

Refraction of Light

Exercise – 1

Question 1.

- (a) What do you understand by the term refraction of light?
(b) How does the light deviate when it travels from ?

1. a rarer to a denser medium
2. a denser to a rarer medium?

Answer:

(a) **Refraction of light** : “When light travels from one optical medium to other optical medium, it changes its path, this change in path is called refraction of light”.

(b) (i) Towards the normal, (ii) Away from normal.

Question 2.

- (a) State the laws of refraction.
(b) What do you understand by the statement that refractive index of water is 1.33 ?

Answer:

(a) **Laws of refraction** :

(i) **Snell's law** : The ratio between the values of the sine of angle of incidence and the sine of angle of refraction for two given optical media is a constant quantity.

$$\mu = \sin i / \sin r$$

(ii) The incident ray, the refracted ray and the normal lie on the same plane at the point of incidence.

(b) Refractive index of water is 1.33 means that speed of light in air is 1.33 times faster than in water.

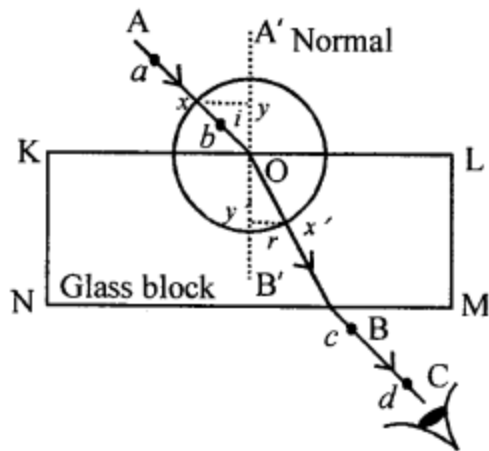
Question 3.

Describe how will you verify the laws of refraction ?

Answer:

Experiment To Verify The Laws :

Fix a white sheet of paper on a drawing board. Place a rectangular glass slab in the middle of paper and draw its boundary with a pencil. The block is removed and on the boundary line KL a point O is chosen and a normal is drawn.



Through O a line OA at an angle i (say 60°) with the normal is drawn. The block is replaced on its boundary line. Two pins a and b are fixed vertically on the board about 10 cm apart on the line AO. Looking from the other side NM of the slab two more pins c and d are fixed such that legs of pins c and d and images of pins a and b seen through glass are in a straight line.

Pins are removed and pin pricks are marked with pencil.

Slab is removed and marks c and d are joined by line BC to meet the boundary at B. OB is joined.

AO represents INCIDENT RAY

BC represents EMERGENT RAY

OB represents REFRACTED RAY

$\angle AON$ represents ANGLE OF INCIDENCE i

$\angle BOM$ represents ANGLE OF REFRACTION r

with O as centre and suitable radius draw a circle intersecting AO at X and OB at Y.

Draw normals XY and X' Y'. Measure XY and X' Y'.

