which is stored in fuels such as coal, petroleum, and gas
Electrical energy
Energy generated due to movement of free electrons from one charged body to another charged body
Nuclear energy
Energy released in nuclear reaction such as nuclear fusion and nuclear fission
Sound energy
It is the form of energy which produces the sensation of hearing
Trace the Mind Map
First Level
Second Level
Third Level

CHAPTER

2 WORK, ENERGY AND POWER

Syllabus

- *Work, energy, power and their relation with force.*

  Definition of work, W = Fscos ϑ; special cases of q = 0°, 90°, W = mgh, definition of energy, energy as work done. Various units of work and energy and their relation with S.I. units. [erg, calorie, kWh and eV]. Definition of power, P = W/t; S.I. and C.G.S units, other units, kilowatt (kW), megawatt (MW) and gigawatt (GW); and horse power (1 hp = 746 W) [simple numerical problems on work, power and energy]

  Different types of energy (e.g., chemical energy, mechanical energy, heat energy, electrical energy, nuclear energy, sound energy, light energy).

  Mechanical energy : potential energy U = mgh (derivation included) gravitational PE, examples; kinetic energy K = 1/2 mv² (derivation included); forms of kinetic energy : translational, rotational and vibrational – only simple examples [Numerical problems on K and U only in case of translational motion]; qualitative discussions of electrical, chemical, heat, nuclear, light and sound energy, conversion from one form to another; common examples.

  Principle of conversion of energy.

  Statement of the principle of conservation of energy; theoretical verification that U + K = constant for a freely falling body. Application of this law to simple pendulum (qualitative only); simple numerical problems

REVISION NOTES

Work, Energy and its Conservation

- Energy is the capacity of a body to do work. Its S.I. unit is joule.
- When a non-zero force (F) is applied on an object, it displaces by (d) by making an angle (θ) with the direction of force. Then work done mathematically, is defined as.

  $W = Fd \cos \theta$
- Work is said to be done only when force applied on a body makes the body move. S.I. unit of work is joule.
- Work is equal to force multiplied by displacement in the direction of force.
- Work can be positive, negative or zero.
- If the angle between force and the displacement is acute, then work is said to be positive.
- If the angle between force and the displacement is 90° *i.e.*, displacement is perpendicular to the force applied, work is said to be zero.
- If the angle between the force and the displacement is obtuse, then the work dine is said to be negative.
- When a coolie walks horizontally while carrying a load on his head, no work is done against the force of gravity.

Scan to know more about this topic

Work and energy

- When a body rotates in a circular path, no work is done against the centripetal force, as force and displacement are normal to each other.
- Work done can be zero if :
  - **(i)** force applied is zero *i.e.*, no force acts on the body.
  - **(ii)** displacement of body is zero.
  - **(iii)** angle between force and displacement is 90°.
- C.G.S. unit of energy or work is erg.
- One joule of work is said to be done when a force of 1 Newton displaces a body through a distance of 1 metre in its own direction.
- 1 erg of work is said to be done when a force of 1 dyne displaces a body through a distance 1 cm in its own direction.
- One kilowatt hour (1 kWh) is the energy spent (or work done) by a source of power 1 kW in 1 hour.
- One calorie is the (heat) energy required to raise the temperature of 1 gram of water by 1°C *i.e.*, from 14.5 °C to 15.5 °C.
- Mechanical energy is of two types *i.e.*,
  - **(i)** Kinetic energy = $\frac{1}{2}mv^2$
  - **(ii)** Potential energy = mgh
- Kinetic energy is the energy possessed by a body by virtue of its motion. Examples include a moving train, a running boy, etc.
- **Types of kinetic energy :**
  - **(i)** Translational kinetic energy (e.g.,→ a car moving in straight path, a freely falling body posses translational kinetic energy)
  - **(ii)** Rotational kinetic energy (e.g.,→ a spinning top, a rotating fan posses rotational kinetic energy)
  - **(iii)** Vibrational kinetic energy (e.g.,→ a wire clamped at both the ends when struck in the middle vibrates, possessing vibrational kinetic energy)
- Potential energy is the energy possessed by a body by virtue of its position or configuration.
- Potential energy is of two types :
  - **(i)** Elastic potential energy
  - **(ii)** Gravitational potential energy
- According to the law of conservation of energy, energy can neither be created nor be destroyed but it can be changed from one form to another.
- According to the work-energy theorem, the work done by a force on a moving body is equal to increase in its kinetic energy.

Scan to know more about this topic

Law of conservation of energy

- **Derivation of potential energy, U = *mgh***

  Let a body of mass 'm' be lifted upwards to a height 'h' above the ground.

  Then, work done on the body against the force of gravity = force × displacement

  Force, F = mg

  Work done, W = $mg \times h$

  This work done will be stored in the body in form of potential energy, U = mgh

- **Derivation of Kinetic energy, K = $\frac{1}{2}mv^2$**

  A body of mass 'm' moving with initial velocity 'v' is acted upon by a constant opposing force 'F' which produces retardation and the body is brought to rest.

  Force, F = mass × retardation … (i)

  Using 2nd kinematic equation of motion, $v^2 = u^2 + 2as$ …. (ii)

  Where, initial velocity, $u = v$

  Final velocity, $v = 0$

  Acceleration, $a = -a$

  So, the equation (ii) becomes

  $$0^2 = v^2 + 2 \times (-a) \times s$$

  $$s = \frac{v^2}{2a} \quad \text{… (iii)}$$

  Kinetic energy will be equal to the amount of work the body does before coming to rest.

$$\text{Kinetic energy} = F \times s$$

$$= ma \times \frac{v^2}{2a} \quad \text{(Using equation (i) and (iii))}$$

$$K = \frac{1}{2}mv^2$$

Power and Sources of Energy

- Power is the rate of doing work. Its S.I. unit is Watt.
- 1 Watt = 1 Js^{-1}
- If one Joule of work is done in 1 second, the power spent is said to be 1 Watt.
- 1 horse power = 746 Watts = 0.746 kW
- 1 kW = 1000 W, 1 MW = 10^6 W and 1 GW = 10^9 W
- The C.G.S unit of power is erg per second.
- 1 Watt = 1 J s^{-1} = 10^7 erg s^{-1}
- Solar energy is the energy radiated by the Sun.
- Solar panels, solar furnaces and solar cells use solar energy to do useful work.
- The energy released on burning coal, oil, wood or gas is the heat energy.
- Light is also a form of energy. We can see objects in presence of light only.
- The energy contained in fossil fuels such as coal, petroleum and natural gas is called chemical energy.
- The energy possessed by the fast moving water is called the hydro energy. It is used to generate electricity.
- The energy released due to loss in mass during nuclear reaction is called nuclear energy.
- The heat energy stored in the core of Earth is called geo-thermal energy.
- The energy possessed by the fast-moving air is called wind energy. Windmills use this energy to produce electricity.
- Sound energy is possessed by vibrating bodies.
- A natural source providing us energy continuously is called a renewable or non-conventional source of energy.
- Examples of renewable source of energy are solar energy, wind energy, energy from flowing water, energy from biomass, ocean thermal energy, geothermal energy, etc.
- The sources of energy which have accumulated in nature over a very long period and cannot be quickly replaced when exhausted are called non-renewable sources of energy or conventional sources of energy.
- Examples of non-renewable sources of energy are coal, petroleum and natural gas.

MNEMONICS

Concept : Positive, Negative and Zero work done.

Mnemonics : Appu **P**lanned **O**n a **D**ay to visit **N**ew **Z**ealand.

Interpretation : A : Acute
P : Positive
O : Obtuse
N : Negative
N : Ninety
Z : Zero

When angle between the force and displacement is **acute**, the work done is **positive**.
When angle between the force and displacement is **obtuse**, the work done is **negative**.
When angle between the force and displacement is **ninety** degree, the the work done is **zero**.

MULTIPLE CHOICE QUESTIONS

STAND ALONE MCQs

Q. 1. Work done by a force acting on an object is equal to the
(A) magnitude of the force multiplied by the displacement in the direction of the force.
(B) magnitude of the force multiplied by the displacement in the direction perpendicular to the the force.
(C) magnitude of the force divided by the displacement in the direction of the force.
(D) Displacement divided by the magnitude of the force.

Ans. Option (A) is correct.

Explanation: Work is defined as the product of the force and displacement in the direction of force.
Work done = force × displacement
$W = F\,s$

AI **Q. 2.** Work has
(A) Neither magnitude nor direction
(B) Only direction, no magnitude
(C) Only magnitude, no direction
(D) Both direction and magnitude

Ans. Option (C) is correct.

Explanation: Work is the dot product of force vector and displacement vector. Dot product of two vectors yields a scalar quantity. Scalar quantity has only magnitude, no direction.

Q. 3. A force of 5 N is acting on an object. The object is displaced through 2 m in the direction of the force. The work done is
(A) 2.5 J
(B) 10 J
(C) 2.5 watt
(D) 10 watt

Ans. Option (B) is correct.

Explanation: Work done = 5 N × 2 m
=10 N m or 10 J.

AI **Q. 4.** Work done is
(A) negative when the force acts opposite to the direction of displacement and positive when the force is in the direction of displacement.
(B) positive when the force acts opposite to the direction of displacement and negative when the force is in the direction of displacement.
(C) Always positive
(D) None of the above

Ans. Option (A) is correct.

Explanation: Work done is defined as the product of force and displacement in the direction of the force. This work is negative when the force acts opposite to the direction of displacement and positive when the force is in the direction of displacement.

AI **Q. 5.** Which of the following quantities have the same unit?
(A) Work and power
(B) Power and energy
(C) Work and energy
(D) Work, power and energy

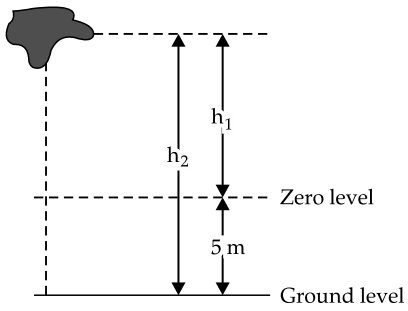
Ans. Option (C) is correct.

Explanation: S.I. unit of work and energy is Joule.

AI **Q. 6.** Which of the following possess potential energy?
(A) Falling coconut
(B) Stretched bow
(C) Running car
(D) Flying aircraft

Ans. Option (B) is correct.

Q. 7. An object is at a height h_2 from earth surface. Zero level is chosen at a height 5 m from the earth surface.

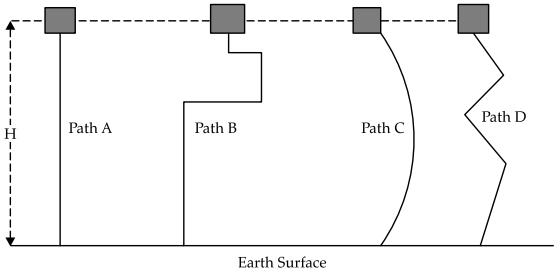


The potential energy of the object with respect to ground level and zero level are respectively is PE_G and PE_Z.
(A) $PE_G = PE_Z$
(B) $PE_G > PE_Z$
(C) $PE_G < PE_Z$
(D) $PE_Z = 0$

Ans. Option (B) is correct.

Explanation: Potential energy = mgh
Since distance of the object from the zero level is less than the distance from the ground level, $PE_G > PE_Z$

AI **Q. 8.** A body is raised to same height (H) from earth surface through different paths. In which path work done will be maximum and in which path it will be minimum?



(A) Maximum in path D, minimum in path A
(B) Maximum in path B, minimum in path C
(C) Maximum in path D, minimum in path C
(D) Same in all paths

Ans. Option (D) is correct.

> ***Explanation:*** Work done = $mg \times h$
> So, work done depends on the initial and final position of the object and not on the path followed.

AI **Q. 9.** What should the angle between forces and displacement to get the minimum and maximum work? U

(A) 90^0 and 0^0
(B) 0^0 and 90^0
(C) 45^0 and 90^0
(D) 0^0 and 45^0

Ans. Option (A) is correct.

> ***Explanation:*** W = Fscosθ
> When θ = 90°, cosθ = 0, W = 0. Hence work done is minimum.
> When θ = 0°, cosθ = 1, W = Fs. Hence work done is maximum.

AI **Q. 10.** When is the potential energy of an oscillating simple pendulum maximum and minimum?

(A) The potential energy is maximum when bob is at extreme position.
The potential energy is minimum when bob is at mean position.
(B) The potential energy is minimum when bob is at extreme position.
The potential energy is maximum when bob is at mean position.
(C) Oscillating pendulum does not have potential energy.
(D) Potential energy of oscillating pendulum has a fixed value.

Ans. Option (A) is correct.

> ***Explanation:*** Potential When the pendulum is in its mean position, the height of its bob is minimum from ground level. Hence potential energy is minimum.
> When the pendulum is at extreme position, it is at the maximum height from the ground level. Hence the potential energy is also maximum.

Q. 11. Relation between kinetic energy and momentum of a moving body is

(A) $P = 2mK$
(B) $P^2 = 2mK$
(C) $P^2 = mK$
(D) $P = 2m/K$

Ans. Option (B) is correct.

> ***Explanation:*** Momentum = P = mv
> Kinetic energy K = ½ mv^2
> Or, K = $m^2v^2 / 2m$
> Or, K = $P^2/2M$
> ∴ $P^2 = 2mK$

Q. 12. H.P. is the unit of

(A) Force
(B) Work
(C) Energy
(D) Power

Ans. Option (D) is correct.

> ***Explanation:*** 1 H.P. = 746 Watt

Q. 13. Which of the following relations is true?

(A) Power = Force × velocity
(B) Power = Force × displacement
(C) Power = Work × time
(D) Power = Energy × time

Ans. Option (A) is correct.

> ***Explanation:*** Power = work done per unit time
> = W/t
> = Fs/t
> = Fv

Q. 14. Energy stored in the core of earth is called

(A) Thermal energy
(B) Magnetic energy
(C) Geo-thermal energy
(D) Hydro energy

Ans. Option (C) is correct.

AI **Q. 15.** Relation between S.I. and C.G.S. unit of work is

(A) 1 J = 10^7 erg
(B) 1 J = 10^{-7} erg
(C) 1 J = 10 erg
(D) 10^7 J = 1 erg

Ans. Option (A) is correct.

> ***Explanation:*** Power 1 J = 1 N × 1 m
> Or, 1 J = 10^5 dyne × 100 cm
> ∴ 1 J = 10^7 ergs

Q. 16. Which of the following possess potential energy?

(A) A moving cricket ball
(B) A running train
(C) A piece of stone placed on the roof of a building
(D) Bob of a pendulum at its mean position
(E) When a longbow is pulled back with an arrow cocked

Ans. Option (C) and (E) are correct.

> ***Explanation:*** A moving cricket ball, a running train and a bob of a pendulum at its mean position have kinetic energy due to motion.
>
> The piece of stone placed on the roof has gravitational potential energy due to its position and it is given by U = mgh, where m = mass of the stone, g = acceleration due to gravity and h = height of the building.
>
> Long bow is like a spring. When it is drawn back, potential energy developed in it according to Hook's law is ½ kx^2, where k = force constant of the bow, x = distance pulled.

Q. 17. Which of the following has both rotational and translational kinetic energy?

(A) A falling body
(B) A rolling ball
(C) A spinning top
(D) A stretched spring
(E) A mango hanging from a tree

Ans. Option (B) is correct.

> ***Explanation:*** The ball moves along a straight line while itself rotating. So, it has both translational and rotational kinetic energy.

Q. 18. Joule is the unit of

(A) Energy
(B) Work
(C) Power
(D) Both (A) and (B)
(E) Both (B) and (C)

Ans: Option (D) is correct.

> ***Explanation:*** Joule is the S.I. unit of both work and energy.

Q. 19. A boy of mass 50 kg runs up a flight of 50 steps of each of 10 cm high in 10 seconds. Assuming g = 10 ms^{-2} select the correct statements from the followings.

(A) Power developed is 250 W
(B) Work done by the boy is 2000 J
(C) Total distance travelled is 500 m
(D) Force of gravity on the boy is 50 N
(E) Work done by the boy is 2500 J
(F) Power developed is 250 J

Ans. Option (A) and (E) are correct.

> ***Explanation:*** Force of gravity on the boy
>
> = F = mg = 50 × 10 = 500 N
>
> Total distance covered in vertical direction
>
> = Number of steps × height of each step
>
> = 50 × 10 = 500 cm = 5 m
>
> Work done by the boy = Force × distance covered = 500 × 5 = 2500 J
>
> Power developed = Work done / time
>
> = 2500/10 = 250 W

Q. 20. Which of the following statements are true?

(A) Electric motor converts electrical energy to mechanical energy.
(B) Electric oven converts electrical energy to heat energy.
(C) Steam engine converts mechanical energy is heat energy.
(D) Loudspeaker converts sound energy to electrical energy.
(E) Electromagnet converts magnetic energy to electrical energy.
(F) Burning candle converted heat energy to chemical energy.

Ans. Options (A) and (B) are correct.

> ***Explanation:*** In an electric motor when current is passed through a coil placed in a magnetic field, a couple acts on it (due to magnetic effect of current) and the coil rotates. In electric oven, passage of electric current produces heat in a resistance wire (due to heating effect of current) according to Joule's law.

ASSERTION AND REASON MCQs

Directions: In the following questions, A statement of Assertion (A) is followed by a statement of **Reason (R).** Mark the correct choice as:

(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is NOT the correct explanation of A.
(C) A is true but R is false.
(D) A is false and R is true.

Q. 1. Assertion (A): A person stands still for a 300 s with a 20 kg load on his head. Work on the load is zero.

Reason (R): Work done = Force × displacement

Ans. Option (B) is correct.

Explanation: Work done = Force × displacement
Since displacement is zero, work done is also zero.
So, assertion and reason both are true. But the reason does not explain the assertion.

Q. 2. Assertion (A): A car is moving with a uniform velocity along a particular direction. A retarding force, F, is applied in the opposite direction, and the car stops after a displacement *d*. The work done by the force is negative.

Reason (R): Work done = $Fd\cos\theta$ and the angle (θ) between the force (F) and displacement (d) is 180^0.

Ans. Option (A) is correct.

Explanation: $\theta = 180°$.
$\therefore \cos\theta = -1$
$\therefore$ work done = $Fd\cos\theta = Fd\cos 180° = -Fd$
Hence the work done is negative.

Q. 3 Assertion (A): A 15 H.P. pump is used for lifting 100 kg of water to a height 100 m in 10 s.

Reason (R): 1 HP = 746 Watt.

Ans. Option (A) is correct.

Explanation: Power of the pump required to lift 100 kg of water to a height 100 m in 10 s
$= mgh / t$
$= 100 \times 9.8 \times 100 / 10$
$= 9800$ watt
746 W = 1 H.P.
$\therefore$ 9800 watt = 9800/746 = 13.1 H.P.
So, 15 H.P. pump is suitable for the work.
The assertion and reason both are true and the reason explains the assertion.

Q. 4 **Assertion (A):** A body cannot have energy without having momentum but it can have momentum without having energy.

Reason (R): Momentum = mass × velocity.

Ans. Option (D) is correct.

Explanation: Momentum = mass × velocity.
So, the reason is true.
If momentum = 0, velocity = 0.
So, Kinetic energy = 0
But potential energy may be there.
If energy of a body = 0,
Then Potential energy = 0, Kinetic energy = 0
i.e. velocity = 0.
Since velocity = 0, the momentum is also equal to zero.
So, the assertion is false.

Q. 5. Assertion (A): If kinetic energy is quadrupled, the velocity is also quadrupled.

Reason (R): Kinetic energy = $\frac{1}{2} mv^2$

Ans. Option (D) is correct.

Explanation: Kinetic energy = $\frac{1}{2} mv^2$.
The reason is true.
So, K.E. $\propto v^2$

$$\frac{KE_{initial}}{KE_{final}} = \frac{v^2_{initial}}{v^2_{final}}$$

$$\frac{1}{4} = \frac{v^2_{initial}}{v^2_{final}}$$

$$v^2_{final} = 4v^2_{initial}$$

$$\therefore v_{final} = 2v_{initial}$$

So, the assertion is false.

Q. 6. Assertion(A): During the free fall of an object, the decrease in potential energy, at any point in its path, appears as an equal amount of increase in kinetic energy.

Reason (R): For freely falling object, there is a continual transformation of gravitational potential energy into kinetic energy.

Ans. Option (A) is correct.

Explanation: An object of mass *m* is made to fall freely from a height, *h*. At the start, the object possess only gravitational potential energy (*mgh*) and kinetic energy is zero, since velocity is zero).
As it falls, its gravitational potential energy changes into kinetic energy i.e. the potential energy decreases while the kinetic energy increases.
When the object is about to reach the ground, the kinetic energy is the largest and potential energy is the least. However, the sum of the potential energy and kinetic energy of the object would be the same at all points.
The decrease in potential energy, at any point in its path, appears as an equal amount of increase in kinetic energy. Thus there is a continual transformation of gravitational potential energy into kinetic energy.
Hence the assertion and reason both are true and the reason explains the assertion.

Q. 7. Assertion (A): When a body is sliding down an inclined plane, the work done by the friction on the body is positive.

Reason (R): If the angle between force and displacement is acute or if both are in the same direction, work done is positive.

Ans. Option (D) is correct.

> ***Explanation:*** When a body is sliding down an inclined plane, the angle between the force of friction and the displacement is 180°; so, the work done is negative. Hence, the assertion is false.
>
> If the angle between force and displacement is acute or if both are in the same direction i.e. the angle is 0°, then the value of cosθ is positive and the work done is also positive. Hence the reason is true.

Q. 8. Assertion (A): When a winded toy car is placed on a horizontal plane surface, it starts moving.

Reason (R): By winding, kinetic energy is stored which causes the motion.

Ans. Option (C) is correct.

> ***Explanation:*** By winding a car potential energy is stored in a spring situated inside the car. This potential energy is converted into kinetic energy and the car starts moving. So, the assertion is true but the reason is false.

Q. 9. Assertion (A): kWh is the unit of energy.

Reason (R): 1 kW h is the energy consumed in one hour at the rate of 1000 J s^{-1} .

Ans. Option (A) is correct.

> ***Explanation:*** 1Kwh = 1kW × 1 h
>
> = 1000 W × 1 h
>
> = 1000 J/s × 1 h
>
> So, assertion and reason both are true and the reason explains the assertion.

Q. 10. Assertion (A): Kinetic energy = $\frac{1}{2} mv^2$

Reason (R): Work done is equal to the change in the kinetic energy of an object.

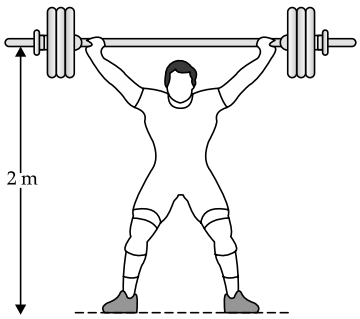
Ans. Option (A) is correct.

> ***Explanation:*** If an object is moving with uniform acceleration, then its displacement is given by
>
> $s = (v^2 - u^2)/2a$
>
> If the force applied is F, then
>
> Work done = F*s*
>
> $= ma \times \frac{v^2 - u^2}{2a}$
>
> $= \frac{1}{2} \times m \times (v^2 - u^2)$
>
> $= \frac{1}{2} mv^2 - \frac{1}{2} mu^2$
>
> = Final kinetic energy – initial kinetic energy
>
> Hence the assertion and reason both are true and the reason explains the assertion.

CASE-BASED MCQs

I. Work done is defined as the product of force applied and the displacement in the direction of force.

Unit of work is Joule. 1 Joule is defined as the work done when a force of 1 Newton moves an object through a distance 1m.



Now, when a weightlifter lifts the barbell above his head, the work done is
weight of the barbell × distance moved.

In order to do this work, chemical energy which the weightlifter absorbed from the food eaten is converted into mechanical energy which is ultimately stored in the barbell as the gravitational potential energy.