$$\frac{XY}{X'Y'} \text{ is found to be } 1.5 = \mu$$

Or

Measure angle i and angle r then $\frac{\sin i}{\sin r} = 1.5 = \mu$ calculated

Repeat the experiment by taking $\angle i = 30^\circ, 40^\circ, 50^\circ$ or 70°

$$\text{Each time } \frac{\sin i}{\sin r} = 1.5 \mu$$

Or

$$\frac{XY}{X'Y'} = 1.5\mu$$

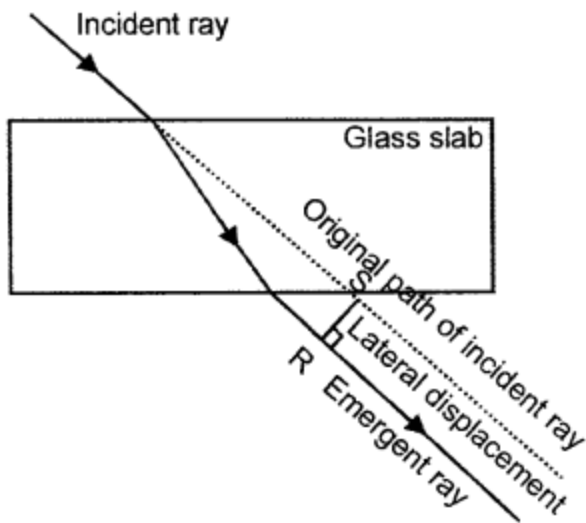
This verifies the second law of refraction. Also Incident ray AO, refracted ray OB and normal at O are on the same paper *i.e.* on the same plane this verifies the first law of refraction.

Question 4.

- (a) What do you understand by the term lateral displacement ?
- (b) State three factors which determine lateral displacement ?

Answer:

(a) **Lateral Displacement** : "The perpendicular shift in the path of the incident ray while emerging out of an optical slab is called Lateral Displacement."



(b) Factors :

1. Angle of incidence
2. Thickness of optical slab
3. Refractive index of optical material.
4. Wavelength of light.

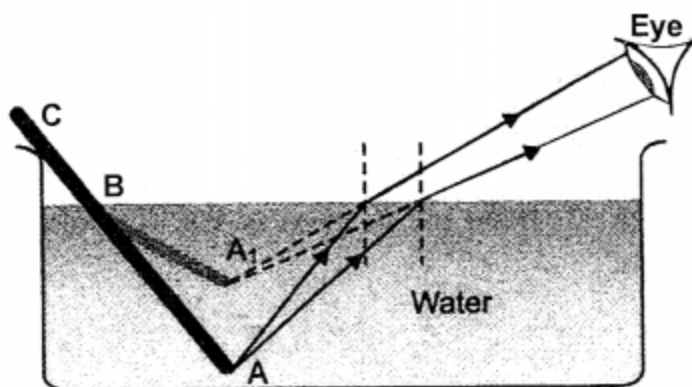
Question 5.

By drawing neat diagrams explain :

- (a) Why does a stick immersed obliquely in water, appear bent and short ?
- (b) Why does a stamp placed under a glass block, appear raised?
- (c) Why is twilight formed, before sunrise or sunset ?
- (d) Why do stars twinkle, but not the planets ?
- (e) Why do the faces of people sitting around a camp fire appear to shimmer ?
- (f) Why does a tank filled with water and seen from above appear shallow ?
- (g) Why does a fisherman aim his spear at the tail of a fish during spear fishing.
- (h) Why is more than one image formed in a thick glass mirror?
- (i) Why does the sun appear bigger during sunrise or sunset?

Answer:

- (a) The stick appears to be bent and raised up in place of BA as BA' due to refraction of light on passing from denser medium (water) to rarer medium (air)



(b) A stamp placed under a glass block appears raised because of refraction of light as light travels from denser to rarer medium, also due to R.I of glass observed depth is less than real depth.

(c) Twilight is formed, before the sunrise or sun set due to refraction of sun light as even when the sun is below the horizon its rays manage to reach the earth due to refraction.

(d) Stars twinkle : because of refraction of light as light passes through different layers of air of different densities mix, changes the apparent position of star. When the star is with in the line of sight it is visible but when it falls out of the line of sight, it is no longer visible. The collective effect of the above changes shift the apparent position of the star and it appears to twinkle.

Planets do not twinkle : Planets are very close to us compared to the stars. Their apparent of position also changes with change of density of different layers of the atmosphere. However the size of their apparent image is still fairly large and seldom fall out side the line of sight. Hence they do not appear to twinkle.

(e) The rays of light reflected from the face of the person, sitting opposite to you, on passing through hot air (produced by burning wood), get refracted. Since the hot air is rapidly moving and its density is continuously changing, therefore the path of the refracted rays also changes. This gives rise to the shimmering effect and person appears to shimmer.

(f) Due to refraction of light when light travels from optically denser medium (water) to optically rarer medium (air) observed depth is less than real depth, and the water tank appears to be shallow.