He holds the barbell above his head for 20 seconds. During this time, no work is done by him since there is no displacement of the barbell.

Q. 1. If the total mass of the barbell is 50 kg, then the work done by the weightlifter to lift it above his head is

(A) 980 Joules
(B) 980 watt
(C) 100 Joule
(D) 100 watt

Ans. Option (A) is correct.

> ***Explanation:*** Weight of the barbell = 50 × 9.8
>
> Work done = (50 × 9.8) × 2 = 980 J

Q. 2. The potential energy stored in the barbell when it is lifted overhead is
(A) 980 Joules
(B) 980 watt
(C) 100 Joule
(D) 100 watt

Ans. Option (A) is correct.

Explanation: Potential energy = $m \times g \times h$
$= 50 \times 9.8 \times 2$
$= 980$ J

Q. 3. How much work is done when the weightlifter holds the barbell overhead for 10 seconds?
(A) 980 J (B) 100 J
(C) 0 (D) 50 J

Ans. Option (C) is correct.

Explanation: No work is done since there is no displacement of the barbell.

Q. 4. What type of energy conversion takes place in this phenomenon?
(A) Kinetic energy to potential energy
(B) Chemical energy to kinetic energy
(C) Chemical energy to potential energy
(D) None of the above

Ans. Option (C) is correct.

Explanation: In order to do the work of lifting the barbell against the gravitational force, chemical energy which the weightlifter absorbed from the food eaten is converted into mechanical energy which is ultimately stored in the barbell as the gravitational potential energy.

Q. 5. The potential energy stored in barbell is called _____ potential energy?
(A) Chemical
(B) Gravitational
(C) Elastic
(D) Electric

Ans. Option (B) is correct.

Explanation: The potential energy, the barbell possesses is due to its position in gravitational field.

II. To calculate the consumption of an electrical appliance we have to take into account 3 factors:

(a) Capacity of electrical appliance expressed in watts.

(b) Number of hours the appliance is being used per day.

(c) Number of days the appliance is used every month.

The calculation is as follows:

Consumption in kWh

$$= \frac{\text{capacity expressed in watt}}{1000} \times \text{No. of hours of use per day} \times \text{no. of days used per month}$$

1 kW h is the energy used in one hour by an appliance at the rate of 1000 J s^{-1} .

1 kWh = 3.6×10^6 J.

Q. 1. To calculate the consumption of an electrical appliance which of the following factors are to be taken into account?
(A) Supply voltage, wattage of the appliance, number of hours of daily use
(B) Current drawn by the appliance, wattage of the appliance, number of hours of daily use
(C) wattage of the appliance, number of hours of daily use, number of days of usage per month
(D) Supply voltage, current drawn by the appliance, wattage of the appliance

Ans. Option (C) is correct.

Q. 2. 1 kWh is the energy defined as the
(A) energy used in one hour by an appliance at the rate of 1000 J s^{-1} .
(B) energy used in one hour by an appliance at the rate of 1 J s^{-1} .
(C) energy used in 1000 hour by an appliance at the rate of 1000 J s^{-1} .
(D) energy used in one hour by an appliance at the rate of 1000 kJ s^{-1} .

Ans. Option (A) is correct.

Q. 3. 1 kW = ____ Joule.
(A) 36×10^5
(B) 36×10^{-5}
(C) 3.6×10^{-6}
(D) 36×10^6

Ans. Option (A) is correct.

Explanation: 1 kWh = 1 kW ×1 h
$= 1000$ W $\times$ 3600 s
$= 3600000$ J
$= 36 \times 10^5$ J.

Q. 4. An electric bulb of 100 W is used for 10 h per day. Total energy consumed in a month of 30 days is
(A) 3×10^4 kWh
(B) 30 kWh
(C) 0.3 kWh
(D) None of the above

Ans. Option (B) is correct.

Explanation: Energy consumed
$$= \frac{100}{1000} \times 10 \times 30$$
$= 30$ kWh

Q. 5. If a 500 W lamp is switched on for 1 s, the amount of energy consumed is
(A) 500 Wh
(B) 500 kWh
(C) 0.5 kWh
(D) 500 Ws

Ans. Option (D) is correct.

> *Explanation:* Energy consumed
> = Power × time
> = 500 × 1
> = 500 Ws.

III. Hydroelectric power is a renewable energy source which harnesses the power of moving water to produce electricity.

Hydroelectricity projects typically involve dams. Running river water is deposited in a reservoir. As the height of water in the lake increases the potential energy increases.

A hydroelectric dam converts the potential energy stored in a water reservoir behind a dam to kinetic energy. As the water flows down through the dam its kinetic energy is used to turn a turbine.

A alternator converts the turbine's mechanical energy into electricity.

Since fuel is not burnt there is minimal air pollution. Hydroelectric plant plays a major role in reducing emission of greenhouse gases.

Q. 1. As the height of water level in a dam rises, the
(A) Kinetic energy increase
(B) Potential energy increase
(C) Kinetic energy decreases
(D) Potential energy decreases

Ans. Option (B) is correct.

> *Explanation:* In a gravitational field as the height increases, the gravitational potential energy increases.

Q. 2. As the water flows from the reservoir to the turbine
(A) Potential energy is converted into kinetic energy
(B) Kinetic energy is converted into potential energy
(C) No energy conversion takes place
(D) Solar energy is converted into kinetic energy

Ans. Option (A) is correct.

> *Explanation:* As stagnant water starts flowing, its potential energy is converted into kinetic energy due to its velocity.

Q. 3. Turbines _____ energy is converted into _____ energy by an alternator.
(A) Potential, electrical
(B) Kinetic, electrical
(C) Heat, electrical
(D) None of the above

Ans. Option (B) is correct.

> *Explanation:* An alternator is coupled with the turbine. As the turbine rotates the armature of the alternator rotates in a magnetic field and electricity is generated.

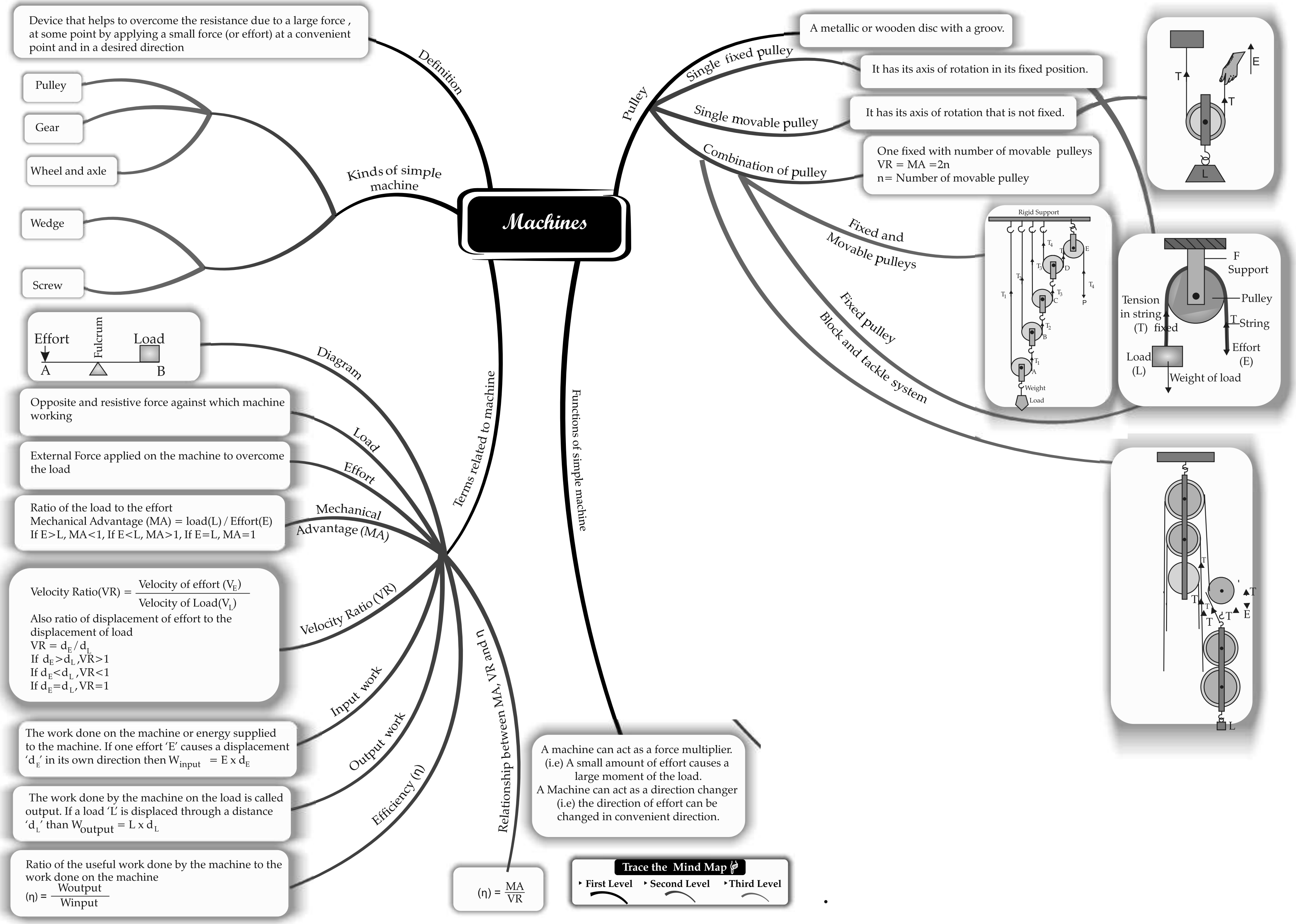
Q. 4. Hydroelectric power is a
(A) Non-conventional energy source
(B) Renewable energy source
(C) Non-renewable energy source
(D) None of the above

Ans. Option (B) is correct.

> *Explanation:* In hydroelectric project, the water from turbine goes back to river. So, water itself is not reduced or used up in the process. The same water can be used for hydroelectric power generation at some other place. Hence it is a renewable energy source.

Q. 5. Which of the following statements regarding hydro power is true?
(A) There is minimal air pollution.
(B) There is no emission of greenhouse gases.
(C) It is a non-renewable source of energy.
(D) Both (A) and (B)

Ans. Option (D) is correct.


Machines
Definition
Device that helps to overcome the resistance due to a large force, at some point by applying a small force (or effort) at a convenient point and in a desired direction
Kinds of simple machine
Pulley
Gear
Wheel and axle
Wedge
Screw
Terms related to machine
Diagram
Effort
Fulcrum
Load
A
B
Load
Opposite and resistive force against which machine working
Effort
External Force applied on the machine to overcome the load
Mechanical Advantage (MA)
Ratio of the load to the effort
Mechanical Advantage (MA) = load(L) / Effort(E)
If E>L, MA<1, If E<L, MA>1, If E=L, MA=1
Velocity Ratio (VR)
Velocity Ratio(VR) = Velocity of effort (V_E) / Velocity of Load(V_L)
Also ratio of displacement of effort to the displacement of load
VR = d_E / d_L
If d_E>d_L, VR>1
If d_E<d_L, VR<1
If d_E=d_L, VR=1
Input work
The work done on the machine or energy supplied to the machine. If one effort 'E' causes a displacement 'd_E' in its own direction then W_{input} = E x d_E
Output work
The work done by the machine on the load is called output. If a load 'L' is displaced through a distance 'd_L' than W_{output} = L x d_L
Efficiency (η)
Ratio of the useful work done by the machine to the work done on the machine
(η) = Woutput / Winput
Relationship between MA, VR and η
(η) = MA / VR
Functions of simple machine
A machine can act as a force multiplier. (i.e) A small amount of effort causes a large moment of the load.
A Machine can act as a direction changer (i.e) the direction of effort can be changed in convenient direction.
Pulley
Single fixed pulley
A metallic or wooden disc with a groov.
It has its axis of rotation in its fixed position.
Single movable pulley
It has its axis of rotation that is not fixed.
Combination of pulley
One fixed with number of movable pulleys
VR = MA =2n
n= Number of movable pulley
Fixed and Movable pulleys
Fixed pulley
Block and tackle system
T
E
L
Rigid Support
Weight
Load
F
Support
Pulley
String
Tension in string (T) fixed
Effort (E)
Load (L)
Weight of load
Trace the Mind Map
First Level
Second Level
Third Level

CHAPTER

3 MACHINES

Syllabus

- *Machines as Force multipliers ; load, effort, mechanical advantage, velocity ratio and efficiency; *simple treatment of levers, pulley systems showing the utility of each type of machine.*
- *Functions and uses of simple machines : Terms – effort E, load L, mechanical advantage MA = L/E, velocity ratio VR = V_E /V_L = d_E/d_L, input (W_i), output (W_o), efficiency (η), relation between η and MA, VR (derivation included); for all practical machines η < 1; MA < VR.*
- *Pulley system : Single fixed, single movable, block and tackle; MA, VR and η in each case.*

REVISION NOTES

Simple Machine, Levers

- A machine is a device by which we can either overcome a large resistive force (or load) at some point by applying a small force (or effort) at a convenient point and in a desired direction or by which we can obtain a gain in speed.
- The external resistance against which any machine acts is called Load (L).
- The force applied on the machine to overcome the load is called effort (E).
- The ratio of the load to the effort is called the mechanical advantage of the machine, *i.e.*,

$$\text{Mechanical advantage (M.A.)} = \frac{\text{Load (L)}}{\text{Effort (E)}}$$

  Mechanical advantage is a ratio. Hence, it has no unit.
- The ratio of the velocity of effort to the velocity of load is called the velocity ratio of machine *i.e.*,

$$\text{Velocity ratio (V.R.)} = \frac{\text{Velocity of effort } (V_E)}{\text{Velocity of load } (V_L)}$$

Scan to know more about this topic

Introduction to Machines

- The velocity ratio is also defined as the ratio of the displacement of effort to the displacement of load.
- Velocity ratio is a ratio. Hence, it has no unit.
- A machine in which there is no loss of energy is called an ideal machine.
- The efficiency of an ideal machine is 100% but in practice, it is not possible.
- No machine does work by itself. For an ideal machine, output = input.
- Examples of some simple machines are : the lever, the pulley, inclined plane, etc.
- A machine is a device that makes work easier for us. It does so by enabling us to
  - multiply force
  - apply force at a convenient point or in a convenient direction and
  - obtain gain in speed.

- The efficiency of a machine is the ratio of the useful work done by the machine (the output) to the total work done on the machine (input)

$$\text{Efficiency, } \eta = \frac{\text{output}}{\text{input}} \times 100\%$$

- For a practical machine,

$$\text{Efficiency} = \frac{\text{Mechanical advantage}}{\text{Velocity ratio}}$$

Scan to know more about this topic

Relationship between mechanical advantage velocity-ratio and efficiency

Pulley Systems

- A pulley is simply a grooved wheel that is used along with a rope or a chain.
- A pulley which has its axis of rotation fixed in position is called a fixed pulley.
- For a pulley, mechanical advantage $= \frac{\text{Load}}{\text{Effort}}$
- For a single fixed pulley, ideal M.A. = 1 and V.R. = 1.
- A pulley whose axis of rotation is movable is called a movable pulley. A single movable pulley can act as a force multiplier.
- For a single movable pulley, ideal M.A. = 2 and V.R. = 2.
- We use single fixed pulley to change the direction of application of effort.
- A combination of pulleys enables us to multiply force by a factor that is dependent on the number of strands used to support the load.
- The block and tackle system of pulleys is made by having two blocks of pulleys in which the lower block is movable but the upper one is attached to a fixed support.
- When the weight of the lower movable block of pulley is negligible as compared to that of load and there is no friction, then M.A. = V.R. = n = number of strands of tackle supporting the load.

Scan to know more about this topic

Comparison between single fixed pulley and single movable pulley

Scan to know more about this topic

Combination of pulleys

MULTIPLE CHOICE QUESTIONS

STAND ALONE MCQs

AI **Q. 1.** Mechanical advantage of a machine is

(A) $\frac{\text{Effort}}{\text{Load}}$

(B) $\frac{\text{Load}}{\text{Effort}}$

(C) Load × effort

(D) None of the above

Ans. Option (B) is correct.

Q. 2. Unit of velocity ratio and mechanical advantage

(A) ms^{-1} , m

(B) ms^{-1}, N

(C) No unit, No unit

(D) ms^{-1}, no unit

Ans. Option (C) is correct.

Explanation: Both are the ratio of similar quantities. Hence they have no unit.

AI **Q. 3.** Relationship among mechanical advantage, velocity ratio and efficiency is

(A) Efficiency $= \frac{\text{Mechanical advantage}}{\text{velocity ratio}}$

(B) Efficiency $= \frac{\text{Velocity ratio}}{\text{Mechanical advantage}}$

(C) Efficiency = Mechanical advantage × velocity ratio

(D) None of the above

Ans. Option (A) is correct.

AI **Q. 4.** For an ideal single fixed pulley

(A) M.A. = 1, V.R. = 2

(B) M.A. = 1, V.R. = 1

(C) M.A. = 2, V.R. = 2

(D) M.A. = 2, V.R. = 1

Ans. Option (B) is correct.

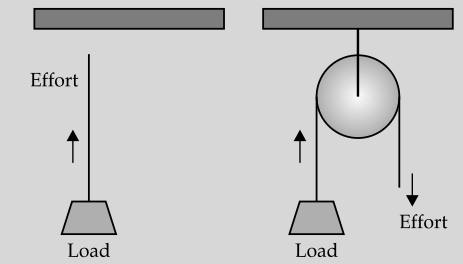
AI **Q. 5.** For an ideal single movable pulley
(A) M.A. = 1, V.R. = 2
(B) M.A. = 1, V.R. = 1
(C) M.A. = 2, V.R. = 2
(D) M.A. = 2, V.R. = 1

Ans. Option (C) is correct.

Q. 6. Single fixed pulley is used
(A) To have more mechanical advantage
(B) To have more velocity ratio
(C) To achieve more efficiency
(D) To change the direction of effort to be applied

Ans. Option (D) is correct.

Explanation: Single fixed pulley has no gain in mechanical advantage. It is used only to change the direction of effort to be applied conveniently.



Inconvenient to lift the load applying effort upward without a pulley

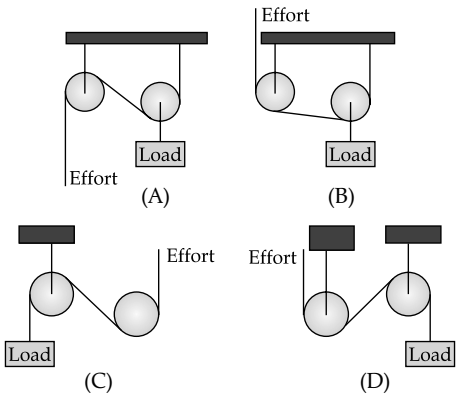
Convenient to lift the load applying effort downward with the help of a pulley

AI **Q. 7.** Efficiency of single movable pulley is not 100% due to
(A) Friction
(B) Weight of string and pulley
(C) Air resistance
(D) Both (A) and (B)

Ans. Option (D) is correct.

Explanation: The friction between the pulley and the string is unavoidable. String and pulley are always having some weight. For these two reasons, 100% efficiency cannot be achieved.

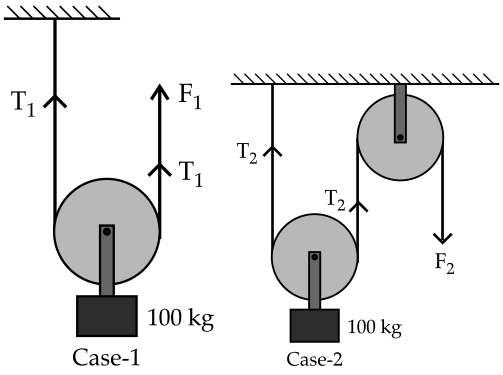
Q. 8. Which of the following diagrams shows correct arrangement of pulleys?



(A) Diagram A
(B) Diagram B
(C) Diagram C
(D) Diagram D

Ans. Option (A) is correct.

Q. 9. The force ratio in the following two cases is



(A) 1:2 (B) 2:1
(C) 1:1 (D) 1:4

Ans. Option (C) is correct.

Explanation: Here, $mg = 100 \times 10 = 1000$ N
In first case, $2T_1 = 1000$ N
$T_1 = 500$ N
$\therefore F_1 = 500$ N
In second case, $2T_2 = 1000$ N
$T_2 = 500$ N
$\therefore F_2 = 500$ N
So, $F_1 : F_2 = 1 : 1$

AI **Q. 10.** When a machine is used as a force multiplier then
(A) Effort = load
(B) Effort > load
(C) Load > effort
(D) None of the above

Ans. Option (C) is correct.

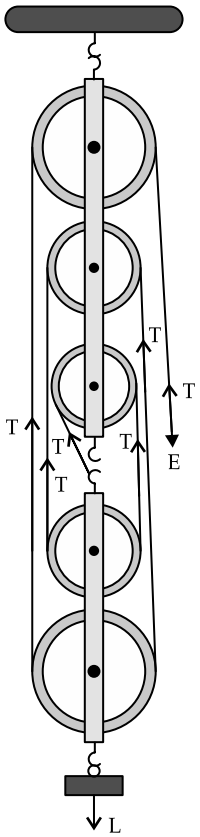
Explanation: When a machine is used as a force multiplier, then M.A. is greater than 1.
So, Load > Effort.

Q. 11. For an ideal machine
(A) Input = output
(B) Input < output
(C) Input > output
(D) Input ≥ Output

Ans. Option (A) is correct.

Explanation: Ideal machine is a hypothetical machine in which there is no loss due to friction, wear and tear etc. So, input = output.

Q. 12. In the following block and tackle system, there are ____ pulleys in block and ____ pulleys in tackle.



(A) 2, 3 (B) 3, 2
(C) 4, 1 (D) 1, 4

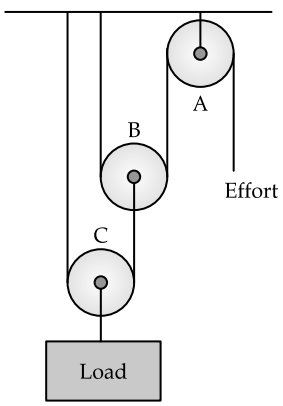
Ans. Option (B) is correct.

> ***Explanation:*** Upper 3 pulleys are connected to a rigid support and constitute the block. Lower 2 pulleys are movable and constitute the tackle.

AI **Q. 13.** In a block and tackle pulley system, number of pulleys in the tackle should be
(A) Greater than the number of pulleys in the block
(B) Equal to the number of pulleys in the block
(C) One less than the number of pulleys in the block.
(D) Equal to or one less than the number of pulleys in the block

Ans. Option (D) is correct.

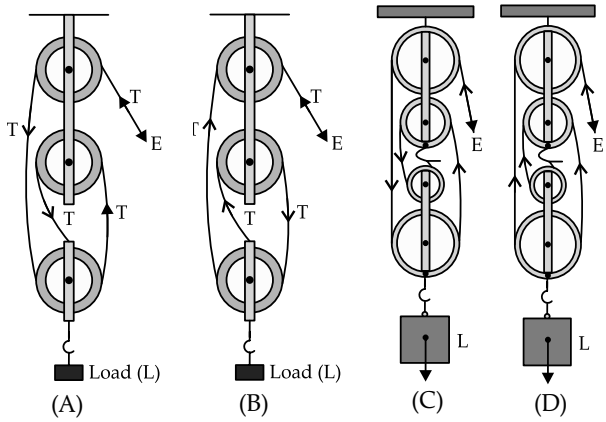
Q. 14. In the following pulley system



(A) Pulley A is fixed, Pulley B and C are movable
(B) Pulley A is movable, Pulley B and C are fixed
(C) All the three pulleys are movable
(D) Pulley C is fixed, Pulley A and B are movable

Ans. Option (A) is correct.

Q. 15. Which of the following diagram properly shows the tension, load and effort?



(A) Diagram (A)
(B) Diagram (B)
(C) Diagram (C)
(D) Diagram (D)

Ans. Option (D) is correct.

Q. 16. A block and tackle pulley system has n pulleys. If the load moves up through a distance d, the effort end moves through a distance
(A) d
(B) nd
(C) d/n
(D) $d + nd$
(E) n/d

Ans. Option (B) is correct.

> ***Explanation:*** If there are n pulleys in a block and tackle system, there are n string-sections. If the load moves through a distance d, each section of the string supporting the load is loosened by a length d. So, total distance the effort end has to move to bring back the tension is nd.

Q. 17. To calculate the power input and output of a machine, having efficiency 50%, which is driven a mass 100 kg falling from a height 10 m in 5 seconds and lifts a load of 400 kg vertically upward, steps are given below. Choose the option which has the correct sequence of steps to find the power input and output.
(i) Force = Mass × acceleration due to gravity
(ii) Power output = Power input × efficiency
(iii) Power input = Work done / time
(iv) Work done = Force × displacement
(A) (i), (iv), (iii), (ii)
(B) (iii), (iv)
(C) (i), (iii), (ii)
(D) (i), (iv), (ii), (iii)
(E) (iv), (iii), (ii)

Ans. Option (A) is correct.

Explanation:

Force applied = mass × acceleration due to gravity = 100 × 10 = 1000 N

Work done = Force × displacement

= 1000 × 10 = 10000 J

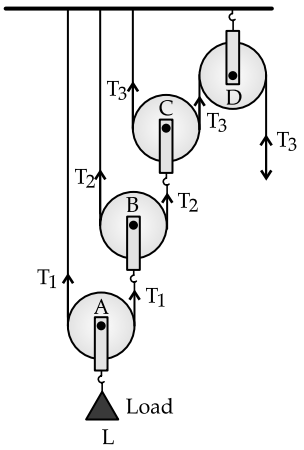
Power input = Work done / time

= 10000 / 5 = 2000 W

Power output = power input × efficiency

= 2000 × 50% = 1000 W

Q. 18. In the following pulley system there are 1 fixed pulley and 3 movable pulleys.



The mechanical advantage of the system is

(A) 4
(B) 3
(C) 2^4
(D) 2^3
(E) $1 + 3 \times 2$

Ans. Option (D) is correct.

Explanation: $2T_1 = L$,

$\therefore T_1 = L / 2$

$2T_2 = T_1$,

$\therefore T_2 = T_1/2 = L/2^2$

$2T_3 = T_2$,

$\therefore T_3 = T_2/2 = L/2^3$

In equilibrium, $T_3 = E$

$\therefore E = L/2^3$

$\therefore$ Mechanical advantage = $L/E = 2^3$

Q. 19. A pulley system of velocity ratio 5 is used to lift a load of 100 kgf through 10m vertical height using an effort 50 kgf. Calculate the distance moved by effort and the mechanical advantage.

(A) 50 m
(B) 2 m
(C) 2
(D) 50
(E) 0.5
(F) 0.5 m

Ans. Option (A) and (C) are correct.

Explanation:

$$\text{Velocity ratio} = \frac{\text{Distance moved by effort}}{\text{Distance moved by load}}$$

Or, $5 = d_E / 10$

$\therefore d_E = 50$ m

Mechanical advantage = Load/ Effort

= 100/50 = 2

Q. 20. Which of the following quantities are unit-less?

(A) Load
(B) Effort
(C) Velocity ratio
(D) Work input
(E) Work output
(F) Efficiency

Ans. Option (C) and (F) are correct.

Explanation:

$$\text{Velocity ration} = \frac{\text{Velocity of effort}}{\text{Velocity of load}}$$

Since it is the ratio of two similar quantities, it has no unit.

$$\text{Efficiency} = \frac{\text{Work output}}{\text{Work input}}$$

Since it is also the ratio of two similar quantities, it also has no unit.

ASSERTION AND REASON MCQs

Directions: In the following questions, A statement of Assertion (A) is followed by a statement of **Reason (R).** Mark the correct choice as:

(A) Both A and R are true and R is the correct explanation of A.
(B) Both A and R are true but R is NOT the correct explanation of A.
(C) A is true but R is false.
(D) A is false and R is true.

Q. 1. Assertion (A): A machine which is a force multiplier is a speed multiplier also.

Reason (R): Force multipliers are those machines which reduce the amount of force necessary to move an object.

Ans. Option (D) is correct.

Explanation: It is not possible for a machine to act as a force multiplier and speed multiplier simultaneously since the machines which are force multipliers cannot gain speed and vice versa. Moreover force multipliers have mechanical advantage more than 1 and speed multipliers have mechanical advantage less than 1. So, simultaneously a machine cannot have M.A. greater than 1 and less than 1.
Hence the assertion is false.
Force multipliers are those machines which are used to reduce the amount of force necessary to move an object. Hence the reason is true.

Q. 2. Assertion (A): For all practical machines mechanical advantage is less than velocity ratio.

Reason (R): Efficiency of all practical machines is less than 1.

Ans. Option (A) is correct.

Explanation: Efficiency of practical machine is less than 1 since all parts of a machine are not frictionless, weightless and perfectly rigid. Strings are not perfectly elastic. So, the reason is true.
Mechanical advantage = velocity ratio × efficiency.
For practical machines, efficiency being less than 1, mechanical advantage is less than velocity ratio.

Q. 3. Assertion (A): As the number of pulleys in a block and tackle pulley system increases, the mechanical advantage increases.

Reason (R): If there are n number of pulleys in a block and tackle pulley system, then there are n segments of string supporting the load and tension in each string segment is same (T).

Ans. Option (A) is correct.

Explanation: If there are n number of pulleys in a block and tackle pulley system, then there are n segments of string supporting the load. Tension in entire string length is T.
So, load = nT and effort = T
$\therefore$ Mechanical advantage = load / effort = nT/T = n
So, as the number of pulleys in a block and tackle pulley system increases, the mechanical advantage also increases.
Hence assertion and reason both are true and reason explains the assertion.

Q. 4. Assertion (A): In ideal situation, the efficiency of a block and tackle pulley system is 100%.

Reason (R): Efficiency increases, if the pulleys of the tackle section is light as possible.

Ans. Option (B) is correct.

Explanation: In ideal situation, M.A. = V.R. = n (number of pulleys)
So, efficiency = M.A. / V.R. = 1
Hence the assertion is true.
If w is the weight of the tackle section, then
Effort = T
Load = nT – w

$$\text{M.A.} = \frac{\text{Load}}{\text{effort}} = \frac{n\text{T} - w}{\text{T}} = n - \left(\frac{w}{\text{T}}\right) = n - \left(\frac{w}{E}\right)$$

V.R. = n

$$\therefore \text{Efficiency} = \frac{\text{M.A.}}{\text{V.R.}} = \frac{n - \frac{w}{E}}{n} = 1 - \left(\frac{w}{n\text{E}}\right)$$

So, as w decreases, efficiency increases.
Hence the reason is also true. But it does not explain the assertion.

Q. 5. Assertion (A): Single fixed pulley is used as a force multiplier.

Reason (R): The weight of the pulley itself does not affect its mechanical advantage.

Ans. Option (D) is correct.

Explanation: Single fixed pulley is not used as a force multiplier. It is used to change the direction of effort. So, the assertion is false.
The weight of the pulley itself does not affect its mechanical advantage since it is used just to change the direction of effort. Hence the reason is true.

Q. 6. Assertion (A): A machine in which displacement of load is more than the displacement of effort is said to have velocity ratio more than 1.

Reason (R): Velocity ratio = $\dfrac{\text{Velocity of effort}}{\text{velocity of load}}$

Ans. Option (D) is correct.

Explanation: Velocity ratio $= \dfrac{\text{Velocity of effort}}{\text{velocity of load}}$

The reason is true.

Velocity ratio $= \dfrac{\text{Velocity of effort}}{\text{velocity of load}}$

If d_E and d_L are the distances moved, in the same time t, by the load and the effort respectively, then

Velocity ratio $= \dfrac{d_E/t}{d_L/t} = \dfrac{d_E}{d_L}$

So, if $d_L > d_E$, the velocity ratio cannot be more than 1. Hence the assertion is false.

Q. 7. Assertion (A): No machine can have efficiency more than 100%.

Reason (R): Output energy of a machine can never be greater than input energy.

Ans. Option (A) is correct.

Explanation: Efficiency $= \dfrac{\text{output energy}}{\text{input energy}} \times 100\%$

From law of conservation of energy, output energy can never be greater than input energy. So, efficiency can never be greater than 100%. Hence the assertion and reason both are true and the reason explains the assertion.

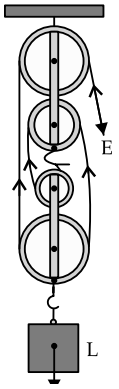
Q. 8. Assertion (A): In a block and tackle pulley system, if the load moves up through a distance d, the effort end moves through a distance nd (where n is the number of pulley).

Reason (R): In a block and tackle pulley system, if the load moves up through a distance d, then each section of the string supporting the load is loosened by a length d.

Ans. Option (A) is correct.

Explanation: It is a single string which is wound on all the pulleys of the block and tackle system. If there are n pulleys, then there are n sections of the string. If the load moves d distance, then each of the n string sections will be loosened by d distance. So, the total nd distance is moved by the effort.
Hence the assertion and reason both are true and the reason explains the assertion.

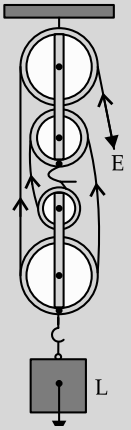
Q. 9. Assertion (A): The direction of tension in a clock and pully is as shown below



Reason (R): Direction in each string section is away from the force.

Ans. Option (D) is correct.

Explanation: Direction in each string section is away from the force. The reason is true.
So, in the string section which is connected to the effort will be in the opposite direction i.e. upward which is properly shown. But the other string sections are connected to load. So in these string sections the tension will be in the opposite direction i.e. upward.



Hence the assertion is false.

Q. 10. Assertion (A): As the number of pulleys increases in a block and tackle system, the tension (T) in string section decreases and becomes w/n (where w = load, n = number of pulleys) and mechanical advantage increases.

Reason (R): For a block and tackle pulley system consisting n number of pulleys, Load = $w = nT$

Effort = T.

Mechanical advantage = Load / Effort = $nT/T = n$

Ans. Option (A) is correct.

Explanation: Mechanical advantage of a block and tackle system is n, where n is the number of pulleys. So, the reason is true.
So, if number of pulley increases, the mechanical advantage increases and tension in each string section reduces and becomes w/n.
Hence assertion and reason both are true and the reason explains the assertion.

CASE-BASED MCQs

I. Some machines are designed to function as force multiplier. Their mechanical advantage is greater than 1. These machines require smaller input force and provide greater output force.

$$F_O > F_i$$

Following the law of conservation of energy,

$$v_i > v_O \text{ and } d_i > d_O$$

These machines are necessarily speed and displacement dividers.

Example: steering wheel, electric drill, screwdriver, pliers, scissor, Door knob etc.

Some machines are designed to function as speed and displacement multiplier. Their mechanical advantage is less than 1 but not negative. Mechanical advantage is fraction in such machines. They are necessarily force dividers.

So, in these machines

$$v_i < v_O \text{ and } d_i < d_O$$

But $$F_i > F_O$$

Example: Excavator, catapult, Broom, our arms and legs etc.

Q. 1. Mechanical advantage of a force divider and speed divider are respectively
(A) Greater than 1, less than 1
(B) Less than 1, greater than 1
(C) Greater than 1, greater than 1
(D) Less than 1, less than 1

Ans. Option (B) is correct.

Explanation: For force multiplier, M.A. >1.
So, for force divider, M.A. < 1.
For speed multiplier, M.A. <1.
So, for speed divider, M.A. > 1.

Q. 2. Mechanical advantage of displacement multiplier is
(A) Less than zero
(B) Zero
(C) Less than 1 but greater than zero.
(D) Greater than 1

Ans. Option (C) is correct.

Explanation: M.A. of displacement multiplier is less than 1. But it cannot be negative. Hence it lies between 0 and 1.

Q. 3. For a force multiplier
(A) $F_O > F_i$
(B) $v_i > v_O$
(C) $v_i < v_O$
(D) Both (A) and (B)

Ans. Option (D) is correct.

Explanation: For force multiplier, $F_O > F_i$
Following the law of conservation of energy, $v_i > v_O$

Q. 4. Which of the following is a force multiplier?
(A) Screwdriver
(B) Excavator
(C) Broom
(D) None of the above

Ans. Option (A) is correct.

Explanation: Driving in screws becomes easier if the handle of screwdriver is made larger in diameter than the screw head. In this way, the small force exerted by the hand on the handle becomes a large force acting on the slot in the screw head. So, the screwdriver is a force-multiplier.

Q. 5. Mechanical advantage of our arm is
(A) Greater than 0
(B) Less than 0
(C) Equal to 0
(D) Less than 1 but greater than 0

Ans. Option (D) is correct.

Explanation: Movement of biceps is less than the movement of fore arm. Hence, it is a displacement multiplier. M.A. of distance multiplier is Less than 1 but greater than 0.

II. Axle of single fixed pulley is attached to a rigid support and an inextensible string of negligible mass passes around the grooved rim of the pulley. One end of the string is connected to the load and effort is applied at the other free end.

Mechanical advantage of single fixed pulley is 1.

Weight of pulley does not affect the mechanical advantage since it just changes the direction of effort.

Single movable pulley is not attached to a rigid support. The load is suspended from the axle. One

end of the string is attached to a rigid support and the effort is applied at the other free end.

Mechanical advantage of single movable pulley is 2.

Practically mechanical advantage is less than 2, if the friction in the pulley, weight of the pulley and string are taken into consideration.

Q. 1. Which of the following statements is correct?

(A) Effort is applied at the free ends of the strings passing around the rim of single fixed pulley and single movable pulley.

(B) One end of the string passing around the rim of single movable pulley and axle of the single fixed pulley are connected to a rigid support.

(C) Load is suspended from the axle of the single fixed pulley and one end of the string passing around the rim of the single movable pulley

(D) Both (A) and (B)

Ans. Option (D) is correct.

Q. 2. If 20 kgf load is suspended from a single fixed pulley, the applied effort in Newton will be

(A) 196 N

(B) 98 N

(C) 20 N

(D) 10 N

Ans. Option (A) is correct.

> ***Explanation:*** Since M.A. =1, Load = applied effort.
> So, effort = 20 kgf = 20 × 9.8 = 196 N

Q. 3. Single movable pulley is a

(A) Force divider

(B) Force multiplier

(C) Speed multiplier

(D) None of the above

Ans. Option (B) is correct.

> ***Explanation:*** In single movable pulley, a load can be lifted by applying an effort equal to half of the load since its M.A. is 2. So, single movable pulley acts as a force multiplier.

Q. 4. Which of the following statements is true?

(A) Practical M.A. is less than ideal M.A. for a single fixed pulley

(B) Practical M.A. is less than ideal M.A. for a single movable pulley

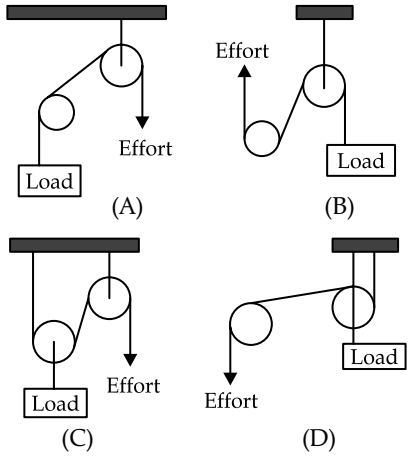
(C) Practical M.A. is equal to ideal M.A. for both single fixed pulley and single movable pulley.

(D) Practical M.A. is greater than ideal M.A. for a single fixed pulley.

Ans. Option (B) is correct.

> ***Explanation:*** Practically mechanical advantage of single movable pulley is less than 2, if the friction in the pulley, weight of the pulley and string are taken into consideration.

Q. 5. Which of the following drawing shows the correct connection of a single movable pulley and a single fixed pulley to achieve M.A.= 2 with a direction of the effort?



(A) Drawing (A)

(B) Drawing (B)

(C) Drawing (C)

(D) Drawing (D)

Ans. Option (C) is correct.

III. 6 pulleys are available to make a block and tackle system of M.A. = 6 and M.A. = 5.

3 pulleys are of 5 gram each and 3 pulleys are of 20 gram each. Two blocks are to be made – one lower block of movable pulleys known as tackle and one upper block of fixed pulleys known as block.

Mechanical advantage is equal to the number of pulleys used.

Number of pulleys in the tackle should be equal to or one less than the number of pulleys in the block.

For greater efficiency, the pulleys in the tackle should be as light as possible.

Q. 1. For M.A. = 5 system, there should be ____ pulleys in the block and ____ pulleys in the tackle.

(A) 1, 4

(B) 2, 3

(C) 3, 2

(D) 4, 1

Ans. Option (C) is correct.

> ***Explanation:*** Number of pulleys in the tackle should be equal to or one less than the number of pulleys in the block.

Q. 2. For M.A. = 6 system, there should be ____ pulleys in the block and ____ pulleys in the tackle.

(A) 1, 5

(B) 5, 1

(C) 2, 4

(D) 3, 3

Ans. Option (D) is correct.

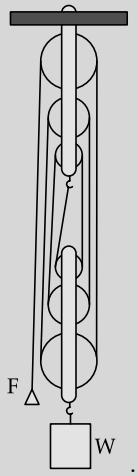
> ***Explanation:*** Number of pulleys in the tackle should be equal to or one less than the number of pulleys in the block.

Q. 3. For M.A. = 6 system, one end of the string will be fixed to

(A) Lower end of the axle of the block
(B) Upper end of the axle of the tackle
(C) Anywhere of the axle of block
(D) Anywhere of the axle of the tackle.

Ans. Option (A) is correct.

Explanation:

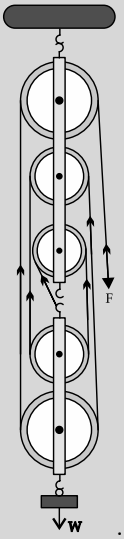


Q. 4. For M.A. = 5 system, one end of the string will be fixed to

(A) Lower end of the axle of the block
(B) Upper end of the axle of the tackle
(C) Anywhere of the axle of block
(D) Anywhere of the axle of the tackle.

Ans. Option (B) is correct.

Explanation:



Q. 5. For the block and tackle pulley system,

(A) 5 gram pulleys are to be used in tackle.
(B) 5 gram pulleys are to be used in block.
(C) At least one 20 gram pulley is to be used in tackle.
(D) Any combination may be used.

Ans. Option (A) is correct.

Explanation: For greater efficiency, the pulleys in the tackle should be as light as possible

Refraction of light at plane surfaces

Refraction

Phenomenon that causes a change in direction of a ray of light when it travels from one optical medium to another optical medium is called refraction.

Terms related to refraction

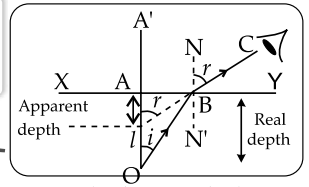
- **Incident ray**: A ray of light travelling from one optical medium towards another optical medium
- **Normal**: Perpendicular drawn at the point of incidence is called the normal
- **(i) Angle of incidence**: The inclination between the incident ray and the normal
- **(r) Angle of refraction**: The inclination between the refracted ray and the normal
- **Refracted ray**: Ray of light which deviates from its straight path and gets bent when travel from one optical medium to another
- **(δ) Angle of deviation**: Angle between refracted ray and direction of incident ray.

Real and apparent depth

Depth at which object appear due to refraction is called apparent depth.

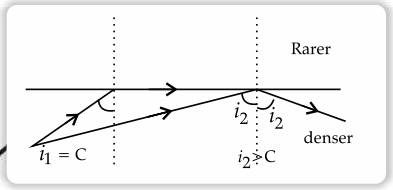
$$\text{Refractive index} = \frac{\text{Real depth}}{\text{Apparent depth}}$$

Ray diagram



Real and apparent depths.

Ray diagram for TIR and critical angle



Total internal reflection

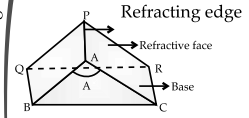
When the angle of incidence is greater than critical angle and the ray of light travelling from denser to rarer medium get reflected in denser medium.

Critical angle

A particular angle of incidence when the angle of refraction is equal to 90° and light goes from denser to rarer medium

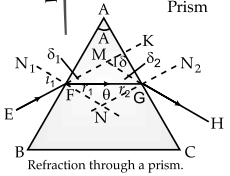
Prism

A piece of glass or any other transparent refracting medium bounded by five plane surfaces inclined at some angles



Prism

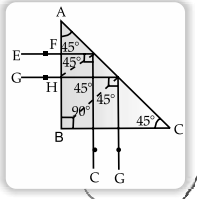
Reflection of light through prism



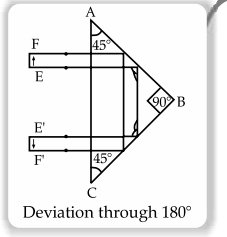
Refraction through a prism.

$i_1 + i_2 = A + \delta$ and $A = (r_1 + r_2)$

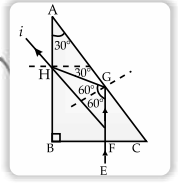
Total internal reflection at different angles of incidence on prism

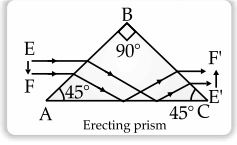


Deviation through 90°

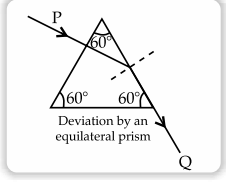


Deviation through 180°





Erecting prism



Deviation by an equilateral prism

Laws of refraction

- The incident ray, the refracted ray and the normal at the point of incidence lie in the same plane
- The ratio of the sine of angle of incidence to the sine of angle of refraction is a constant quantity, is called refractive index

$$\frac{\text{Sin (i)}}{\text{Sin (r)}} = \mu$$

Refractive (μ) index

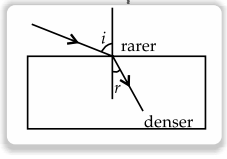
The ratio of speed of light in vacuum to the speed of light in medium $\mu = \frac{c}{v}$

c = Speed of light in air

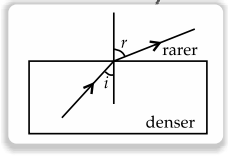
v = Speed of light in medium

Ray diagram when a ray of light travels from one medium to other

When a ray of light travels from rarer to rarer, it bends away from the normal.



When a ray of light travels from denser medium to denser medium, it bends towards the normal.



Factors effecting refractive index of a medium

- **Wavelength**: Refractive index of a medium increases with decrease in wavelength.
- **Temperature**: Speed of light increases with increases in temperature
- **Optical density**: Optical denser medium will have high refractive index than optical rarer medium

Trace the Mind Map

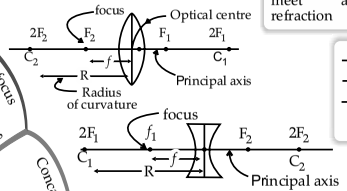
First Level · Second Level · Third Level

Refraction of lights through lens

Terms related to a lens

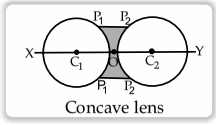
Diagram

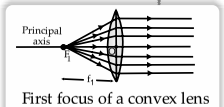
- (C) Centre of curvature — It is the centre of the sphere of which the lens is a part
- (P) Principal axis — An imaginary line joining the centres of curvatures of two spherical surfaces
- (R) Radius of curvature — It is the radius of the sphere of which the lens is a part
- (O) Optical centre — The centre point of a lens is know as its optical centre.