(g) Due to refraction of light when light travels from denser medium (water) to rarer medium (air). The real depth is more than apparent depth.

(h) In a thick glass mirror, light partially gets reflected (4%) and remaining 96% passes into the glass plate suffers refraction again and again and multiple images are formed.

(i) Sun appears to be bigger during sun set or sun rise as "The rays of light travel through maximum length of atmosphere" due to refraction, the image of sun is very much closer to the eye. Thus, it appears bigger.

Question 6.

What is refractive index of a material ? How is it related to (a) real and apparent depth

(b) velocity of light in vacuum or air and the velocity of light in a given medium?

Answer:

Refractive index of a material : "Is the ratio of speed of light in vacuum (air) to the speed of light in that material".

(i) Relation of R.I. :

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

$$(ii) \quad \text{R.I.} = \frac{\text{vel. of light in vacuum or air}}{\text{vel. of light in medium}}$$

Multiple Choice Questions

Tick (✓) the most appropriate option.

1. When a beam of light strikes a glass slab a part of it is :

- (a) reflected
- (b) absorbed
- (c) transmitted
- (d) all of these

Answer:

- (a) reflected

2. The phenomenon due to which a ray of light deviates from its path while travelling from one optical medium to another optical medium is called :

- (a) dispersion
- (b) refraction
- (c) reflection
- (d) diffraction

Answer:

- (b) refraction

3. When a ray of light travelling in an optically denser medium, emerges into an optically less denser medium it :

- (a) deviates towards the normal
- (b) deviates away from normal
- (c) does not deviate
- (d) gets reflected

Answer:

- (b) deviates away from normal

4. A ray of light strikes a glass slab at 90° . The angle of incidence is :

- (a) 90°
- (b) zero
- (c) less than 90° , but not zero
- (d) none of these

Answer:

- (b) zero

5. Two medium 'a' and 'b' have same refractive index. A ray of light travelling from medium 'a' to medium 'b'. will suffer?

- (a) refraction at the interfaces
- (b) partly suffer reflection at the interfaces
- (c) partly gets absorbed in medium 'b'
- (d) both (b) and (c)

Answer:

- (b) partly suffer reflection at the interfaces

6. A ray of light on entering from medium 'a' to medium 'b' does not suffer refraction. The angle of incidence in medium 'a' is :

- (a) 90°
- (b) zero
- (c) 45°
- (d) 60°

Answer:

- (b) zero

7. During sun rise or sun set, the sun appears bigger because the rays of light coming from it pass through

- (a) larger length of atmosphere
- (b) smaller length of atmosphere
- (c) the earth gets closer to sun
- (d) none of these

Answer:

- (a) larger length of atmosphere

8. The highest refractive index is of:

- (a) glass
- (b) water
- (c) diamond
- (d) cold air

Answer:

- (d) cold air

9. During spear fishing a fisherman aims at the :

- (a) tail of fish
- (b) head of fish
- (c) slightly ahead of the head of fish
- (d) none of these

Answer:

- (a) tail of fish

10. When a ray of light enters into another optical medium, its wavelength and velocity change. The material in which wavelength and velocity decrease maximum, when the ray is travelling through air is :

- (a) alcohol
- (b) diamond
- (c) glass
- (d) water

Answer:

- (b) diamond

11. A thick glass slab with a silvered side forms multiple images on account of :

- (a) reflection of light
- (b) dispersion of light
- (c) refraction of light
- (d) both reflection and refraction of light

Answer:

- (d) both reflection and refraction of light

Numerical Problems on Refraction of Light Through Optical Slabs

Practice Problem 1

Question 1.

The velocity of light in air is $3 \times 10^8 \text{ ms}^{-1}$ and in glass is $2 \times 10^8 \text{ ms}^{-1}$ Find the refractive index of glass.

Answer:

$$\text{R.I of glass } {}_a\mu_g = \frac{\text{velocity of light in air}}{\text{velocity of light in glass}}$$

$${}_a\mu_g = \frac{3 \times 10^8}{2 \times 10^8} = 1.5$$

Question 2.

The velocity of light in air is $3 \times 10^8 \text{ ms}^{-1}$. Calculate the velocity of light in diamond or refractive index 2.5.

Answer:

$$\text{Vel. of light in air} = 3 \times 10^8 \text{ ms}^{-1}$$

$$\text{Vel. of light in diamond} = ?$$

$$\text{R.I. of diamond} = 2.5$$

$${}_a\mu_d = \frac{\text{velocity of light in air}}{\text{velocity of light in diamond}}$$

$$2.5 = \frac{3 \times 10^8}{\text{vel. of light in diamond}}$$

$$\therefore \text{vel. of light in diamond} = \frac{3}{2.5} \times 10^8$$

$$v_d = \frac{30}{25} \times 10^8 = 1.2 \times 10^8 \text{ ms}^{-1}$$

Practice Problem 2**Question 1.**

The angle of refraction in a glass block of refractive index 1.5 is 19° . Calculate the angle of incidence.

Answer:

$$\text{Refractive index of glass} = \frac{\sin i}{\sin r}$$

$$1.5 = \frac{\sin i}{\sin 19^\circ}$$

$$\sin i = 1.5 \sin 19$$

Question 2.

Calculate the refractive index of a material, when angle of incidence in air is 50° and angle of refraction in the material is 36° .

Answer:

$$\text{R.I. Refractive index} = \frac{\sin i}{\sin r}$$

$$\text{R.I.} = \frac{\sin 50}{\sin 36}$$

Practice Problem 3

Question 1.

A coin is placed at a depth of 15 cm in a beaker containing water. The refractive index of water is $\frac{4}{3}$, calculate height through which the image of the coin is raised.

Answer:

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

$$\frac{4}{3} = \frac{15\text{cm}}{x\text{cm}}$$

$$\text{Apparent depth} = x = \frac{15 \times 3}{4} = 11.25 \text{ cm}$$

$$\therefore \text{Height through which image is raised} = 15 - 11.25 = 3.75 \text{ cm}$$

Question 2.

The floor of a water tank appears at a depth of 2.5 m. If the refractive index of water is 1.33, find the actual depth of water.

Answer:

$$\text{Observed depth} = 2.5 \text{ m}$$

$$\text{R.I. of water} = 1.33$$

$$\text{Actual depth} = ?$$

$$\text{R.I.} = \frac{\text{Real depth}}{\text{Apparent depth}}$$

$$1.33 = \frac{x}{2.5}$$

$$\text{Actual depth } x = 1.33 \times 2.5 = 3.325 = 3.325 \text{ m}$$

Practice Problem 4

Question 1.

A stone placed at the bottom of a water tank appears raised by 80 cm. If the refractive index of water is $\frac{4}{3}$, find the actual depth of water in the tank :

Answer:

Let the stone is at actual depth of $= x$ cm

$\therefore$ observed depth $= (x - 80)$ cm

$$\text{R.I.} = \frac{\text{Actual depth}}{\text{observed depth}}$$

$$\frac{4}{3} = \frac{x}{x - 80}$$

$$\therefore 4(x - 80) = 3x$$

$$4x - 3x = 320$$

$$\text{Actual depth} = x = 320 \text{ cm}$$

Exercise – 2

Question 1.

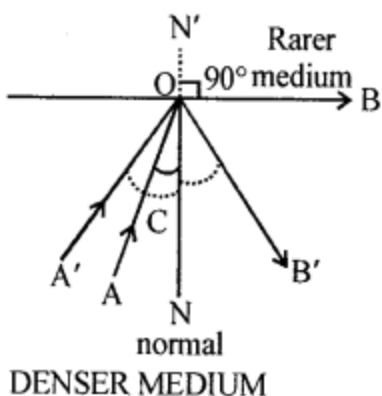
(a) What do you understand by the following terms.