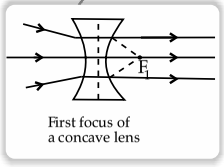


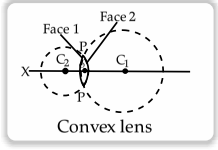
Principal focus

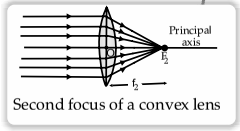
- Convex lens
- Concave lens

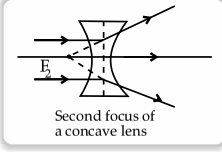












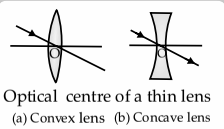
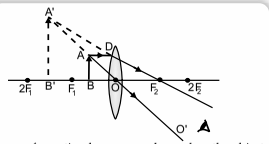


Image formation by a convex lens when the object is between the optical centre and the focus



Ray diagram

Magnifying power

$$M = 1 + \frac{D}{F}$$

Magnifying glass (simple microscope)

Lens

A lens is a piece of optical medium bounded by two curved surface which are generally spherical

Types of lenses

- Convex lens (converging lens) — A lens which has one or two spherical surfaces such that it is thicker in the middle and thinner at the edges
- Concave lens (Diverging lens) — A lens which has one or two spherical surfaces and such that it is thinner in the middle and thicker from edges

Power of a lens

Unit: Dioptre

The reciprocal of focal length

$$P = \frac{1}{f\ (\text{in m})} = \frac{100}{f\ (\text{in cm})}$$

Linear (M) magnification

$$M = \frac{h_2}{h_1} = \frac{-v}{u}$$

Lens formula

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$$

u = Object distance
v = Image distance
f = Focal length

Sign convention

- Distances measured opposite to the incident ray is considered negative while in the same direction considered positive.
- Distances upward to the principal axis are always considered positive and distance downward to the principal axis are considered negative.

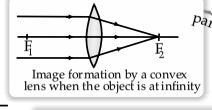
Type of images

- Real Image — Image formed when rays emerging from the lens actually meet after refraction
- Virtual Image — Image formed when rays emerging from the lens after refraction does not meet at a point but appears to diverge from this point

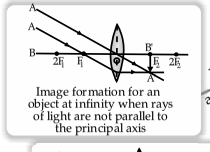
Image formation by a convex lens for

Object is at infinity

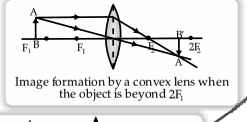
Emerging rays are parallel to principal axis



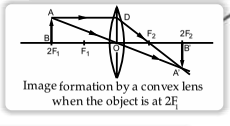
Emerging rays are not parallel to the principal axis



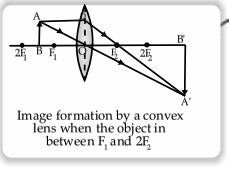
Object is beyond $2F_1$



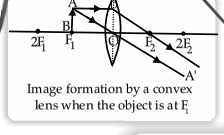
Object is at $2F_1$



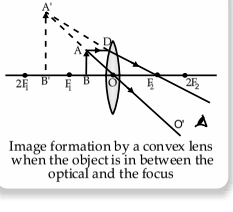
Object is in between F_1 and $2F_1$



Object at F_1



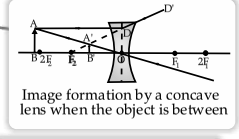
Object is inbetween optical centre (O) and focus (F_1)



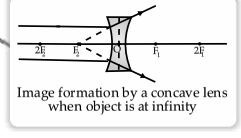
Position of the object	Position of the image	Size of the image	Nature of the image	Use of the lens
At infinity	At F_2	Highly diminished to a point	Real and inverted	Burning glass
Beyond $2F_1$	Between F_2 and $2F_2$	Diminished	Real and inverted	Camera lens
At $2F_1$	At $2F_2$	Same size	Real and inverted	Telescope, photo copy machine
Between F_1 and $2F_1$	Beyond $2F_2$	Magnified	Real and inverted	Slide projector
At F_1	At infinity	Highly magnified	Real and inverted	Searchlight spectrometer
Between O and F_1	same side of the object	Magnified	Virtual and erect	Magnifying glass or simple microscope

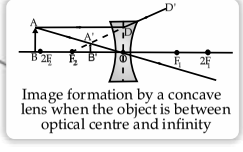
Image formation by a concave lens for

When object is at infinity



Object is anywhere between optical centre and infinity



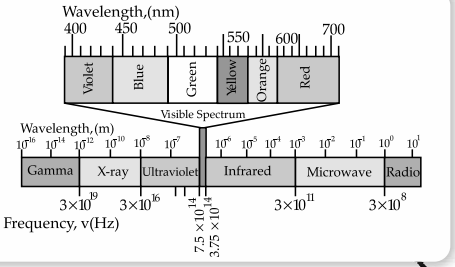


Position of the object	Position of the image	Size of the image	Nature of the image	Use of the lens
At infinity	At F_2 on the same side of lens as the object	Highly diminished to a point	Virtual and erect	Galilean telescope
Between infinity and optical centre	Between focus F_1 and optical centre, on the same side of the lens as the object	Diminished	Virtual and erect	Spectacles

Trace the Mind Map

▸ First Level ▸ Second Level ▸ Third Level

The Electromagnetic Spectrum



Electromagnetic wave

Wave that is capable of transmitting its energy through vacuum.

Electromagnetic spectrum

Electromagnetic waves exist in an enormous range of frequencies and this continuous range of frequencies is known as the electromagnetic spectrum.

Relation between speed (c)

$C = \upsilon\lambda$

(ν) frequency and (λ) wavelength

Electromagnetic spectrum

- Electromagnetic waves are transverse waves or non-mechanical waves.
- These wave can propagate through vacuum and thus do not require material medium.
- Speed of waves of electromagnetic wave is same as the speed of light.
- These waves exhibit the phenomena of reflection refraction, diffraction, interference and polarisation.

Properties of electromagnetic waves

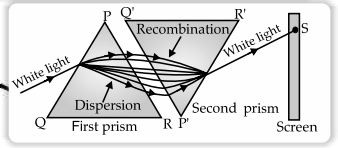
Relationship between intensity of scattered light and wavelength

$I \propto \frac{1}{\lambda^4}$ Violet light scatters the most while the red light scatters the least.

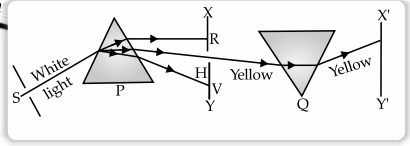
Scattering of light

Absorption and re-emission of light by the dust and air particles in atmosphere

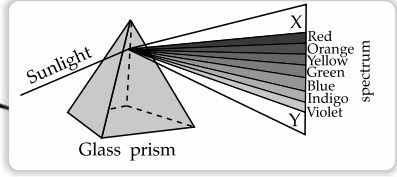
Recombination of colours



Filter the colour by prism



Dispersion of white light through prism



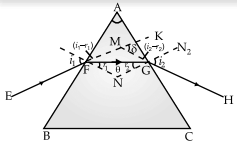
Dependence of deviation on colour or wavelength of incident light

Speed of light decreases with decrease in wavelength of light.
As the refractive index of a material increases, angle of deviation also increases.
Deviation produced by prism increases with the decreases in wavelength of light.
Violet colour with the shortest wavelength has minimum speed and undergoes maximum deviation where as red colour with longest wavelength has maximum speed and undergoes minimum deviation.

Characteristics of electromagnetic spectrum

Electromagnetic region	Wavelength	Frequency (in hertz)	Source	Detector	Application
Gamma rays	<0.01 nm	>3 x 10^{19}	Cosmic rays, decay of radioactive substances, nuclear fusion and fission reactions	Spectrometer	For killing cancerous cells, for checking welds in industries
X-rays	0.01-10 nm	3 x 10^{19} - 3 x 10^{16}	When high velocity electrons collide with a heavy metal target	Photographic plate, fluorescent screen	Medical radiography crystallography, for scanning object
Ultraviolet radiation	10-400 nm	3x10^{16} - 7.5 x 10^{14}	Sun, mercury vapour lamp, arc spark lamp	Photographic plate, fluorescence, chemical effect on dyes	Sterilisation of surgical instruments, vitamin D production detection of fake gems, forgery
Visible lights	400-800 nm	7.5 x 10^{14} - 3.75 x 10^{14}	Sun, electric bulb, flame, hot bodies	Eyes, photographic film	Observing objects, fibre optics
Infrared radiation	800 nm to 1 mm	3.75 x 10^{14} - 3 x 10^{11}	Sun, hot bodies such as fire burning gases	Blackened bulb thermometer, thermopile	Night-vision devices, developing photographs, sensor in missiles
Microwaves	1mm-10 m	3 x 10^{11} - 3x10^{7}	Electronic device special vacuum tubes	Electronic circuits	Radar, television, microwave ovens, cell phones
Radio waves	>10m	below 3.0 x 10^{7}	Electronic circuits and radio transmitters	Aerials of radio and television receiver	TV and radio broadcasting, navigation

Deviation produced by a prism



Factors affecting the angle of deviation

Angle of deviation (δ)
$= i + e - A$

Angle of incidence :
Refractive index of prism material (μ)
Angle of Prism (A)
Colour of wavelength of incident light (λ)

Trace the Mind Map

‣ First Level ‣ Second Level ‣ Third Level

CHAPTER

4 LIGHT

Syllabus

- ***Refraction of light through a glass block and a triangular prism– qualitative treatment of simple applications such as real and apparent depth of objects in water and apparent bending of sticks in water. Applications of refraction of light.***

  Partial reflection and refraction due to change in medium. Laws of refraction; the effect on speed (v), wavelength (λ) and frequency (f) due to refraction of light, conditions for a light ray to pass undeviated. Values of speed of light (c) in vacuum, air, water and glass; refractive index $\mu = \frac{c}{v}$, $v = f\lambda$ *Value of μ for common substances such as water, glass and diamond; experimental verification; refraction through glass block; lateral displacement; refraction though a glass prism, simple applications; real and apparent depth of objects in water; apparent bending of a stick under water.(Simple numerical problems and approximate ray diagrams required).*

- *Total internal reflection : Critical angle; examples in triangular glass prisms : Comparison with reflection from a plane mirror (qualitative only). Applications of total internal reflection.*

  Transmission of light from a denser medium (glass/water) to a rarer medium (air) at different angles of incidence; critical angle (C), $\mu = 1/\sin C$. *Essential conditions for total internal reflection . Total internal reflection in a triangular glass prism; ray diagram, different cases – angles of prism (60°, 60°, 60°),(60°, 30°, 90°), (45°, 45°, 90°); use of right angle prism to obtain* $\delta = 90°$ *and 180° (ray diagram); comparison of total internal reflection from a prism and reflection from a plane mirror.*

- *Lenses (converging and diverging) including characteristics of the images formed (using ray diagrams only); magnifying glass; location of images using ray diagrams and thereby determining magnification.*

  Types of lenses (converging and diverging), convex and concave, action of a lens as a set of prisms; technical terms; centre of curvature, radii of curvature, principal axis, foci, focal plane and focal length; detailed study of refraction of light in spherical lenses through ray diagrams; formation of images-principal rays or construction rays; location of images from ray diagrams for various positions of a small linear object on the principal axis; characteristics of images. Sign convention and direct numerical problems using the lens formula are included. (derivation of formula not required)

  Scale drawing or graphical representation of ray diagrams not required.

  Power of lens (concave and convex), ***magnifying glass location of image and magnification from ray diagram only [formula and numerical problems not included].*** *Applications of lenses.*

- *Using a triangular prism to produce a visible spectrum from white light; Electromagnetic spectrum. Scattering of light.*

  Deviation produced by a triangular prism; dependence on colour (wavelength) of light; dispersion and spectrum; electromagnetic spectrum; broad classification (names only arranged in order of increasing wavelength); properties common to all electromagnetic radiations; properties and uses of infrared and ultraviolet radiations.

REVISION NOTES

Refraction of Light at Plane Surface and Total Internal Reflection

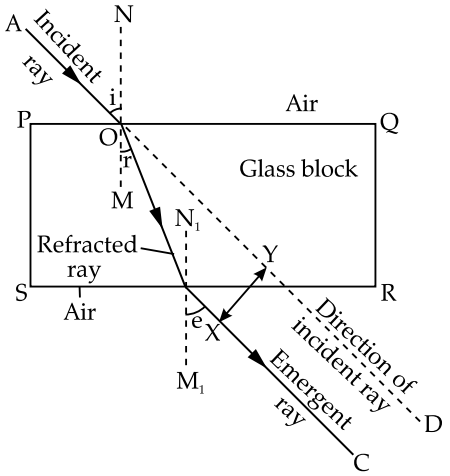
- The speed of light in air/vacuum is 3×10^8 m/s.
- A medium is said to be optically denser if light slows down in it.
- A medium is said to be rarer if light speeds up in it.
- When a ray of light travels from a rarer medium to a denser medium, it bends towards the normal.
- When a ray of light travels from a denser medium to a rarer medium, it bends away from the normal.
- The conditions when light travelling from one medium to another goes undeviated :
  - **(i)** Optical densities of both the media are the same.
  - **(ii)** Angle of incidence is zero. *i.e.,* light falls normally on the surface.
- Refractive index has no unit.
- When light passes from one medium to another, its frequency does not change but wavelength, speed and direction changes.
- When light passes from rarer to denser medium, its wavelength decreases.
- When light passes from denser medium to rarer medium, its wavelength increases.
- In case of minimum deviation of light while passing through the prism, the refracted ray inside the prism is parallel to the base of the prism.
- Factors affecting the angle of deviation of light travelling through the prism are :
  - **(i)** the angle of incidence.
  - **(ii)** the material of the prism (*i.e.,* refractive index).
  - **(iii)** the angle of prism (A).
  - **(iv)** the colour or wavelength (λ) of light used.

Scan to know more about this topic
Spherical lens

- Factors affecting lateral displacement of light passing through a rectangular glass block :
  - **(i)** The thickness of glass block
  - **(ii)** The angle of incidence
  - **(iii)** The refractive index of the glass and therefore, the wavelength of light used
- Cause of refraction is that light has different speeds in different medium.
- The refractive index of a transparent medium is always greater than 1.
- Factors affecting refractive index of a medium :
  - **(i)** Nature of medium
  - **(ii)** Physical conditions such as temperature
  - **(iii)** The colour or wavelength of light

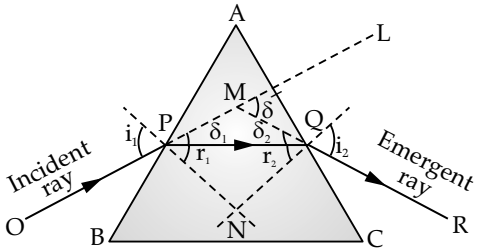
Scan to know more about this topic
Angle of minimum deviation of prism

- Speed of light in glass is 2×10^8 m/s and in water is 2.25×10^8 m/s.
- Refractive index of glass is 1.5, of water is 1.33 and of diamond is 2.41
- Refraction of light through a rectangular glass block.



- Refraction of light through a glass prism

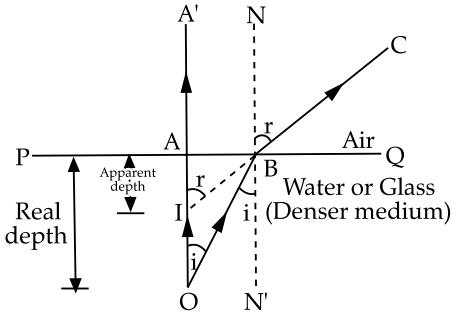
Scan to know more about this topic
Dispersion of light



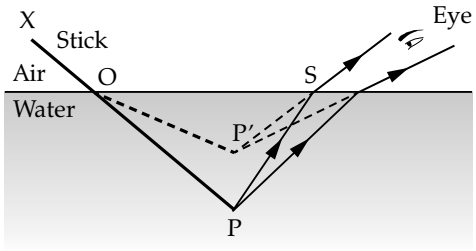
- Applications of refraction of light

(a) Real and apparent depths of object in water

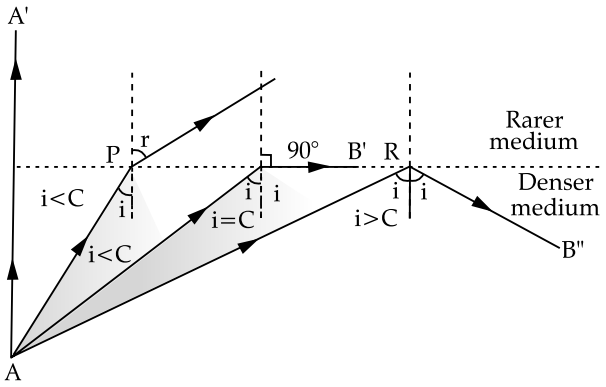
Scan to know more about this topic
Refraction of light by glass slab



(b) Bending of stick under water

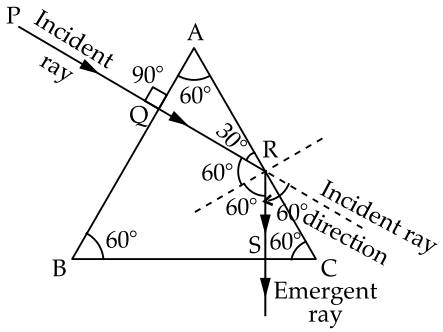


- Critical angle is the angle of incidence in the denser medium for which angle of refraction in the rarer medium is 90°.
- When a ray of light travels from a denser to a rarer medium with an angle of incidence greater than critical angle, then no refraction takes place and the entire light is reflected back in the denser medium. This is known as total internal reflection.
- Essential conditions for total internal reflection to take place :
  - **(i)** Light must travel from a denser to a rarer medium.
  - **(ii)** The angle of incidence should be greater than the critical angle for the given pair of medium.

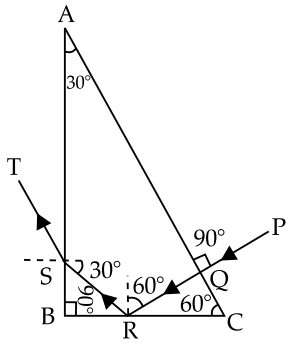


- Total internal reflection in a triangular glass prism

(a) An equilateral prism (60°,60°,60°)

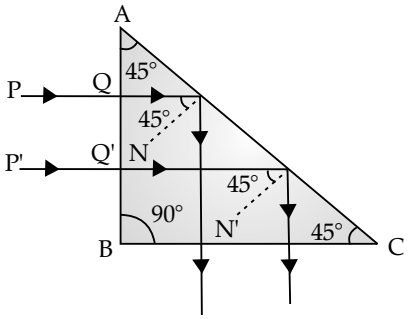


(b) A prism with angles (60°,30°,90°)

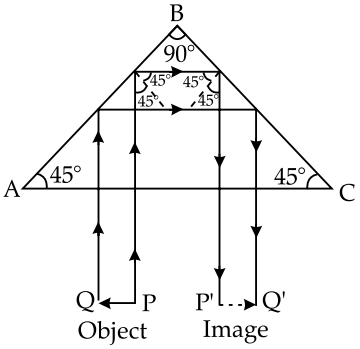


(c) A prism with angles (45°,45°,90°)

(i) To deviate the incident ray by 90° *i.e.* (δ = 90°)



(ii) To deviate the incident ray by 180° *i.e.* (δ = 180°)



- Comparison between total internal reflection and reflection from a plane mirror

(i) In total internal reflection, light enters from a denser to a rarer medium, whereas in reflection from a plane mirror, light can be incident from any medium.

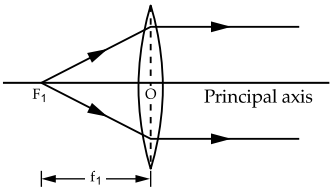
(ii) There is no loss of energy in total internal reflection, as the entire light is internally reflected, whereas in case of reflection from plane mirror, there is a loss of energy due to absorption and refraction of light.

Know the Terms

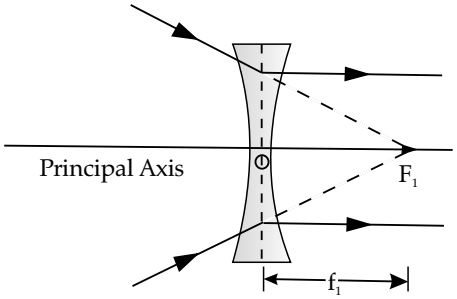
- **Refraction** : The change in direction of the path of light, when it passes from one transparent medium to another transparent medium is called refraction. It is a surface phenomenon.
- **Denser medium** : A medium is said to be optically denser if the speed of light in it decreases.
- **Rarer medium** : A medium is said to be optically rarer if the speed of light in it increases.
- **Angle of incidence** : It is the angle between incident ray and the normal to the surface at point of incidence.
- **Angle of refraction** : It is the angle between the refracted ray and the normal at the point of incidence.
- **Laws of refraction** :
  - **1st Law** : The incident ray, the refracted ray and the normal at the point of incidence, all lie in the same plane.
  - **2nd Law** : The ratio of the sine of the angle of incidence i to the sine of the angle of refraction r is constant for the pair of given media. This constant is called refractive index. This law is also called Snell's Law.
- **Refractive index** : The refractive index of the second medium with respect to the first medium is defined as the ratio of the sine of the angle of incidence in the first medium to the sine of the angle of refraction in the second medium.
- **Lateral displacement** : The distance between the incident ray produced and the emergent ray when light travels through the rectangular glass slab is called lateral displacement.
- **Angle of deviation** : The angle between the emergent ray and the incident ray produced when light passes through a prism is called angle of deviation.
- Frequency, $f = \dfrac{\text{Speed of light in medium, } v}{\text{Wavelength of light in that medium, } \lambda}$
- Refractive index (or absolute refractive index), $\mu = \dfrac{\text{Speed of light in air, } c}{\text{Speed of light in that medium, } v}$
- Refractive index of second medium with respect to first medium $= \dfrac{\text{Absolute refractive index in medium 2, } \mu_2}{\text{Absolute refractive index in medium 1, } \mu_1}$
- $A + \delta = i + e$,
  where A is angle of prism, δ is the angle of deviation, i is the angle of incidence and e is the angle of emergence
- $\mu = \dfrac{\text{Real depth}}{\text{Apparent depth}}$
- $\mu = \dfrac{1}{\sin C}$,where C is the critical angle.

Refraction Through a Lens

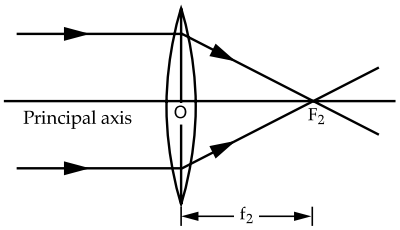
- A lens is a transparent refracting medium bounded by two surfaces, both of which are either spherical in shape or one is plane and other is spherical. A lens may be regarded as being made up of a set of prisms. (A lens is not made up of prisms.)
- There are mainly two types of lenses :
  - **(i)** Convex or converging lens.
  - **(ii)** Concave or diverging lens.
- Convex or converging lenses are thin at the edges and thick at the middle.
- Concave or diverging lenses are thick at the edges and thin at the middle.
- The principal axis of a lens is the line joining the centres of the two spheres of the two surfaces of which lens is a part.
- Optical centre of a thin lens is the point on the principal axis of the lens through which a ray of light passes undeviated.
- For a convex lens, the first focal point is a point F_1 on the principal axis of the lens such that the rays of light coming from it, become parallel to the principal axis of the lens after refraction from the lens.



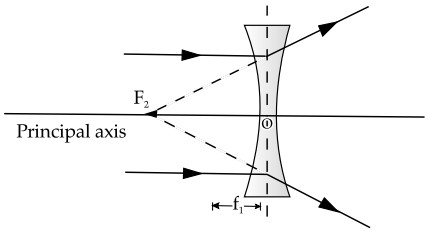
- For a concave lens, first focal point is a point F_1 on the principal axis of the lens such that the incident rays of light appearing to meet at it, become parallel to the principal axis of the lens after refraction from the lens.



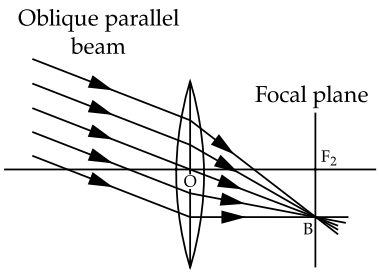
- For a convex lens, the second focal point is a point F_2 on the principal axis of the lens such that the rays of light incident parallel to the principal axis passes through it after refraction from the lens.



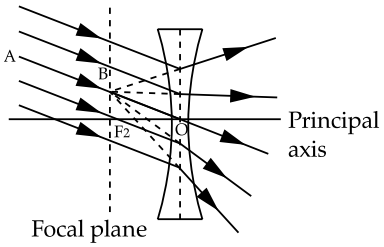
- For a concave lens, the second focal point is a point F_2 on the principal axis of the lens such that the rays of light incident parallel to the principal axis appear to be diverging from this point after refraction from the lens.



- A concave lens always produces a virtual, erect and diminished image of a real object.
- The power of a lens is the reciprocal of its focal length measured in metre. It is measured in units of **dioptre (D)**.
- Thicker lens has shorter focal length. As the focal length decreases, power of lens increases. So, thicker lens has higher power. Thinner lens has less power.
- A convex lens of small focal length may be used as a simple magnifying glass or a reading lens. For this, the object is kept between the optical centre and the focus of the lens. When it is used in this manner, it is also known as a **simple microscope**.
- The magnification produced by a lens is the ratio of a size of the image produced by it to the size of the object.
- **Refraction of an oblique parallel beam by a convex lens :**



➢ **Refraction of an oblique parallel beam by a concave lens :**



➢ **Distinction between a real and virtual image :**

S. No.	Real image	Virtual image
1.	A real image is formed due to actual intersection of the rays refracted by the lens.	A virtual image is formed when the rays refracted by the lens appear to meet if they are produced backwards.
2.	A real image can be obtained on a screen.	A virtual image cannot be obtained on a screen.
3.	A real image is inverted with respect to the object.	A virtual image is erect with respect to the object.
	Example : The image of a distant object formed by a convex lens.	*Example :* The image of a distant object formed by a concave lens.

➢ **Relative positions of the object and image in a convex lens :**

Positions of object	Position of image	Size of image	Name of image	Application
1. At infinity	At F_2	Highly diminished	Real and inverted	Burning glass
2. Beyond $2F_1$	Between F_2 and $2F_2$	Diminished	Real and inverted	Camera lens
3. At $2F_1$	At $2F_2$	Same size	Real and inverted	Terrestrial telescope
4. Between F_1 and $2F_1$	Beyond $2F_2$	Magnified	Real and inverted	Slide projector
5. At F_1	At infinity	Highly magnified	Real and inverted	Collimator of spectrometer
6. Between the lens and F_1	On same side, behind the object	Magnified	Virtual and upright	Corrective lens for Magnifying glass

➢ **Relative positions of object and image in a concave lens :**

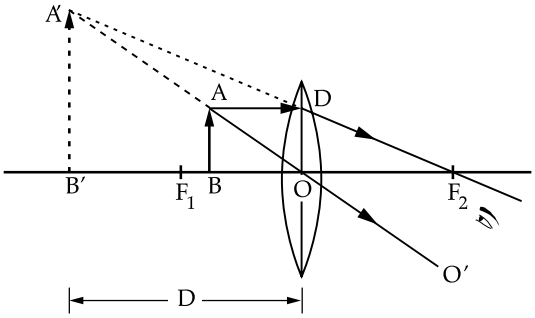
Position of the object	Position of the image	Nature of the image	Size of the image	Application
1. At infinity	At the focus, on the same side of the lens as the object.	Virtual and upright	Highly diminished	Galilean telescope
2. At any position between infinity and optical centre.	Between the focus and optical centre, on the same side of the lens as the object.	Virtual and upright	Diminished	Corrective lens for myopic eye

➢ **Difference between the image formed by a convex lens and by a concave lens :**

S. No.	Image by a convex lens	Image by a concave lens
1.	The image may be real as well as virtual. It is real if the object lies at or beyond focus, while it is virtual if the object lies between focus and optical centre.	The image is always virtual for all position of the object.
2.	The image may be magnified, of the same size, as well as diminished.	The image is always diminished.
3.	The image may be inverted, as well as erect. The image is inverted if the object is at or beyond focus and erect if the object is between focus and optical centre.	The image is always erect.

- The deviation produced by a lens in the path of rays refracted through it, is a measure of its power. Power of a lens is positive for the convex lens and negative for the concave lens.
- Power of lens (in D) = 1/*f*
- **Magnifying power** : The magnifying power of the microscope is given as :

  Magnifying power = $1 + \frac{D}{f}$
- **Ray diagram for location of image in magnifying glass :**



- **Focal Length of Lens :** The distance between focus and optical centre of the lens is called **focal length of a lens**.
- **Focal Plane :** The plane passing through the focus and perpendicular to the principal axis is called **Focal plane**.
- **Aperture :** The effective diameter of the circular outline of a spherical lens is called its **aperture**.
- Centre of curvature of a surface of a lens is the centre of the sphere of which lens is a part. A lens having two spherical surfaces has two centres of curvature.
- Radius of' curvature is the distance between the optical centre and centre of curvature.
- **Sign Conventions :**
  - All distances are measured from the optical centre of the lens.
  - Distances measured in the direction of the incident ray are taken as positive and opposite to the direction of the incident ray are taken as negative.
  - Distances measured upwards and perpendicular to principal axis are taken as positive, whereas distances measured downwards are taken as negative.
- Lens formula

  $$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$

  Where, u = Object distance (always negative)

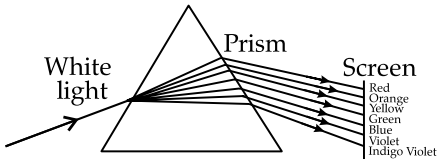
  v = Image distance (may be positive or negative)

  f = Focal length (positive the for convex lens and negative for the concave lens)
- Lenses are used for eye defect correction, magnifying glass, telescope, camera.

Spectrum and Scattering of Light

- The phenomenon of splitting of white light by a prism into its constituent colours is known as **dispersion**.
- The band of colours seen on passing white light through a prism is called the **spectrum**.
- **Cause of dispersion** :

  The cause of dispersion is the change in speed of light with wavelength. When white light enters the first surface of a prism, light of different colours due to their different speeds in the glass gets deviated toward the base of prism through different angles.
- **Dispersion by a prism** :



- The angle of deviation depends upon, (i) angle of incidence at first surface (ii) angle of prism (iii) refractive index of the material.

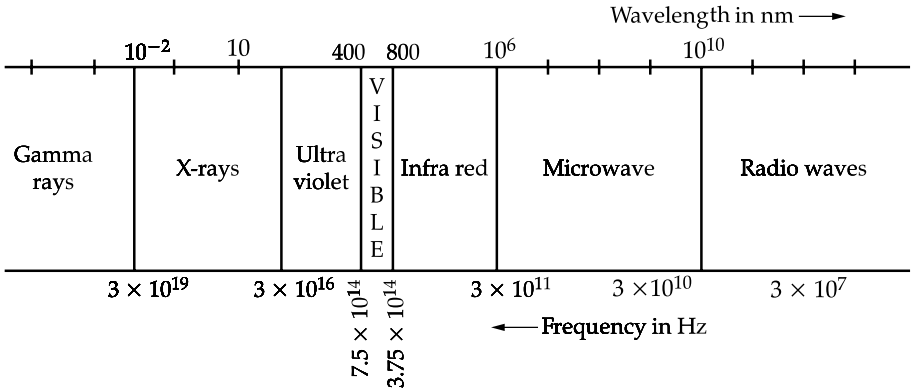
➢ **Wavelengths and frequencies of different colours in white light** :

Colour	Wavelength range (nearly)	Frequency range in 10^{14} Hz
Violet	4000 Å to 4460 Å	7.5 – 6.73
Indigo	4460 Å to 4640 Å	6.73 – 6.47
Blue	4640 Å to 5000 Å	6.47 – 6.01
Green	5000 Å to 5780 Å	6.01 – 5.19
Yellow	5780 Å to 5920 Å	5.19 – 5.07
Orange	5920 Å to 6200 Å	5.07 – 4.84
Red	6200 Å to 8000 Å	4.84 – 3.75

➢ The complete electromagnetic spectrum in the increasing order of their wavelength (or decreasing order of their frequency) is given below :

(1) Gamma rays, (2) X-rays, (3) Ultraviolet rays, (4) Visible light, (5) Infrared radiations, (6) Microwaves, and (7) Radio waves.

Thus, infrared spectrum is the part of the spectrum just beyond the red end while the ultraviolet spectrum is the part of the spectrum just before the violet end.



Electromagnetic spectrum

Name of the wave	Frequency in Hz	Discoverer	Source	Method of detection
Ultraviolet	$3 \times 10^{16} - 7.5 \times 10^{14}$	Ritter	Sunlight, arc-lamp or spark	By their chemical activity on dyes. Photographic plates get affected. It causes fluorescence.
Visible light	$7.5 \times 10^{14} - 3.75 \times 10^{14}$	Newton	Sunlight, light from electric bulb, flame, white hot bodies.	Other objects can be seen in its presence.
Infrared waves	$3.75 \times 10^{14} - 3 \times 10^{11}$	Herschel	Lamp with thoriated filament, heated silicon carbide rod, red hot bodies	Heating effect is more. The mercury rises rapidly when a thermometer with the blackened bulb is kept in these radiations.

- **Properties common to all electromagnetic spectrum :**
  - **(i)** The electromagnetic waves of the entire wavelength range do not require any material medium for their propagation.
  - **(ii)** They all travel with the same speed in a vacuum which is the same as the speed of light in vacuum *i.e.*, 3×10^{8} m/s.
  - **(iii)** They exhibit the properties of reflection and refraction.
  - **(iv)** These waves are not deflected by the electric and magnetic fields.
  - **(v)** These waves are transverse waves.

- **Properties and uses of the electromagnetic spectrum :**

➢ **Ultraviolet Radiation**

It was discovered by Ritter in 1801. They are produced by some special lamps and very hot bodies. Ultraviolet rays coming from the Sun are absorbed by the ozone layer in the Earth's atmosphere. The wavelength range varies from 10 nm to 400 nm.

- **Properties of ultraviolet radiation are as follows :**
  - **(i)** They can pass through quartz but absorbed by glass.
  - **(ii)** They can be scattered by dust particles in the atmosphere.
  - **(iii)** They cause health hazards like skin cancer, if our body is exposed for a long period of time.
- **Uses of ultraviolet radiation are as follows :**
  - **(i)** For sterilizing purposes.
  - **(ii)** For detecting the purity of gold, eggs, *ghee*, etc.
  - **(iii)** For producing vitamin D in food of plants and animals.

➢ **Visible Light**

It is the narrow region of the electromagnetic spectrum which can be detected by the human eyes. Its wavelength ranges from 390 nm to 700 nm.

➢ **Uses of visible light are as follows:**

(i) The visible light emitted or reflected from the object around us provides the information surrounding us.

(ii) It is used in photography, photosynthesis and to see objects around us.

➢ **Infrared Radiation**

It was discovered by Herschel. They are sometimes called heat waves, because their absorption causes the heating effect in the bodies and surroundings. They are produced by hot bodies and molecules. Its range is from 700 nm to 1 mm.

- **Properties of infrared radiation are as follows :**
  - **(i)** They do not affect ordinary photographic film.
  - **(ii)** They are absorbed by the glass but are not absorbed by rock salt.
  - **(iii)** They are detected by their heating property.
  - **(iv)** They are less scattered by the atmosphere.
- **Uses of infrared radiation are as follows :**
  - **(i)** They are used in photography at night and also in mist and fog.
  - **(ii)** They are used for therapeutic purpose.
  - **(iii)** They are used in remote control of TV and other gadgets.
  - **(iv)** They are used as signals during the war.

MNEMONICS

Concept : Electromagnetic spectrum (Left to right arrangement of electromagnetic waves in order of increasing frequency and decreasing wavelength)
Mnemonics : Russian **M**agician showed **I**nteresting and **V**ery **U**nusual **X**-ray eye **G**ame.
Interpretation : R : Radio wave M : Microwave I : Infra red V : Visible light U : Ultraviolet X : X-rays G : Gamma rays

MULTIPLE CHOICE QUESTIONS

STAND ALONE MCQs

AI **Q.1.** Speed of light in vacuum is
(A) 3×10^8 ms^{-1}
(B) 3×10^8 cm s^{-1}
(C) 3×10^8 km s^{-1}
(D) 3×10^8 mm s^{-1}

Ans. Option (A) is correct.

Explanation: Speed of light in vacuum is a universal physical constant and its value in S.I. system is 3×10^8 ms^{-1}.

AI **Q. 2.** When light travels from denser to rarer medium
(A) $\angle i = \angle r$
(B) $\angle i > \angle r$
(C) $\angle i < \angle r$
(D) $\angle i \geq \angle r$

Ans. Option (C) is correct.

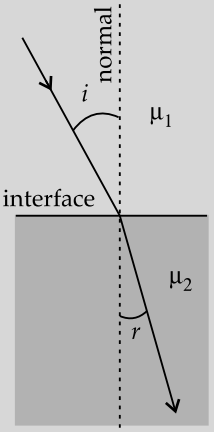
Explanation: When light refracts from denser to a rarer medium, the refracted ray moves away from the normal.

Q. 3. When a ray of light is incident normally on the surface separating two media, then
(A) $\angle r = 0^0$
(B) $\angle r = 90°$
(C) $\angle i = \angle r = 0°$
(D) None of the above

Ans. Option (C) is correct.

Explanation: Snell's Law: $\frac{\sin i}{\sin r} = \frac{\mu_1}{\mu_2}$

$\therefore \mu_2 \sin i = \mu_1 \sin r$



For normal incidence, $\angle i = 0°$, $\therefore \sin i = 0$

From the above relation, $\mu_1 \sin r = 0$

But, $\mu_1 \neq 0$, $\therefore \sin r = 0$

$\therefore \angle r = 0°$

AI **Q. 4.** Absolute refractive index of a transparent medium is always
(A) Smaller than 1
(B) Greater than 1
(C) Lies between 0 and 1
(D) Negative

Ans. Option (B) is correct.

Explanation: $\mu = c/v$

c = velocity of light in vacuum

v = velocity is light in the medium

Since $c > v$,

so, $\mu > 1$

Q. 5. If absolute refractive index of a medium is 1.5 then velocity of light in that medium is
(A) 3×10^8 ms^{-1}
(B) 2×10^8 ms^{-1}
(C) 4.5×10^8 ms^{-1}
(D) 0.5×10^8 ms^{-1}

Ans. Option (B) is correct.

Explanation: $\mu = c/v$

$\therefore v = c/\mu = 3 \times 10^8 / 1.5 = 2 \times 10^8$ ms^{-1}

AI **Q. 6.** Light passes from one medium to another undeviated when
(A) Refractive indices of both the media are same
(B) Angle of incidence is 0°
(C) Angle of incidence is 90°
(D) Both (A) and (B)

Ans. Option (D) is correct.

Explanation: Refer Q. No. 3 which shows that for normal incidence (i.e. angle of incidence = 0°), light passes from one medium to another undeviated.

Also, when when the refractive indices of the two the media are same, then there is no change in velocity of light. So there is no refraction. So, light passes from one medium to another undeviated.

Q. 7. When light passes from one medium to another
(A) Frequency and wavelength remain same, velocity changes
(B) Frequency remains same, velocity and amplitude change
(C) Velocity remains same, frequency and amplitude change
(D) Velocity, frequency, wavelength remain same.

Ans. Option (B) is correct.

Explanation: Frequency of light depends on the source of light. So, it does not change from medium to medium. But the velocity changes.

Since $v = \nu\lambda$, ν remaining constant, λ changes from medium to medium.

Q. 8. When light passes from denser to rarer medium, amplitude _____ and when light passes from rarer to denser medium, amplitude _____.

(A) Increases, increases
(B) Decreases, decreases
(C) Increases, decreases
(D) Decreases, increases

Ans. Option (C) is correct.

Explanation: Frequency of light depends on the source of light. So, it does not change from medium to medium. But the velocity changes.

Velocity of light is denser medium and less than the velocity of light in rarer medium.

$v = \nu\lambda$ and ν remains constant.

So, in denser medium velocity decreases, amplitude also decreases and in rarer medium when velocity increases, amplitude also increases.

Q. 9. Due to refraction of light through a glass block, the lateral dispersion depends on

(A) Angle of incidence
(B) Thickness of the block
(C) Refractive index of the block
(D) All of the above

Ans. Option (D) is correct.

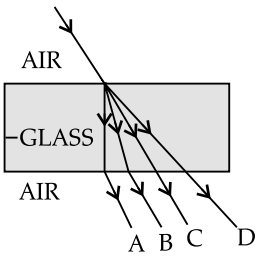
Q.10. Which one of the following has the highest refractive index?

(A) Diamond
(B) Glass
(C) Water
(D) Kerosene oil

Ans. Option (A) is correct.

Explanation: Refractive index of diamond is around 2.4. It is the highest.

AI **Q. 11.** Which ray is the correct. light path through a glass slab?

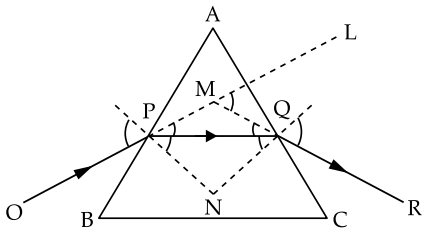


(A) Ray A
(B) Ray B
(C) Ray C
(D) Ray D

Ans. Option (B) is correct.

Explanation: Glass is a denser medium than air. So, when the ray refracts from air to glass, it bends towards the normal and when it refracts from glass to air, it bends away from the normal.

AI **Q. 12.** Due to refraction through prism, the angle of deviation is



(A) $\angle$MPQ (B) $\angle$MQP
(C) $\angle$PNQ (D) $\angle$LMQ

Ans. Option (D) is correct.

Explanation: It is the angle between the incident ray and the emergent ray.

AI **Q. 13.** Air bubble in a glass block when viewed from above appears to be raised due to

(A) Refraction of light
(B) Reflection of light
(C) Reflection and refraction of light
(D) None of the above

Ans. Option (A) is correct.

Explanation: Apparent depth = Real depth / Refractive index

Q. 14. When light travels from denser to a rarer medium, if the angle of incidence is equal to the critical angle for the pair of media then the angle of refraction is

(A) 0°
(B) 90°
(C) 45°
(D) None of the above

Ans. Option (B) is correct.

Explanation: Critical angle is defined as the angle of incidence in the denser medium corresponding to which the angle of refraction is 90^0.

Q. 15. Which of the following conditions is to be satisfied for total internal reflection?

(A) Angle of incidence should be greater than the critical angle
(B) Light should pass from denser to rarer medium
(C) Light should be incident perpendicularly
(D) Both (A) and (B)

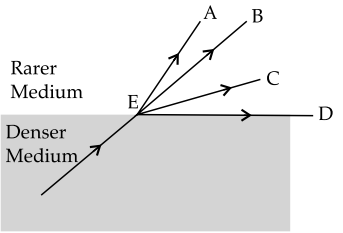
Ans. Option (D) is correct.

Explanation: For total internal reflection, the essential conditions which are to be satisfied are:

(i) The light has to travel from denser to rarer medium

(ii) The angle of incidence should be greater than the critical angle for the pair of media.

Q. 16. If OE is the incident ray, and angle of incidence is equal to the critical angle then ____ ray shows the correct path of refracted ray.



(A) ED
(B) EC
(C) EB
(D) EA

Ans. Option (A) is correct.

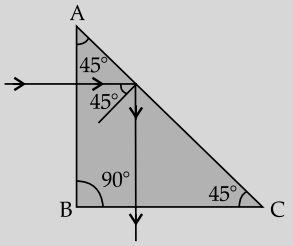
> ***Explanation:*** If $\angle i$ = critical angle for the pair of media, then
> $\angle r = 90^0$.

AI Q. 17. Critical angle for glass-air media pair is
(A) 42°
(B) 24°
(C) 36°
(D) 45°

Ans. Option (A) is correct.

Q. 18. A total reflecting right angle isosceles prism is used to deviate a ray of light through
(A) 180°
(B) 90°
(C) 0°
(D) 60°

Ans. Option (B) is correct.

> ***Explanation:***
>
> 
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AI Q. 19. A ray of light directed towards the optical centre of a this lens suffers
(A) **0**° deviation
(B) 90° deviation
(C) 180°deviation
(D) None of the above.

Ans. Option (A) is correct.

> ***Explanation:*** For this lens, ray of light directed towards the optical centre passes undeviated.

Q. 20. 1st focal length and 2nd focal length of a thin lens are equal
(A) Only if the media on both sides of the lens are same
(B) Even if the media on both side of the lens are not same
(C) Only if medium on both sides of the lens is air
(D) Only if the material of the medium is glass

Ans. Option (A) is correct.

> ***Explanation:*** Focal length of a lens depends on the surrounding medium. So, if the media on both sides of the lens are same, then only the 1st focal length and 2nd focal length are equal.

AI Q. 21. Which of the following statement is true?
(A) Both the foci of a convex lens are virtual.
(B) Both the foci of a concave lens are real.
(C) For both convex and concave lens one of the foci is real and the other is virtual.
(D) Both the foci of convex lens are real.

Ans. Option (D) is correct.

> ***Explanation:*** Foci of convex lens are real since the incident rays parallel to the principal axis, after refraction, pass through 2nd focal point and rays passing through the 1st focal point, after refraction, become parallel to the principal axis.

AI Q. 22. If a lens is immersed in water, its focal length
(A) Decreases
(B) Increases
(C) Remains same
(D) May increase or decrease depending on the refractive index of liquid.

Ans. Option (B) is correct.

> ***Explanation:*** As the difference in refractive indices of the material of the lens and the surrounding medium decreases, the bending of rays also decreases. Hence after refraction, the parallel rays meet at a greater distance i.e focal length increases.
>
> Say, the refractive index of the material of lens be 1.5.
>
> Refractive index of air is 1. Say, refractive index of water be 1.33.
>
> So, difference of refractive indices when water is the surrounding medium is less than the difference when air is the surrounding medium.
>
> So, if the lens is immersed in water, focal length increases.

AI Q. 23. If a lens becomes thick, its focal length
(A) Decreases
(B) Increases
(C) Remains same
(D) May increase or decrease depending on the refractive index of the lens material.

Ans. Option (A) is correct.

> ***Explanation:*** Bending of rays is more in thick lens compared to thin lens. Hence, thick lens has shorter focal length compared to thin lens.

Q. 24. When a convex lens is used as a burning glass, the object is at
(A) F
(B) ∞
(C) 2F
(D) O

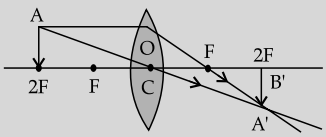
Ans. Option (B) is correct.

Explanation: When the object (here the object is the sun) is at infinity, rays parallel to principal axis are incident on the lens and after refraction meet at the second focal point.

Q. 25. For which object position, the image formed by a convex lens is of equal size of the object?
(A) At F
(B) At 2F
(C) At ∞
(D) Between F and O.

Ans. Option (B) is correct.

Explanation:



Q. 26. For which object position, the object distance is equal to image distance?
(A) O
(B) f
(C) $2f$
(D) ∞

Ans. Option (C) is correct.

Explanation: $\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$

Putting $u = -2f$

$$\frac{1}{v} = \frac{1}{f} - \frac{1}{2f}$$

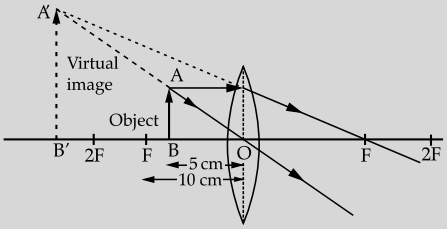
$$\frac{1}{v} = \frac{1}{2f}$$

$$\therefore v = 2f$$

Q. 27. If an object placed at a distance 5 cm from a convex lens of focal length 10 cm, the image formed is
(A) Real, inverted, magnified
(B) Virtual, inverted, magnified
(C) Real, erect, diminished
(D) Virtual, erect, magnified

Ans. Option (D) is correct.