1. Total internal reflection
2. Critical angle ?

(b) State two conditions for total internal reflection ?

Answer:

(a) (i) **Total internal reflection** : When ray of light travels from optically denser medium to optically rarer medium and $\angle i$ is greater than critical angle $\angle r$ becomes more than 90° and reflects in the same denser medium and obeys the laws of reflection. The phenomenon is called total internal reflection. Hence total internal reflection : “The phenomenon due to which, a ray of light while travelling from denser medium to rarer medium gets reflected totally internally (i.e. in the same denser medium) at the surface of separation is called total internal reflection.” i.e. $\angle A'ON = \angle B'ON$



(ii) Critical angle : When a ray of light travels from denser to rarer medium angle of incidence for when angle of refraction is of 90° , then this angle of incidence is called critical angle" i.e. $\angle AON = \text{critical angle}$

$\therefore$ Angle of refraction $\angle N'OB = 90^\circ$

(b) Two conditions for total internal reflection :

1. light should travel from denser to rarer medium.
2. Angle of incidence should be more than critical angle.

Question 2.

(a) What do you understand by the statement, "critical angle for water is 48° ?

(b) Explain, how that refractive index of material is related to the critical angle.

Answer:

(a) The statement the critical angle for water is 48° means if light in water travels at $\angle i = 48^\circ$ it will come out in air along the surface of water

[i.e. $\angle r = 90^\circ$]

(b) R.I. is related to critical angle as

$$\text{R.I.} = \frac{1}{\sin I_c} = \frac{1}{\sin \text{ of critical angle}}$$

$$\text{R.I.} = \frac{1}{\sin C}$$

Question 3.

Explain the following :

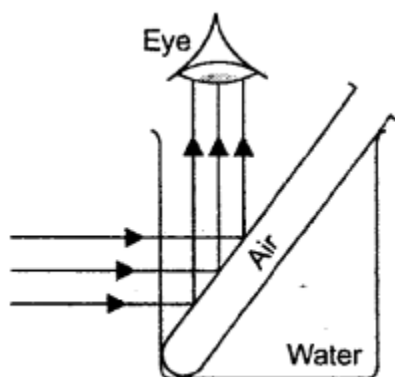
(a) An empty test tube placed obliquely in water, appears to be filled with mercury.

(b) Bubbles rising up in a fish tank appear silvery.

- (c) Air bubbles trapped in a glass paper weight appear silvery.
- (d) A crack in window pane appear silvery.
- (e) Diamonds sparkle for sometime in dark.
- (f) The top surface of water contained in a beaker and held above the eye level appear silvery.

Answer:

(a) An empty test tube placed in water with its mouth up ward and out side the water surface shines like mercury when seen at certain angle greater than critical angle of water. This is due to total internal reflection of light.



- (b) This is due to total internal reflection. When light rays strike the bubbles at angle greater than 48° which is critical angle of water.
- (c) This is due to total internal reflection of light. Light rays strike the glass-air interface at angle more than critical angle of glass (42°) and get totally internally reflected.
- (d) A crack in a glass window pane appear silvery on account of the presence of air in the crack due to total internal reflection.
- (e) Diamond is cut in such a way that a number of refracting surfaces are present and total internal reflection takes place at a number of places and critical angle of diamond beings 24° cuts at very sharp angles are made so that the ray gets trapped with in the diamond for some time.
- (f) When light gets totally internally reflected at water air interface, it appears silvery.

Question 4.

- (a) What is a totally reflecting prism ?
- (b) By drawing neat diagram explain how totally reflecting prisms are used to turn (i) rays through 90° (ii) rays through 180° .
- (c) How is a totally reflecting prism used as an erecting prism ?

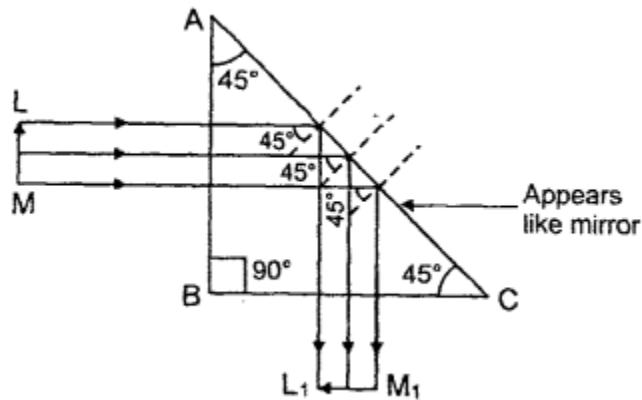
Answer:

(a) **Totally reflecting prism** : "A prism having on angle of 90° between its two refraction surfaces and the other two angles each equal to 45° is called total reflecting prism

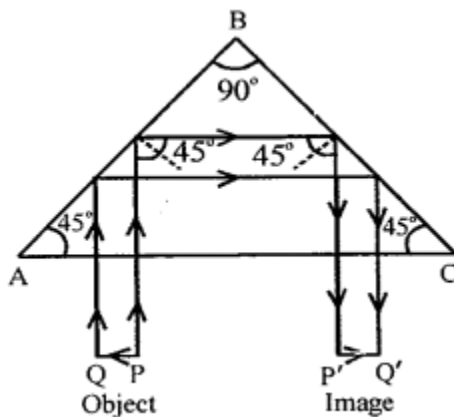
because the light incident normally on any of its faces, suffers total internal reflection inside the prism."

(b)

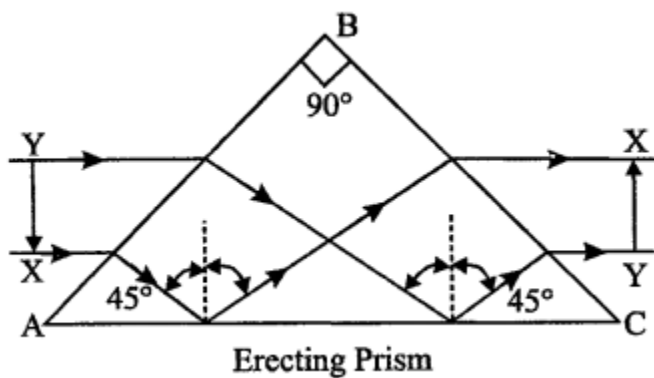
1. To turn rays through 90°



2. To turn rays through 180°



(c) Totally reflecting prism as erecting prism :



Light rays from object PQ suffer refraction air to glass and strike the face AC of prism from glass to air at angle greater than critical angle (42°) and suffers total internal reflection. Then strikes face BC at angle less than critical angle and suffers refraction

from glass to air and bends away from normal and beam emerges parallel to face AC. Erect image P'Q' is obtained and prism acts as erecting prism.

Question 5.

(a) Trace the course of rays through an equilateral glass prism, showing clearly

1. angle of incidence
2. angle of refraction
3. angle of the prism
4. angle of deviation
5. angle of emergence.

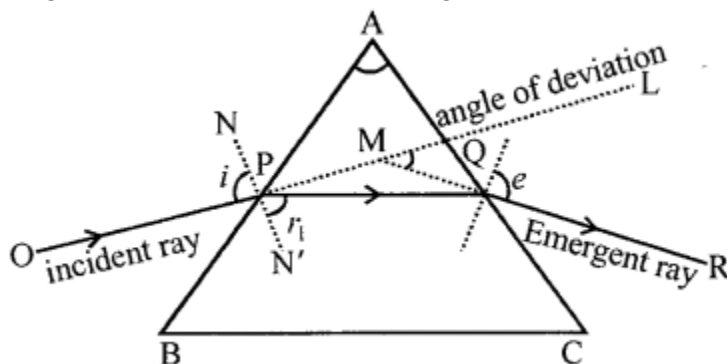
(b) On what factors do the angle of deviation in a prism depend?