Explanation:



Q. 28. Powers of a convex lens and a concave lens are respectively _____ and _____ .
(A) Positive, Positive
(B) Negative and negative
(C) Positive, negative
(D) Negative, positive

Ans. Option (C) is correct.

Explanation: Focal lengths of a convex and a concave lens are respectively positive and negative. Hence, the powers are also positive and negative respectively.

Q. 29. Two equi-convex lenses L_1 and L_2 have radii of curvature 15 cm and 30 cm respectively. Which lens has higher power?
(A) Both have same power
(B) Power of L_1 > power of L_2
(C) Power of L_2 > Power of L_1
(D) Insufficient data

Ans. Option (B) is correct.

Explanation: As radius of curvature increases, focal length of a lens increases. As focal length increases, power of the lens decreases (since $P = 1/f$). So, L_1 has higher power compared to that of L_2.

Q. 30. In a medium, ____ light has maximum speed and _____ light has minimum speed.
(A) Red, violet
(B) Violet, red
(C) Green, yellow
(D) Yellow, green

Ans. Option (A) is correct.

Q. 31. For refraction through a prism, the deviation of red light is
(A) Equal to the deviation of violet light
(B) Less than the deviation of violet light
(C) Greater than the deviation of violet light
(D) Depends on the shape of the prism

Ans. Option (B) is correct.

Explanation: In a medium,

$v_{red} > v_{violet}$

$\therefore \mu_{violet} > \mu_{red}$

Since $\mu = \sin i / \sin r$

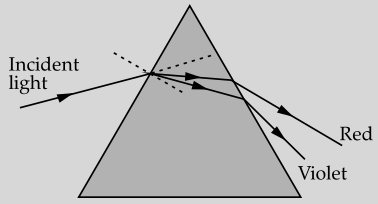
$r_{red} > r_{violet}$

$\therefore \delta_{violet} > \delta_{red}$

Q. 32. When a ray of while light is incident on a prism, the ray at its first surface suffers
(A) Only refraction
(B) Only dispersion
(C) Only deviation
(D) All of the above

Ans. Option (D) is correct.

Explanation:



Q. 33. Which of the following arrangements is in correct order of increasing wavelength?

(A) Gamma rays, X-rays, Ultraviolet rays, visible light, Infrared radiations
(B) Infrared radiations, visible light, Ultraviolet rays, X-rays, Gamma Rays
(C) Infrared radiations, Ultraviolet rays, visible rays, Gamma Rays, X-rays
(D) X-rays, Gamma Rays, Ultraviolet rays, Infrared radiations, visible light

Ans. Option (A) is correct.

Explanation:

Name of radiation	Approximate range of wavelength
Gamma rays	< 0.01 nm
X rays	≈ 0.01 – 10 nm
Ultraviolet	≈ 10 – 400 nm
Visible light	≈ 400 – 800 nm
Infrared radiation	≈ 800 nm – 1 mm

AI **Q. 34.** Which of the followings is the common property of all electromagnetic radiations?

(A) All electromagnetic waves have the same frequency.
(B) All electromagnetic waves have the same velocity in vacuum.
(C) All electromagnetic waves have the same wavelength.
(D) All electromagnetic waves have the same intensity.

Ans. Option (B) is correct.

Explanation: Velocity of all electromagnetic waves in vacuum is 3×10^8 ms^{-1}.

Q. 35. Which of the following rays produce vitamin D in human body?

(A) Infrared
(B) Ultraviolet
(C) Visible light
(D) All of the above

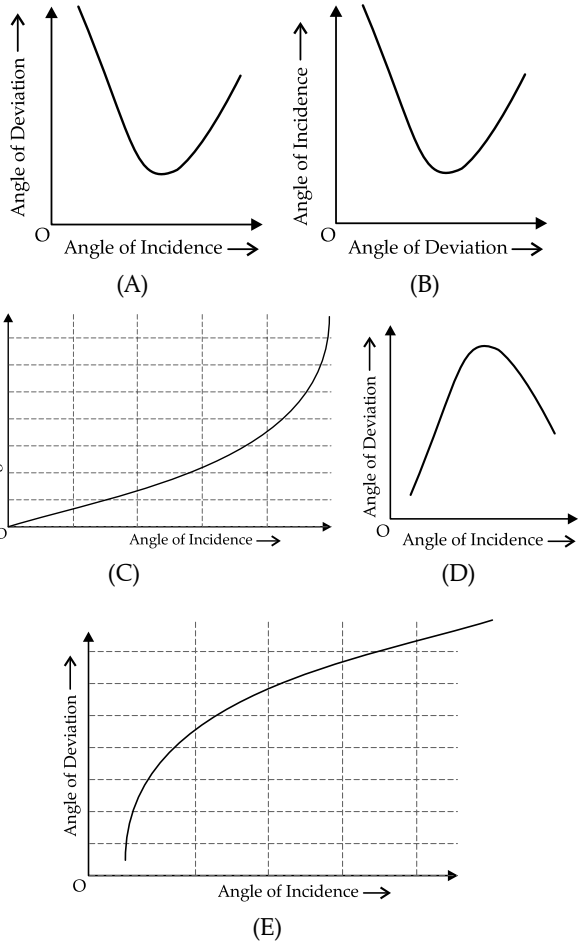
Ans. Option (B) is correct.

Q. 36. Which of the following rays is used for night photography?

(A) Infrared
(B) Ultraviolet
(C) Visible light
(D) All of the above

Ans. Option (A) is correct.

Q. 37. Which one of the following is the correct *i*-δ graph for a prism ?



(A) Graph (A)
(B) Graph (B)
(C) Graph (C)
(D) Graph (D)
(E) Graph (E)

Ans. Option (A) is correct.

Explanation: *i*-δ graph for a prism is obtained by plotting angle of incidence (*i*) along x-axis and angle of deviation (δ) along y-axis.

Initially as the angle of incidence increase, the angle of deviation decreases. Thus, the deviation reaches a minimum value. The angle of deviation then starts increasing with the increase of angle of incidence.

Q. 38. An object appears to be at a 1 m depth of water. If the refractive index of water is 1.35, the actual depth of the object is

(A) 1.35 m
(B) 1 m
(C) 1/1.35 m
(D) 0.35 m
(E) 13.5 m

Ans. Option (A) is correct.

Explanation: Real depth = Refractive index × apparent depth.

Here apparent depth = 1 m,

refractive index = 1.35

So, real depth = 1.35 × 1 = 1.35 m

Q. 39. The relation between critical angle and the refractive index of the medium is

(A) $\mu = \sin\theta_C$
(B) $\mu = \text{cosec}\,\theta_C$
(C) $\mu = \cos\theta_C$
(D) $\mu = \sec\theta_C$
(E) $\mu = \cot\theta_C$

Ans. Option (B) is correct.

Explanation: Refractive index of a medium = $\mu = 1/\sin\theta_C$

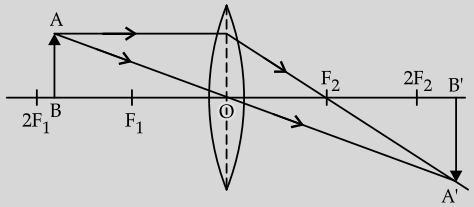
$\therefore \mu = \text{cosec}\,\theta_C$

Q. 40. For which of the following positions of object, convex lens produces magnified image?

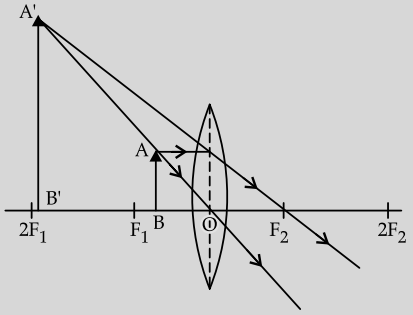
(A) (i) $u = f$ and (ii) $u = 2f$
(B) (i) $u > 2f$ and (ii) $u < f$
(C) (i) $2f > u > f$ and (ii) $u < f$
(D) (i) $u = f$ and (ii) $u = \infty$
(E) (i) $u = 2f$ and $u < f$

Ans. Option (C) is correct.

Explanation: (i) When $2f > u > f$, the image is real, inverted and magnified.



(ii) When $u < f$, the image is virtual, erect and magnified.



Q. 41. Which one of the following is a polychromatic light?

(A) Violet
(B) Yellow
(C) Red
(D) Green
(E) White

Ans. Option (E) is correct.

Explanation: Light is called polychromatic when it has multiple optical frequencies. White light consists of 7 different optical frequencies. Hence, it is a polychromatic light.

Q. 42. For which of the following activities infrared is used?

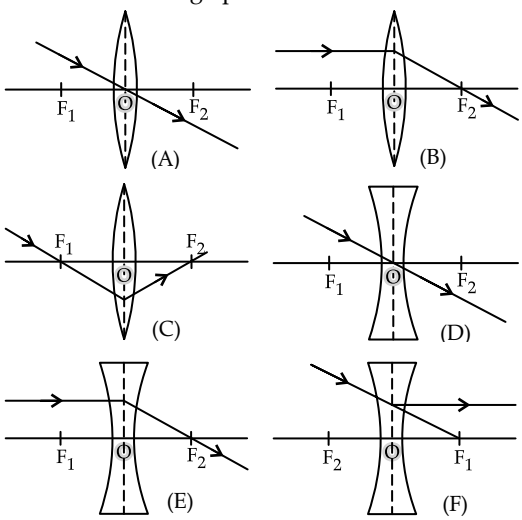
(A) Night photography
(B) Remote control
(C) Fluorescence
(D) Heating
(E) Both (A) and (B)

Ans. Option (E) is correct.

Explanation: Infrared suitable for night photography and remote control. Infrared is also known as heat rays since it produces sensation of heat.

[While solving Board's specimen paper I find that two correct answers in 5 option question is a format . I have tried to follow that in few questions.]

Q. 43. In the following six diagrams there are two diagrams which are not correct. Identify those two diagrams from the following options.



(A) Diagram (A)
(B) Diagram (B)
(C) Diagram (C)
(D) Diagram (D)
(E) Diagram (E)
(F) Diagram (F)

Ans. Option (C) and (F) are correct.

Explanation: In diagram (C): A ray passing through the focus becomes parallel to the principal axis after refraction by a convex lens.

In diagram (F): A ray incident parallel to the principal axis appears to diverge from F_1 after refraction by a concave lens.

Q. 43. There are four convex lenses A, B, C, D, E, F of focal length 10 cm, 20 cm, 40 cm , 60 cm, 80 cm and 100 cm. From the following options find which lens has highest power and which one produces virtual image for object distance 60 cm.

(A) Lens A
(B) Lens B
(C) Lens C
(D) Lens D
(E) Lens E
(F) Lens F

Ans. Option (A) and option (F).

Explanation: Power of a lens = $1/f$

So, as focal length decreases, power increases. Lens A has the lowest focal length. So it has the largest power.

For virtual image, object distance u should be $f > u > 0$. Only for lens F this condition is satisfied. So, lens F produces virtual image.

ASSERTION AND REASON MCQs

Directions : In the following questions, A statement of **Assertion (A)** is followed by a statement of **Reason (R).** Mark the correct. choice as:

(A) Both A and R are true and R is the correct. explanation of A.
(B) Both A and R are true but R is NOT the correct. explanation of A.
(C) A is true but R is false.
(D) A is false and R is true.

Q. 1. Assertion (A): Air bubble shines in water.

Reason (R): Air bubble shines due to refraction of light.

Ans. Option (C) is correct.

Explanation: Medium inside the bubble is air and the surrounding medium is water which is denser than air. When light rays through water are incident on the bubble surface, they suffer total internal reflection when the angle of incidence is greater than critical angle. So, the bubbles shine.

So, the assertion is true but the reason is false.

Q. 2. Assertion (A): Different colours of light have different speeds in vacuum.

Reason (R): Different colours of light have different wavelengths.

Ans. Option (D) is correct.

Explanation: Light is electromagnetic wave. Electromagnetic waves have the speed 3×10^8 ms^{-1} in vacuum. So, the assertion is false.

Different colours of light have different wavelengths. The reason is true.

Q. 3. Assertion (A): Images formed due to total internal reflection is brighter than the image produced by normal reflection.

Reason (R): There is no loss of intensity in total internal reflection.

Ans. Option (A) is correct.

Explanation: In total internal reflection there is no loss of intensity. But due to normal reflection certain portion of intensity is lost due to partial refraction and absorption. For this reason, images formed due to total internal reflection is brighter than the image produced by normal reflection.

So, assertion and reason both are true and the reason explains the assertion.

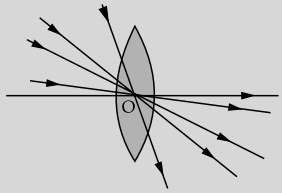
Q. 4. Assertion (A): Ray passing through the optical centre of a lens suffers zero deviation.

Reason (R): When a ray of light passes through the optical centre, the angle of incidence being zero the angle of refraction is also zero.

Ans. Option (C) is correct.

Explanation: For this lens, ray passing through the optical centre of a lens suffers zero deviation. The assertion is correct.

But the angle of incidence passing through the optical centre may have different values as shown below:



So the reason is false.

Q. 5. Assertion (A): Unit of power of lens is m^{-1}.

Reason (R): Power of a lens is the reciprocal of its focal length expressed in metre.

Ans. option (A) is correct.

Explanation: Power $= \dfrac{1}{f \text{ (in metre)}}$

So, unit of power is m^{-1}, which is known as dioptre.

So, the assertion and reason both are true and the reason explains the assertion.

Q. 6. Assertion (A): As the refractive index of a medium decreases, the velocity of light through it also decreases.

Reason (R): Refractive index is inversely proportional to the velocity of light through the medium.

Ans. Option (D) is true.

Explanation: $\mu = c/v$

c is the velocity of light in vacuum and it is a constant.

Hence, $\mu \propto 1/v$

So, As the refractive index of a medium decreases, the velocity of light through it increases.

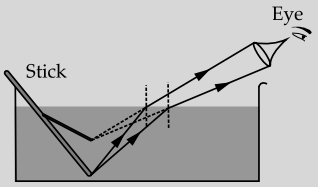
Hence the assertion is false but the reason is true.

Q. 7. Assertion (A): A straight stick partly immersed in a liquid appears to bend from the liquid surface.

Reason (R): The apparent bending of the stick is due to refraction of light.

Ans. Option (A) is correct.

Explanation: Rays of light coming from the immersed portion of the stick, when refracting from liquid to air, bend away from the normal and produce a virtual image which is slightly uplifted and hence the stick appears to bend.



Hence the assertion and reason both are true and the reason explains the assertion.

Q. 8. Assertion (A): Focal length of a concave lens is negative.

Reason (R): Concave lens is a diverging lens.

Ans. Option (B) is correct.

Explanation: Rays incident parallel to principal axis of a concave lens diverge after refraction. Rays when extended backward, they meet at the focus. Focal length is measured from the optical centre in the direction opposite to the direction of light. Hence the focal length of concave lens is negative.

So the assertion is true.

Concave lens is a diverging lens. The reason is also true. But it does not explain the assertion.

Q. 9. Assertion (A): The absolute refractive index of a transparent medium is always greater than 1.

Reason (R): Velocity of light in transparent medium is always greater than $3 \times 10^8 \text{ ms}^{-1}$.

Ans. Option (C) is correct.

Explanation: Absolute refractive index

$$= \frac{\text{velocity of light in vacuum}}{\text{velocity of light in that medium}}$$

Velocity of light in vacuum is the highest. Velocity of light in any other medium is less than that. So, absolute refractive index is always greater than 1.

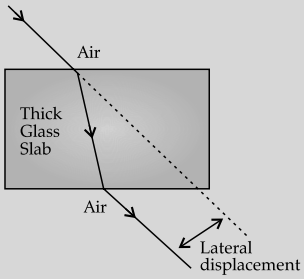
Hence, the assertion is true but the reason is false.

Q. 10. Assertion (A): The perpendicular distance between the incident ray and the emergent ray due to refraction through a glass slab is called lateral displacement.

Reason (R): Wider the glass slab, larger the lateral displacement.

Ans. Option (C) is correct.

Explanation: The perpendicular distance between the incident ray and the emergent ray due to refraction through a glass slab is called lateral displacement.



The assertion is true.

Lateral displacement depends on the thickness of the slab and not on its width. So, the reason is false.

Q. 11. Assertion (A): Red light bends the least in the dispersion of white light through prism.

Reason (R): Red light have highest frequency.

Ans. Option (C) is correct.

Explanation: Wavelength and speed of red colour is maximum. So, deviation is minimum

So, the assertion is true but the reason is false.

Q. 12. Assertion (A): Virtual image cannot be seen on a screen.

Reason (R): Virtual image can be seen by our eyes.

Ans. Option (B) is correct.

Explanation: After refraction through a lens if the rays are diverging, then a virtual image is produced. Since the rays do not actually meet at a point, so the image cannot be seen on a screen. So the assertion is true.

But eye can see the image since eye contains a convex lens which forces the diverging rays meet on the retina. So, the reason is also true but it does not explain the assertion.

CASE-BASED MCQs

I. Palash's uncle was unable to read a book. The letters of the book were too small. So, he asked Palash to bring a magnifying glass.

Palash found three magnifying glasses. He brought all the three and asked his uncle to pick up the suitable one.

Palash's uncle picked up the thickest one.

After reading the book he asked Palash to find its focal length.

Q. 1. Magnifying glass is a
(A) Convex lens
(B) Concave lens
(C) Convex mirror
(D) Concave mirror

Ans. Option (A) is correct.

Q. 2. Why Palsh's uncle selected the thickest one?
(A) Thickest lens has the longest focal length
(B) Thickest lens has the largest magnifying power.
(C) Thickest lens produce erect image.
(D) Thickest lens is less fragile.

Ans. Option (B) is correct.

Explanation: As the thickness of convex lens increases, its focal length decreases. As the focal length decreases, the power of the lens increases since $P = 1/f$.

Q. 3. How easily Palash can find the focal length of the lens?
(A) Palash can form the image of an object on a screen using the lens. He can then measure the object distance and image distance. Applying the lens formula, he can find out the focal length of the lens.
(B) Palash can meaure the curvature of the lens using a spherometer and then applying suitable formula he can find out the focal length.
(C) Palash can place the object and the screen such that the image size becomes equal to the object size. Then half of the object distance is the focal length of the lens.
(D) Palash can hold the lens in front of a wall such that the inverted distinct image of a distant building in formed on the wall. The distance of the lens of the wall is the focal length of the lens.

Ans. Option (D) is correct.

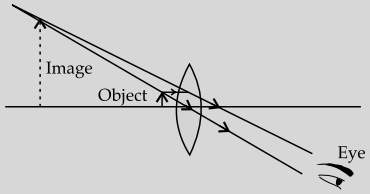
Explanation: In options (A), (B) and (C) Palash requires scale, object, screen, spherometer. But in option (D) he requires only a scale. So, Option (D) is the easiest method.

The object is the distant building. So, the object distance may be considered as infinity. Parallel rays coming from infinity meet at focus and produce a real inverted image. So, the distance of the wall (where the image is formed) from the lens is the focal length of the lens.

Q. 4. When a convex lens is used as magnifying glass, the image formed is
(A) Real and erect
(B) Virtual and erect
(C) Real and inverted
(D) Virtual and inverted

Ans. Option (B) is correct.

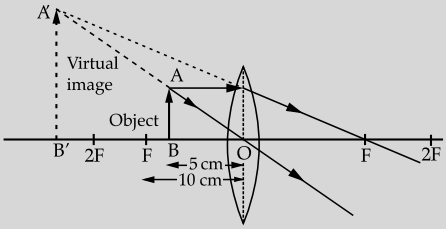
Explanation: The image is virtual, erect and magnified.



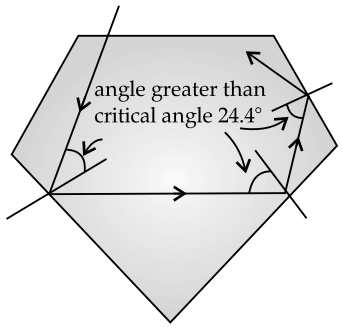
Q. 5. What should be the position of the object to use convex lens as a magnifying glass?
(A) Between F and 2F
(B) Beyond 2F
(C) Between O and F
(D) Between O and 2F

Ans. Option (C) is correct.

Explanation:



II. The refractive index of diamond is 2.3 and that of air is 1. Critical angle for this pair of media is 25°. Diamond is so cut and polished that most of the light approaching the surface is incident at an angle more that the critical angle. Hence they suffer multiple total internal reflection and ultimately come out form the top. This gives the diamond a sparkling brilliance.



If the diamond is immersed in water, the critical angle of water-diamond pair of media increases and the sparkling brilliance of diamond decreases.

Q. 1. The critical angle for the air-diamond pair of media is
(A) 25°
(B) 2.5°
(C) 50°
(D) None of the above

Ans. Option (A) is correct.

Q. 2. The reason of sparkling brilliance of diamond is
(A) Repeated refraction
(B) Repeated reflection
(C) Repeated total internal reflection
(D) Repeated dispersion

Ans. Option (C) is correct.

Q. 3. Refractive index of diamond is
(A) More than that of air
(B) Less than that of air
(C) Equal to that of air
(D) Too low

Ans. Option (A) is correct.

Explanation: Refractive index of air = 1
Refractive index of diamond = 2.3

Q. 4. Critical angle of a material
(A) varies with wavelength of light
(B) varies if surrounding medium changes
(C) A constant quantity irrespective of wavelength of light and surrounding medium
(D) Both (A) and (B)

Ans. Option (D) is correct.

Explanation: Refractive index is wavelength dependent. Critical angle is refractive index dependent. So, critical angle varies with the wavelength of light incident.
Critical angle is fixed for a pair of media. If surrounding medium changes, critical angle also changes.

Q. 5. When diamond is immersed in water
(A) Its sparkling brilliance remains same
(B) Its sparkling brilliance reduces
(C) Its sparkling brilliance increases
(D) None of the above

Ans. Option (B) is correct.

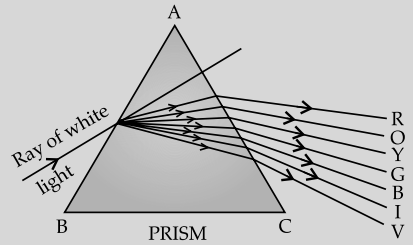
Explanation: ${}_{air}\mu_{diamond} = 2.3$
${}_{air}\mu_{water} = 1.3$
${}_{water}\mu_{diamond} = 2.3 / 1.3$
So, as the refractive index decreases, critical angle increases. So, sparkling brilliance decreases.

III. If white light is incident on a prism, that dispersion will always occur.
If light is incident from air on a prism perpendicularly, then at the 1st surface no refraction occurs. On the 2nd surface if the angle of incidence is greater than the critical angle light suffers total internal reflection instead of refraction. This reflected ray if again incident on the 3rd surface perpendicularly, it emerges to air without any refraction. During this process there is no dispersion. The incident ray and emergent ray suffer 90° or 180° deviation.
There may be another incident when light suffers refraction at 1st and 3rd surfaces of a prism and total internal reflection occurs at the 2nd surface. Here also no dispersion takes place.
So, for dispersion, refraction has to take place at the 1st and light should emerge out from the 2nd surface after another refraction.

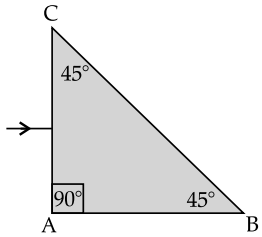
Q. 1. For dispersion through a prism
(A) Light has to be incident with $\angle i = 0$
(B) No total internal reflection should occur inside the prism
(C) Light should be refracted at both the surfaces
(D) Both (B) and (C)

Ans. Option (D) is correct.

Explanation:



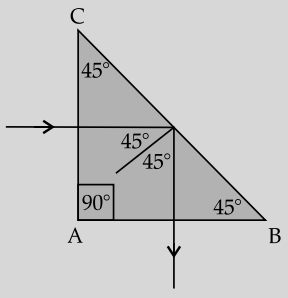
Q. 2. If light is incident on a prism as shown, then what will happen to the ray?



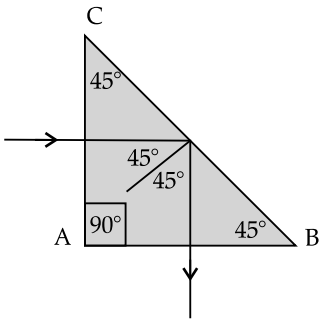
(A) Dispersion will occur
(B) Total internal reflection will occur at BC surface
(C) Total internal reflection occur at AB surface
(D) The ray will suffer a total internal reflection at BC surface and finally will emerge out perpendicularly from AB surface without any dispersion

Ans. Option (D) is correct.

Explanation:



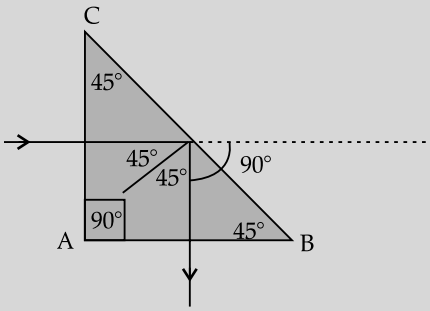
Q. 3. What is the deviation of incident ray in the following diagram?



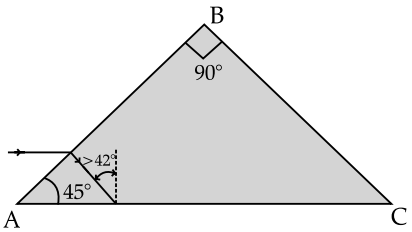
(A) 45°
(B) 90°
(C) 180°
(D) None of the above

Ans. Option (B) is correct.

Explanation:



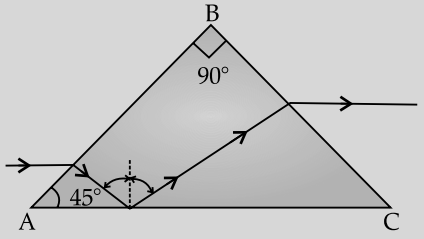
Q. 4. If light is incident on a prism as shown, then what will happen to the ray?



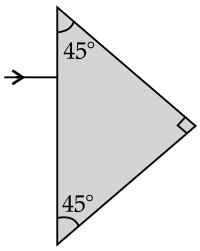
(A) Dispersion will occur
(B) Total internal reflection will occur at BC surface
(C) Total internal reflection occur at AC surface
(D) The ray will suffer a total internal reflection at AC surface and finally will emerge out from BC surface without any dispersion

Ans. option (D) is correct.

Explanation:



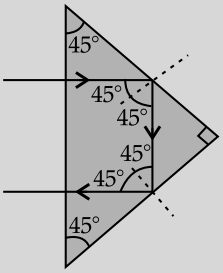
Q. 5. How many total internal reflection will be suffered by the ray in the following diagram?



(A) 1
(B) 2
(C) 3
(D) 0

Ans. Option (B) is correct.

Explanation:



IV. Electromagnetic spectrum has two broad classification:
(i) Visible spectrum
(ii) Invisible spectrum

The part of spectrum beyond the red and violet end is known as invisible spectrum. Visible portion is a very small portion of electromagnetic radiation.

The portion of spectrum situated just beyond the red end is called infra red spectrum. The portion of spectrum just before the violet end is called ultra violet spectrum. So, wavelength of infrared wave is longer than red. Wavelength of ultraviolet is shorter than the wavelength of violet.

Speed of all the waves is 3×10^8 ms^{-1}. Speed, frequency and wavelength are related as $c = \nu\lambda$.

Electromagnetic waves having wavelength range 100 Å to 4000 Å are ultraviolet waves. Sun is a great source of ultraviolet rays. But fortunately ozone layer absorbs most of the ultraviolet waves coming from sun.

Electromagnetic waves having wavelength range 4000 Å to 8000 Å are visible lights.

Electromagnetic waves having wavelength range 8000 Å to 10^7 Å are infrared waves. These waves produce a strong heating effect. For this reason infrared waves are also known as heat waves.

Q. 1. Which of the following statements is true?
(A) Infrared is a part of visible spectrum.
(B) Ultraviolet is a part of invisible spectrum.
(C) Infrared is a part of invisible spectrum.
(D) Both (B) and (C)

Ans. option (D) is correct.

Q. 2. Which of the following statements is true?
(A) Speed of UV rays is 3×10^8 ms^{-1}.
(B) Speed of IR rays is 3×10^8 ms^{-1}.
(C) Speed of visible rays is 3×10^8 ms^{-1}.
(D) All of the above

Ans. Option (D) is correct.

Explanation: Visible light, UV rays, IR rays all are electromagnetic waves. Speed of all the electromagnetic waves is 3×10^8 ms^{-1}.

Q. 3. Wavelength of IR waves is
(A) Larger than UV rays
(B) Larger than visible light
(C) Smaller than UV rays.
(D) Both (A) and (B)

Ans. Option (D) is correct.

Explanation: Electromagnetic waves having wavelength range 100 Å to 4000 Å are ultraviolet waves. Electromagnetic waves having wavelength range 4000 Å to 8000 Å are visible lights.

Electromagnetic waves having wavelength range 8000 Å to 10^7 Å are infrared waves.

So, wavelength of IR wave is larger than UV wave and visible light.

Q. 4. Which one is known as heat wave?
(A) IR wave
(B) UV wave
(C) Visible light
(D) Both (A) and (B)

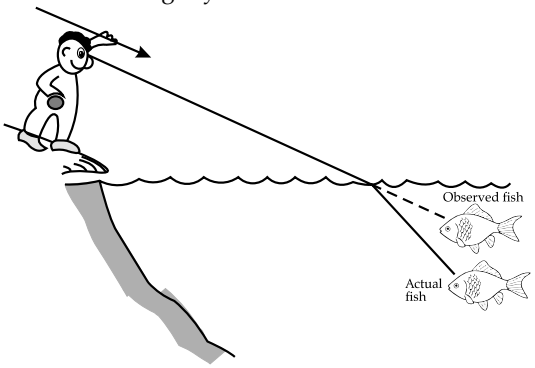
Ans. Option (A) is correct.

Explanation: Since IR waves produce a strong heating effect, so they are known as heat waves.

Q. 5. Ultraviolet rays coming from Sun is absorbed by
(A) Troposphere
(B) Ozone layer
(C) Ionosphere
(D) Mesosphere

Ans. Option (B) is correct.

V. Spear fishermen use a strange trick to catch fish. They aim at a fish slightly *below* where the fish seems to be.



The reason is that light changes direction when it moves from water to air. Air being lighter medium than water, the ray bends away from the normal and produce an image of the little above the actual position of the fish.

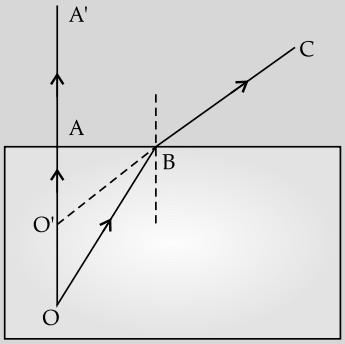
Theoretically, the actual position of the fish can be calculated using the formula,

Actual depth = Refractive index × apparent depth

Q. 1. Why a spear fisherman has to aim a fish slightly below the position where he notices it?
(A) Since the fish is moving
(B) Since his noticed position is the apparent position of the fish.
(C) Since his spear will move little more downward due to inertia
(D) None of the above

Ans. Option (B) is correct.

Explanation: Let O be the actual position of the fish in the following diagram. OB and OA are two rays from the fish refracts from water to air. Air being rarer medium, the refracted ray AB bends away from normal. OA being incident perpendicularly, it moves undeviated.



Now extending AB backward meets OA at O′ where the image of the fish is formed. O′ point is little above O. So, the fish appears little above its actual position.

Q. 2. When light moves from water to air the refracted ray
(A) Moves towards the normal
(B) Moves away from normal
(C) Moves undeviated
(D) Moves along the interface of air and water

Ans. option (B) is correct.

Explanation: Speed of light in air is more than that in water. So, while refracting from water (denser medium) to air (rarer medium) light bends away from normal.

Q. 3. A diver
(A) Locates the fish in its actual position
(B) Locates the fish little below its actual position
(C) Locates the fish little above its actual position
(D) Cannot locate the fish.

Ans. Option (A) is correct.

Explanation: Since diver and fish both are in same medium (water), there will be no refraction of light.

Q. 4. If the fish tries to see the fisherman

(A) The apparent position of the fisherman will be little above his actual position.

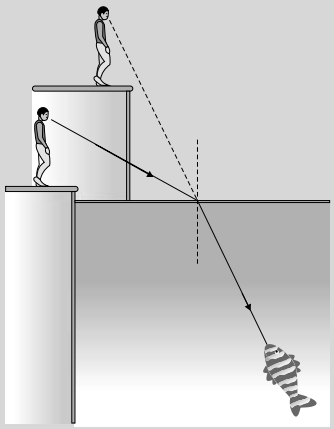
(B) The apparent position of the fisherman will be little below his actual position.

(C) The fisherman will be located at his actual position

(D) Cannot see the fisherman.

Ans. Option (A) is correct.

Explanation: Rays coming from fisherman, in air, bends towards the normal when reaches the fish, in water. Now extending the refracted ray, the image is formed little above the actual position of the fisherman.



Q. 5. What is the actual position of the fish when the fisherman locates it at a depth 5 ft below the surface of water? (refractive index of water = 1.4)

(A) 0.5 m below water surface

(B) 0.6 m below water surface

(C) 0.7 m below water surface

(D) 0.8 m below water surface

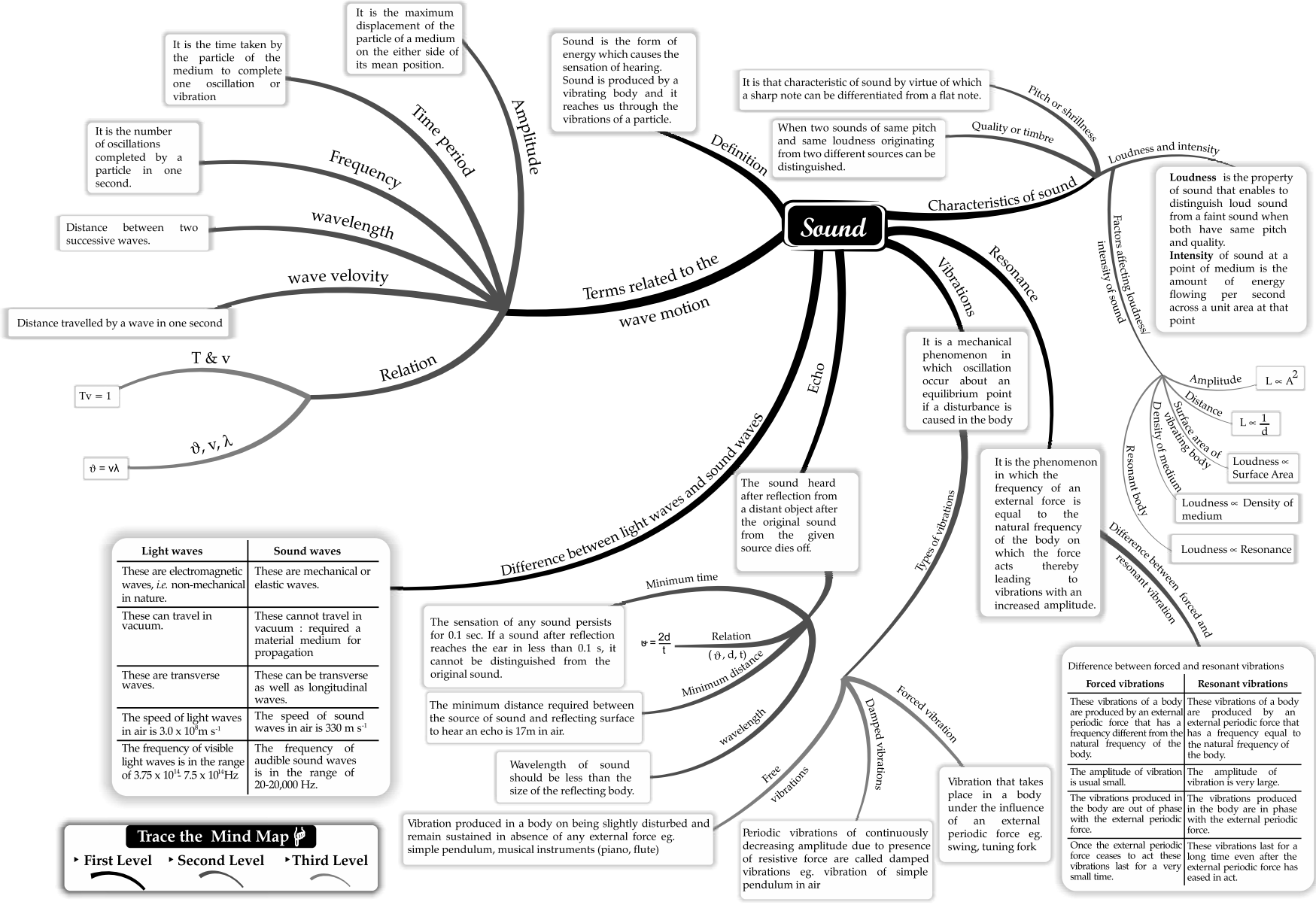
Ans. Option (C) is correct.

Explanation:

Actual depth = refractive index × apparent depth

= 1.4 × 0.5

= 0.7 m


Sound
Definition
Sound is the form of energy which causes the sensation of hearing. Sound is produced by a vibrating body and it reaches us through the vibrations of a particle.
Terms related to the wave motion
Amplitude
It is the maximum displacement of the particle of a medium on the either side of its mean position.
Time period
It is the time taken by the particle of the medium to complete one oscillation or vibration
Frequency
It is the number of oscillations completed by a particle in one second.
wavelength
Distance between two successive waves.
wave velocity
Distance travelled by a wave in one second
Relation
T & v
Tv = 1
ϑ, v, λ
ϑ = vλ
Characteristics of sound
Pitch or shrillness
It is that characteristic of sound by virtue of which a sharp note can be differentiated from a flat note.
Quality or timbre
When two sounds of same pitch and same loudness originating from two different sources can be distinguished.
Loudness and intensity
Loudness is the property of sound that enables to distinguish loud sound from a faint sound when both have same pitch and quality.
Intensity of sound at a point of medium is the amount of energy flowing per second across a unit area at that point
Factors affecting loudness/ intensity of sound
Amplitude
L ∝ A2
Distance
L ∝ 1/d
Surface area of vibrating body
Loudness ∝ Surface Area
Density of medium
Loudness ∝ Density of medium
Resonant body
Loudness ∝ Resonance
Vibrations
It is a mechanical phenomenon in which oscillation occur about an equilibrium point if a disturbance is caused in the body
Resonance
It is the phenomenon in which the frequency of an external force is equal to the natural frequency of the body on which the force acts thereby leading to vibrations with an increased amplitude.
Difference between forced and resonant vibration
Difference between forced and resonant vibrations
Forced vibrations | Resonant vibrations
These vibrations of a body are produced by an external periodic force that has a frequency different from the natural frequency of the body. | These vibrations of a body are produced by an external periodic force that has a frequency equal to the natural frequency of the body.
The amplitude of vibration is usual small. | The amplitude of vibration is very large.
The vibrations produced in the body are out of phase with the external periodic force. | The vibrations produced in the body are in phase with the external periodic force.
Once the external periodic force ceases to act these vibrations last for a very small time. | These vibrations last for a long time even after the external periodic force has eased in act.
Types of vibrations
Forced vibration
Vibration that takes place in a body under the influence of an external periodic force eg. swing, tuning fork
Damped vibrations
Periodic vibrations of continuously decreasing amplitude due to presence of resistive force are called damped vibrations eg. vibration of simple pendulum in air
Free vibrations
Vibration produced in a body on being slightly disturbed and remain sustained in absence of any external force eg. simple pendulum, musical instruments (piano, flute)
Echo
The sound heard after reflection from a distant object after the original sound from the given source dies off.
Minimum time
The sensation of any sound persists for 0.1 sec. If a sound after reflection reaches the ear in less than 0.1 s, it cannot be distinguished from the original sound.
Relation
t = 2d/v
(ϑ, d, t)
Minimum distance
The minimum distance required between the source of sound and reflecting surface to hear an echo is 17m in air.
wavelength
Wavelength of sound should be less than the size of the reflecting body.
Difference between light waves and sound waves
Light waves | Sound waves
These are electromagnetic waves, i.e. non-mechanical in nature. | These are mechanical or elastic waves.
These can travel in vacuum. | These cannot travel in vacuum : required a material medium for propagation
These are transverse waves. | These can be transverse as well as longitudinal waves.
The speed of light waves in air is 3.0 x 10^8 m s^-1 | The speed of sound waves in air is 330 m s^-1
The frequency of visible light waves is in the range of 3.75 x 10^14 - 7.5 x 10^14 Hz | The frequency of audible sound waves is in the range of 20-20,000 Hz.
Trace the Mind Map
First Level
Second Level
Third Level

CHAPTER

5 SOUND

Syllabus

- Reflection of Sound Waves; echoes; their use; simple numerical problems on echoes. Production of echoes, condition for formation of echoes; simple numerical problems; use of echoes by bats, dolphins, fishermen, medical field. SONAR

REVISION NOTES

Reflection of sound – Echo, resonance

- **Range of hearing :**

  The average frequency range over which the human ear is sensitive is called **audible range**. The audible range of sound for human beings is from 20 Hz to 20000 Hz. As people grow older, their ears become less sensitive to higher frequencies.
- **Infrasonic sound :**

  The sound of frequencies lower than 20 Hz are known as infrasonic sounds or infrasound, which cannot be heard by human beings. It is generated during earthquake.
- **Ultrasonic sound :**

  The sounds of frequencies higher than 20000 Hz are called as ultrasonic sounds or ultrasound which cannot be heard by human beings. Dogs can hear ultrasonic sounds of frequency upto 50000 Hz. This is why dogs are used for detective work by the police. Monkeys, bats, cats, dolphins, leopard and tortoise can also hear ultrasonic sounds. Dolphins, tortoise and rats can also produce ultrasonic sounds as well as hear ultrasonic sound.

Scan to know more about this topic

Attributes of sound

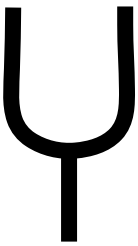
- **Reflection of sound waves :**

  The returning back of the sound wave on striking a surface such as wall, metal sheet, etc., is known as reflection of sound wave. It does not require a smooth and shining surface like mirror. The reflection of sound takes place in accordance with the same laws as those governing the reflection of light. The condition for reflection of sound wave is that the size of the reflecting surface must be bigger than the wavelength of the sound wave.
- **Echo :**

  It is a reflection of sound, arriving at the listener sometime after the original sound. Basically, a reflected sound from an (distant) object is heard after the original sound has ''died down.'' e.g., The echoes are produced by the bottom of a well, by a building or by the walls of an enclosed room and an empty room.
- Bats and dolphins make use of the phenomenon of echoes in nature.

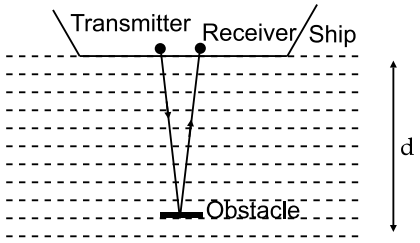
Scan to know more about this topic

Introduction to sound



- Trawlerman makes use of echoes for finding the depth of ocean beds or for detecting submerged objects.
- RADAR and SONAR also make use of echoes for finding the position and distance of an enemy airplane, under water dangers or for sound ranging.
- A tuning fork is made by shaping a metal piece in the form shown alongside. It enables us to produce a pure sound note.
- **Conditions for formation of echo/hearing the echo distinctly :**
  - **(i)** The size of the obstacle/reflector must be large compared to the wavelength of the incident sound (for reflection of sound to take place).
  - **(ii)** The distance between the source of sound and the reflector should be atleast 17 m (so that the echo is heard distinctly after the original sound is over).
  - **(iii)** The intensity or loudness of the sound should be sufficient for the reflected sound reaching the ear to be audible. The original sound should be of short duration.
- Echoes also find use in medical field for imaging of human organs (womb, liver, uterus).
- Echoes find application in SONAR (Sound navigation and ranging). In order to find the distance of obstacle from ship, waves are transmitted and then reflected waves are received by the receiver.

  Let the distance of the obstacle from source of sound be "d" then,



$2d = v \times t$

Where,

v is the velocity of ultrasonic waves in water and t is the time between sending and receiving of waves.

MULTIPLE CHOICE QUESTIONS

STAND ALONE MCQs

Q. 1. The matter or substance through which sound is transmitted is called

(A) Source
(B) Medium
(C) Carrier
(D) Transmitter

[ICSE Board 2019]

Ans. Option (B) is correct.

> ***Explanation:*** The matter or substance through which sound is transmitted is called a medium. It can be solid, liquid or gas. Sound moves through a medium from the point of generation to the listener.

AI **Q. 2.** Sound is

(A) A mechanical wave
(B) An electromagnetic wave
(C) Not a wave
(D) A particle.

Ans. Option (A) is correct.

> ***Explanation:*** A wave is a disturbance that moves through a medium when the particles of the medium set neighbouring particles into motion. They in turn produce similar motion in others. The particles of the medium do not move forward themselves, but the disturbance is carried forward. Since sound waves are characterised by the motion of particles in the medium and are called mechanical waves.

AI **Q. 3.** The compressions of air layers made by sound wave are _____ pressure regions and the rarefaction of air layers are _____ pressure regions.

(A) Low, high
(B) High, low
(C) High, high
(D) Low, low

Ans. Option (B) is correct.

Explanation: Sound propagates by a series of compressions and rarefactions is created in the air. Compression is the region of high pressure and rarefaction is the region of low pressure.

Q. 4. Propagation of sound can be visualised as propagation of ____ variations or _____ variations in the medium

(A) Mass, Volume
(B) Density, pressure
(C) Length, tension
(D) None of the above

Ans. Option (B) is correct.

Explanation: Sound propagates by compression and rarefaction of the layers of the medium. Compression is the region of high pressure and rarefaction is the region of low pressure. Pressure is related to the number of particles of a medium in a given volume. More density of the particles in the medium gives more pressure and vice versa. Thus, propagation of sound can be visualised as propagation of density variations or pressure variations in the medium

AI **Q. 5.** How the speed of sound changes when we go from solid to gaseous medium?

(A) Remains same **(B)** Increases
(C) Decreases **(D)** Fluctuates

Ans. Option (C) is correct

AI **Q. 6.** Are the laws of reflection of light is followed by sound?

(A) Yes
(B) No
(C) Sometimes
(D) Reflection of sound has different laws.

Ans. Option (A) is correct.

Explanation: Like light, sound gets reflected at the surface of a solid or liquid and follows the same laws of reflection. The directions in which the sound is incident and reflected, make equal angles with the normal to the reflecting surface at the point of incidence, and the three are in the same plane.

Q. 7. For reflection of sound

(A) The reflector must be well polished
(B) The reflector may be rough or polished
(C) Reflector should be larger in size than the light reflector
(D) Both (B) and (C)

Ans: Option (D) is correct.

Explanation: An obstacle of large size (since the wavelength of sound is larger than the wavelength of light) which may be polished or rough is needed for the reflection of sound waves.

AI **Q. 8.** The sensation of sound persists in our brain for about

(A) 0.1 second **(B)** 0.1 minutes
(C) 0.1 hour **(D)** 0.1 day

Ans. Option (A) is correct.

AI **Q. 9.** To hear a distinct echo the time interval between the original sound and the reflected one must be at least

(A) 0.1 minute **(B)** 0.05 minute
(C) 0.1 second **(D)** 0.05 second

Ans. Option (C) is correct.

Q. 10. If we take the speed of sound to be 300 m/s at a given temperature, in air, then for hearing distinct echoes, the minimum distance of the obstacle from the source of sound must be

(A) 17.2 m **(B)** 15 m
(C) 34.4 m **(D)** 30 m

Ans. Option (B) is correct.

Explanation: Speed of sound to be 300 m/s. The sound must go to the obstacle and reach back the ear of the listener on reflection after 0.1 s. Hence, the total distance covered by the sound from the point of generation to the reflecting surface and back should be at least (300 m/s) × 0.1 s = 30 m. Thus, for hearing distinct echoes, the minimum distance of the obstacle from the source of sound must be half of this distance, that is, 15 m.

AI **Q. 11.** The rolling of thunder is due to the

(A) successive reflections of the sound
(B) transmission of sound through cloud
(C) change in speed of sound in atmosphere
(D) None of the above

Ans. Option (A) is correct.

Explanation: The rolling of thunder is due to the successive reflections of the sound from a number of reflecting surfaces, such as the clouds and the land.

AI **Q. 12.** The audible range of sound for human beings is

(A) Above 20000 Hz **(B)** 20 Hz - 20000 Hz
(C) Below 20 Hz **(D)** 0 - 2000000 Hz

Ans. Option (B) is correct.

Explanation: The audible range of sound for human beings extends from about 20 Hz to 20000 Hz.

AI **Q. 13.** The acronym SONAR stands for

(A) Sound Navigation And Ranging.
(B) Solar Navigation And Ranging
(C) Sound Navigation And Reflection
(D) None of the above

Ans. Option (A) is correct.

Explanation: The acronym SONAR stands for Sound Navigation And Ranging. Sonar is a device that uses ultrasonic waves to measure the distance, direction and speed of underwater objects.

Q. 14. In stethoscopes the sound of the patient's heartbeat reaches the doctor's ears

(A) By rectilinear propagation of sound
(B) By multiple reflection of sound
(C) By echoing of sound
(D) By a single reflection of sound

Ans. Option (B) is correct.

Explanation: In stethoscopes, the sound of the patient's heartbeat reaches the doctor's ears by multiple reflection of sound.

Q. 15. Bats and porpoises use the phenomenon of _____ of _____ waves to locate their food / prey.

(A) Reflection, sound
(B) Echo, ultrasonic
(C) Echo, infrasonic
(D) Propagation, ultrasonic

Ans. Option (B) is correct.

Q.16. Under the sea, velocity of sound is 1500 ms^{-1}. To hear a distinct echo, the minimum distance of the obstacle should be

(A) 75 m
(B) 17 m
(C) 150 m
(D) Less than 17 m
(E) More than 150 m

Ans. Option (A) is correct.

Explanation: The sensation of sound persistence in our brain is 0.1 s. So, to hear a distinct echo, the time interval between the original sound and the reflected sound should be at least 0.1 s.

So, if v = velocity of sound and d = distance of the obstacle or reflector,

Then $v \times 0.1 = 2d$

$\therefore d = v \times 0.1/2$

$\therefore$ The minimum distance under the sea to hear a distinct echo $= \dfrac{1500 \times 0.1}{2} = 75$ m

Q. 17. Ultrasonic waves are used for SONAR since

(A) It travels in a straight line
(B) It has higher energy
(C) It travels faster
(D) It has lower frequency
(E) It is not absorbed by sea water

Ans. Option (B) is correct.

Explanation: Ultrasonic waves have higher frequency than audible sound and they are having higher energy. So, they can penetrate more through sea water.

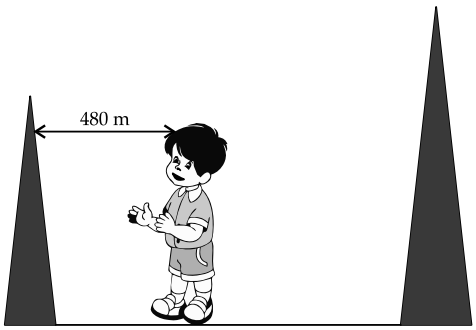
Q. 18. Why reflection of sound requires large reflector compared to that of light?

(A) Wavelength of sound wave is larger than that of light wave
(B) Sound wave is mechanical wave but light wave is electromagnetic wave.
(C) Reflector size is inversely proportional to the speed of the wave
(D) Sound reflected by larger reflector becomes clearly audible
(E) Mechanical wave reflector should be large

Ans. Option (A) is correct.

Explanation: For proper reflection, the size of the reflector should be larger than the wavelength of the incident wave. Frequency range of audible sound is 20 Hz to 20 kHz. Assuming the velocity of sound 330 ms^{-1}, the wavelength range is 16.5 m to 16.5×10^{-3} m. So, if the size of the reflector is greater than 16.5 m, it can successfully reflect the whole audible range of sound.

Q. 19. A boy standing between two vertical hillocks, as shown in the diagram, clapped.



He heard the 1st echo after 3 second and 2nd echo 5 seconds later the 1st one. Steps to find the distance between the two hillocks are given below.

Choose the correct sequence of steps to be followed.

(i) Velocity of sound = 2 × distance of left hillock / time
(ii) Distance between the hillocks = Distance of the left hillock from the boy + distance of the right hillock from the boy
(iii) Actual time required to hear the 2nd echo = (3+5) seconds
(iv) Distance of right hillock from the boy = Velocity of sound × time after which the echo is heard /2

(A) (i), (ii), (iii), (iv)
(B) (i), (iii), (iv), (ii)
(C) (i), (iv), (iii), (ii)
(D) (ii), (i), (iii), (iv)
(E) (iv), (iii), (i), (ii)
(F) (iv), (ii), (i), (iii)

Ans. Option (B) is correct.

Explanation: Velocity of sound = 2 × distance of left hillock / time

= 2 × 480/3

= 320 ms^{-1}

Actual time required to hear the 2nd echo

= 3+5 = 8 second

Distance of the right hillock from the boy

= Velocity of sound × time after which the echo is heard /2

= 320 × 8/2

= 1280 m

Distance between the hillocks = Distance of the left hillock from the boy + distance of the right

hillock from the boy

= 480+1280

=1780 m

Q. 20. If the persistence of hearing of human hearing reduces to 0.05 s then which of the followings incidents may happen?

(A) Minimum distance of hearing distinct echo increases.

(B) Minimum distance of hearing distinct echo decreases.

(C) Infrasonic sound becomes audible.

(D) Ultrasonic sound becomes audible.

(E) Audibility reduces.

(F) The original sound and the reflected sound become clearly distinguishable even if the time interval t is $0.05 < t < 0.1$

Ans. Options (B) and (F) are correct.

Explanation: Persistence of hearing i.e. the sensation of sound persistence reduces to 0.05 s. So, to hear a distinct echo, the time interval between the original sound and the reflected sound should be at least 0.05 s now.

So, if v = velocity of sound and d = distance of the obstacle or reflector,

Then $v \times 0.05 = 2d$

$\therefore\ d = v \times 0.05/2$

So, the minimum distance to hear clear and distinct echo now becomes half than the earlier one i.e. now it becomes 8.5 m (approx.).

The original sound and the reflected sound will be clearly distinguishable, if the time interval becomes more than 0.05 s. So, if the time interval lies between 0.05 s and 0.1 s, then those two sounds will be clearly distinguishable.

ASSERTION AND REASON MCQs

Directions: In the following questions, A statement of Assertion (A) is followed by a statement of Reason (R). Mark the correct choice as:

(A) Both A and R are true and R is the correct explanation of A.

(B) Both A and R are true but R is NOT the correct explanation of A.

(C) A is true but R is false.

(D) A is false and R is true.

Q. 1. Assertion(A): In sound wave propagation, The particles of the medium do not move forward themselves, but the disturbance is carried forward

Reason (R): Sound wave is a mechanical wave.

Ans. Option (A) is correct.

Explanation: Mechanical wave is a disturbance that moves through a medium when the particles of the medium set neighbouring particles into motion. They in turn produce similar motion in others. The particles of the medium do not move forward themselves, but the disturbance is carried forward.

This exactly happens during propagation of sound in a medium. Hence, sound waves are characterised by the motion of particles in the medium and are called mechanical waves.

Hence assertion and reason both are true and reason explains the assertion.

Q. 2. Assertion (A): Sound is a mechanical wave.

Reason (R): Sound can propagate through vacuum.

Ans. Option (C) is correct.

Explanation: Characteristics of propagation of mechanical wave is to move a disturbance through a medium when the particles of the medium set neighbouring particles into motion. This exactly happens during propagation of sound in a medium. Hence, sound waves are called mechanical waves. Hence, assertion is true.

Mechanical waves and hence sound waves require material medium to propagate. Hence sound waves cannot propagate through vacuum. So, the reason is false.

Q. 3. Assertion (A): Ultrasonic sound is a human audible sound

Reason (R): Audible range of human is 20 Hz to 20000 Hz.

Ans. Option (D) is correct.

Explanation: Audible range of human is 20 Hz to 20000 Hz. Hence reason is true.

The frequency of ultrasonic sound is above 20000 Hz. Hence, it is not human audible. So, the assertion is false.

Q. 4. Assertion (A): For hearing distinct echoes, the minimum distance of the obstacle from the source of sound must be half of this distance, that is, 17.2 m.

Reason (R): This distance will change with the velocity of sound.

Ans. Option (B) is correct.

> ***Explanation:*** The sensation of sound persists in our brain for about 0.1 s. To hear a distinct echo, the time interval between the original sound and the reflected one must be at least 0.1 s. If we take the speed of sound to be 344 m/s, then only the minimum distance required to hear a echo is ½ × (344 m/s) × 0.1 s = 17.2 m. If the velocity of sound changes, this minimum distance also changes.

Q. 5. Assertion (A): The roof and walls of the auditorium are generally covered with sound-absorbent materials.

Reason (R): This increases the number of reflection of sound and audibility in an auditorium.

Ans. Option (C) is correct.

> ***Explanation:*** A sound created in a big hall will persist by repeated reflection from the walls until it is reduced to a value where it is no longer audible. The repeated reflection that results in this persistence of sound is called reverberation. In an auditorium or big hall, excessive reverberation is highly undesirable. To reduce reverberation, the roof, walls of the auditorium and seats are generally covered with sound-absorbent materials.

Q. 6. Assertion (A): All echoes are reflection of sound wave but all reflections are not echoes.

Reason (R): For echoes, sound should take minimum 0.1 s to travel from source to reflector and back.

Ans. Option (A) is correct.

> ***Explanation:*** Time taken by sound wave to travel from source to reflector and back has no specified limit. But if a time limit is imposed i.e. the minimum time 0.1 s, then the reflection causes an echo since then only it is possible to distinguish the original sound and the reflected sound. If the time is less than 0.1 s, then the two sounds cannot be distinguished. So, then it is a reflection but not an echo.
>
> So, the assertion and reason both are true and the reason explains the assertion.

Q. 7. The angle of incidence of a sound wave on a reflector is 75° and the angle of reflection is (90° – 75°) = 15°.

Reason (R): Sound wave follows the laws of reflection of light.

Ans. Option (D) is correct.

> ***Explanation:*** Sound wave follows the laws of reflection of light. So, if angle of incidence is 75°, then the angle of reflection will also be 75°.
>
> So, the reason is true but the assertion is false.

Q. 8. Assertion (A): A reflector of length 2 μm can reflect a light wave but cannot reflect a sound wave.

Reason (R): Speed of light and sound is 3×10^8 m/s and 330 m/s respectively.

Ans. Option (B) is correct.

> ***Explanation:*** Frequency of visible light is 4×10^{14} Hz – 8×10^{14} Hz. Velocity of light is 3×10^8 m/s. So, the wavelength of visible light is in μm range. Hence, a reflector of length 2 μm can reflect a light wave.
>
> Frequency of audible sound is 20 Hz – 20000 Hz. Velocity of sound is 330 m/s. So, the wavelength of audible sound is in cm range. Hence a reflector of length 2 μm cannot reflect sound wave.
>
> So, the assertion and reason both are true. But the reason does not properly explain the assertion.

Q. 9. Assertion (A): Megaphones, horns, trumpets, shehnais etc. are designed to send sound in a particular direction.

Reason (R): All these instruments use multiple reflection of sound.

Ans. Option (A) is correct.

> ***Explanation:*** Megaphones, horns, trumpets, shehnais etc. are designed to send sound in a particular direction without spreading it in all directions. In these instruments, a tube followed by a conical opening reflects sound successively to guide most of the sound waves from the source in the forward direction towards the audience.
>
> So, assertion and reason both are true and the reason explains the assertion.

Q. 10. Assertion (A): Ultrasound scanner is an instrument which uses ultrasonic waves for getting images of internal organs of the human body.

Reason (R): Ultrasonic waves travel through the tissues of body and get reflected from a region where there is a change of tissue density.

Ans. Option (A) is correct.

> ***Explanation:*** The main principle of ultrasonic scanner is the reflection of ultrasonic waves from the portion of the tissues where there is difference of density. So, assertion and reason both are true and the reason explains the assertion.

CASE-BASED MCQs

I. The ship "Sapta-Sindhu" was sailing towards Anadaman-Nicobar islands. John read about SONAR in his school book. So, he requested captain to show him how the depth of the sea is measured using SONAR. Captain was glad to show him the procedure. He sent an ultrasonic wave from the transmitter installed in the machine room of the ship. The velocity of the wave in sea water was 1530 m/s. After 3 second the ultrasonic wave, reflected from the sea bed, was detected by the receiver. Captain asked John to calculate the depth of the sea at this point.

Q. 1. What type of wave is used for SONAR?

(A) Infrasonic wave

(B) Ultrasonic wave

(C) Audible sound wave

(D) Light wave

Ans. Option (B) is correct.

Q. 2. What is the velocity of ultrasonic wave in sea water?

(A) 330 m/s

(B) 3×10^8 m/s

(C) 1530 m/s

(D) 5000 m/s

Ans. Option (C) is correct.

Q. 3. For what purpose SONAR is used?

(A) to measure the distance, direction and speed of underwater objects

(B) to measure the direction and speed of sea water

(C) to count the number of fishes in a shoal of fish under the sea

(D) to detect an echo in air

Ans. Option (A) is correct.

Q. 4. What is the depth of the sea calculated by John?

(A) 4590 m

(B) 2295 m

(C) 990 m

(D) 495 m

Ans. Option (B) is correct.

> ***Explanation:*** Velocity of ultrasonic sound in sea water = 1530 m/s
>
> Time taken by the reflected ultrasonic sound to come back = 3 s
>
> ∴ Twice the depth of the sea = 1530 × 3 = 4590 m
>
> ∴ Depth of the sea = ½ × 4590 = 2295 m

Q. 5. May this reflection of ultrasonic wave be considered as an echo?

(A) Yes, since the difference of time between transmission and detection of wave is more than 0.1 s

(B) No, since the wave travels in sea water.

(C) Yes, depth of sea is more than the speed of the wave.

(D) No, since the speed of ultrasonic wave is sea water more that the speed in air.

Ans. Option (A) is correct.

> ***Explanation:*** The sensation of sound persists in our brain for about 0.1 s. To hear a distinct echo, the time interval between the original sound and the reflected one must be at least 0.1 s. Here the time interval is 3 s. So, it can be considered as an echo.

II. In an educational tour, the teacher asked Angshu and Raju to measure the speed of sound. There was a small hill at a distance 100 m from their tent. Teacher asked to use the hill as a reflector. The only equipment available was a stop watch.

Anghu clapped once loudly and Raju immediately started the stop watch. Raju immediately stopped the watch on hearing a clear echo after 0.6s and calculated the velocity of sound.

Q. 1. What was the velocity of sound calculated by Angshu and Raju?

(A) 333.3 m/s

(B) 166.6 m/s

(C) 120 m/s

(D) 60 m/s

Ans. Option (A) is correct.

> ***Explanation:*** $\text{velocity} = \dfrac{2 \times \text{distance of the hill}}{\text{time interval}}$
>
> $= \dfrac{2 \times 100}{0.6} = 333.3 \text{ m/s}$

Q. 2. If the hill were at a distance 10 m, was it possible to determine the velocity of source in this method correctly?

(A) Yes, using more precise stop-watch.

(B) No, since the time interval would have become less that 0.1 s

(C) No, since the stop-watch not very precise.

(D) No. There would have been sufficient error to start and stop the watch.

Ans. Option (B) is correct.

> ***Explanation:*** The sensation of sound persists in our brain for about 0.1 s. To hear a distinct echo, the time interval between the original sound and the reflected one must be at least 0.1 s.
>
> If the distance of the hill were 10 m, then the time interval would have been much less than 0.1 s. Hence, the echo would not have been clearly audible and speed could not be properly calculated.

Q. 3. If instead of hill there were a small object, was it possible to calculate the perform the experiment properly?

(A) Yes

(B) No, since very little portion of sound wave would have been reflected.

(C) No, since for reflection of should wave the reflector should be comparable to the wavelength of the wave.

(D) No, since it was not possible to direct the sound wave accurately to the reflector.

Ans. Option (C) is correct.

> ***Explanation:*** Large reflector is required for proper reflection of sound wave.

Q. 4. Will there be any difference in the result if the experiment is performed at different times of the day?

(A) No.

(B) Yes, since the velocity changes with temperature.

(C) Yes, since echo is more clearly audible at night.

(D) Yes, due to poor visibility of stop-watch graduation.

Ans. Option (C) is correct.

> ***Explanation:*** Velocity of sound is not a constant quantity. It varies with temperature and other parameters.

Q. 5. To find the velocity of sound, the formula used by the students was

(A) $v = d/t$ (where d = distance of the hill, t = time interval)

(B) $v = 2d/t$ (where d = distance of the hill, t = time interval)

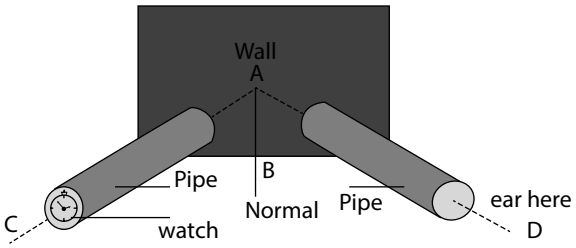
(C) $v = t \times d$ (where d = distance of the hill, t = time interval)

(D) $v = t/2 \times d$ (where d = distance of the hill, t = time interval)

Ans. Option (B) is correct.

> ***Explanation:*** Total distance covered by the sound = $2d$
>
> Time taken = t
>
> $\therefore$ Velocity = $2d/t$

III. Two identical long pipes, as shown in figure are taken. Those are arranged on a table near a wall. A clock is kept near the open end of one of the pipes and it was tried to hear the sound of the clock through the other pipe. The position of the pipes are adjusted so that the sound of the clock can be best heard.



Q.1. Name the phenomenon displayed in the experiment.

(A) Reflection of sound

(B) Rectilinear propagation of sound

(C) Total internal reflection of sound

(D) Refraction of sound

Ans. Option (A) is correct.

Q. 2. If AB is normal to the wall, then $\angle$CAB is angle of _____ and $\angle$DAB is angle of _____.

(A) Reflection, incidence

(B) Incidence, reflection

(C) Incidence, refraction

(D) Incidence, deviation.

Ans. Option (B) is correct.

Q. 3. Which of the following statements is correct?

(A) $\angle CAB \neq \angle DAB$ **(B)** $\angle CAB > \angle DAB$

(C) $\angle CAB < \angle DAB$ **(D)** $\angle CAB = \angle DAB$

Ans. Option (D) is correct.

> ***Explanation:*** For reflection of sound,
> angle of incidence = angle of reflection.

Q. 4. Does reflection of sound follow the laws of reflection of light?

(A) Never

(B) Yes, Always.

(C) Yes, In some special occasions.

(D) Reflection of sound has separate set of laws.

Ans. Option (B) is correct.

Explanation: Like light, sound gets reflected at the surface of a solid or liquid and follows the same laws of reflection. The directions in which the sound is incident and is reflected, make equal angles with the normal to the reflecting surface at the point of incidence, and the three are in the same plane.

Q. 5. Which of the following does not utilise the reflection of sound wave?

(A) Hearing Aid

(B) Stethoscope

(C) Crack detection in metal block using ultrasonic wave

(D) Echo-cardiography

Ans. Option (A) is correct answer.

Explanation: The hearing aid is basically an amplifier. It receives sound through a microphone. The microphone converts the sound waves to electrical signals. These electrical signals are amplified by an amplifier. The amplified electrical signals are given to a speaker of the hearing aid. The speaker converts the amplified electrical signal to sound and sends to the ear for clear hearing.

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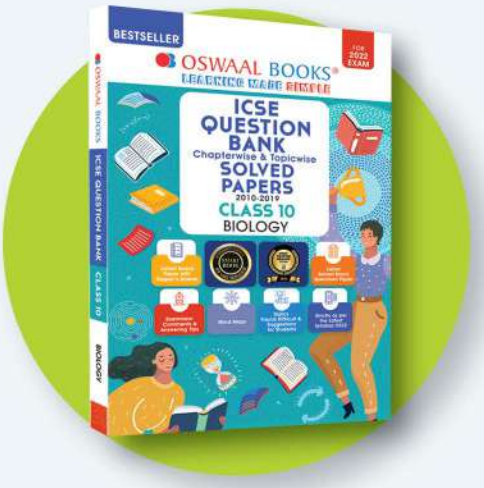

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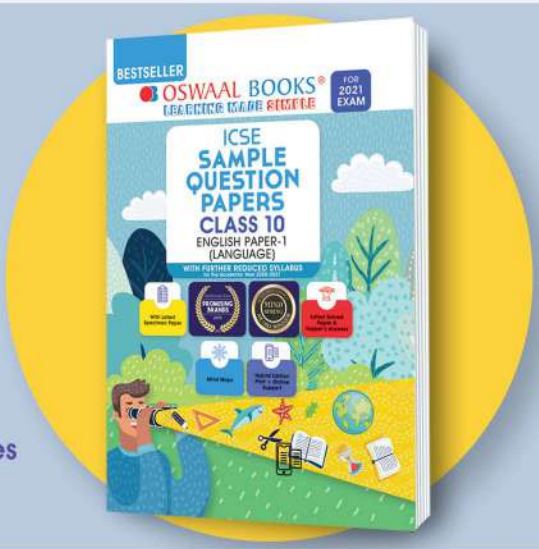

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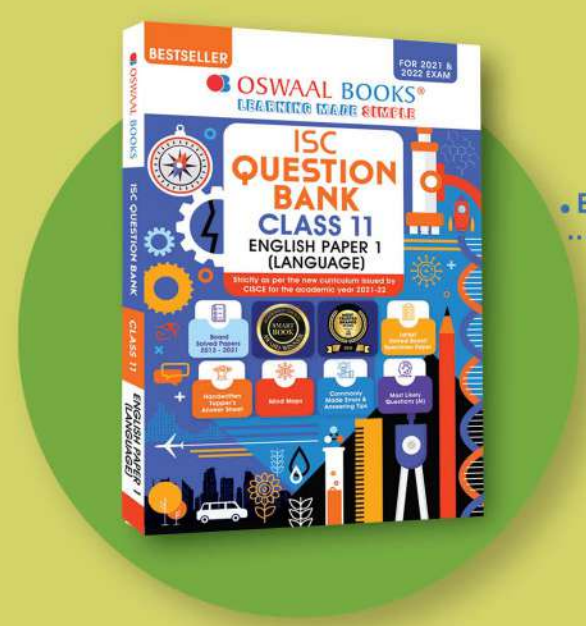

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