(c) What do you understand by the term angle of minimum deviation ? In this position how is the angle of incidence related to the angle of emergence ?

Answer:

(a) **The course of rays through equilateral glass prism :**

1. $\angle OPN$ – angle of incidence
2. Angle of refraction $\angle NPQ$ is angle of refraction



3. $\angle BAC$ is angle of prism.
4. Angle of deviation $\angle LMR$
5. Angle of emergence e

(b) **Factors effecting the angle of deviation :**

1. The angle of incidence i
2. Angle of prism (A)
3. Colour of wavelength (λ) of light used.
4. R.I. of prism (material of prism).

(c) **Angle of minimum deviation :** The angle between incident ray produced and emergent ray produced is called angle of deviation. The angle of deviation decreases

with increase in angle of incidence. A stage comes when for a particular value of angle of incidence, the angle of deviation is minimum.

If the angle of incidence is further increased, the angle, of deviation starts increasing.

Hence

Angle of minimum deviation is the angle of incidence for which angle of deviation is minimum.

Question 6.

State four differences between reflection and total internal reflection.

Answer:

Total Internal Reflection :

1. The entire light is reflected.
2. There is no loss of energy.
3. It takes place only when light passes from denser to rarer medium at an angle of incidence is greater than critical angle.
4. The image is much brighter.

Reflection :

1. Only a part of light is reflected Rest is refracted and absorbed.
2. The energy of reflected ray is less than incident ray.
3. It takes place when light is incident on plane mirror from any medium at any angle of incidence.
4. The image is less bright.

Multiple Choice Questions

Tick (✓) the most appropriate option.

1. For total internal reflection to take place a ray of light must :

- (a) travel from denser to rarer medium
- (b) travel from rarer to denser medium
- (c) medium does not play any role
- (d) none of these

Answer:

- (a) travel from denser to rarer medium

2. The critical angle for glass is 42° . The corresponding angle of refraction is :

- (a) 0°
- (b) 90°
- (c) lesser than 90° but more than 42°

(d) no angle of refraction.

Answer:

(b) 90°

3. The critical angle for a material X is 45° . The total internal reflection will take place, if the angle of incidence in the denser medium is :

(a) less than 45°

(b) 90°

(c) more than 45° , but not 90°

(d) less than 45° , but not zero degree

Answer:

(c) more than 45° , but not 90°

4. Diamonds sparkle more than the glass, because they have :

(a) smaller critical angle than the glass

(b) larger critical angle than the glass

(c) critical angle plays no role

(d) none of these

Answer:

(c) critical angle plays no role

5. Small air bubbles rising up a fish tank appear silvery when viewed from some particular angle because of the phenomenon of :

(a) reflection

(b) refraction

(c) total internal reflection

(d) dispersion

Answer:

(c) total internal reflection

6. An isosceles totally reflecting prism can reflect rays through an angle of :

(a) 60°

(b) 90°

(c) 180°

(d) both (b) and (c)

Answer:

(d) both (b) and (c)

7. A ray of light is incident on the face of an equilateral prism at angle of 90° . The ray gets totally reflected on the second refracting face. The total deviation produced in the path of ray is :

(a) 60°

(b) 90°

- (c) 120°
- (d) 180°

Answer:

- (c) 120°

8. A crack in the window pane appears silvery when viewed from some particular angle. This phenomenon due to :

- (a) reflection light
- (b) refraction of light
- (c) total internal reflection of light
- (d) dispersion of light

Answer:

- (c) total internal reflection of light

9. When an equilateral prism is in minimum deviation position the angle of incidence is :

- (a) greater than the angle of emergence
- (b) smaller than the angle of emergence
- (c) equal to the angle of emergence
- (d) none of these

Answer:

- (c) equal to the angle of emergence

10. A prism has :

- (a) two rectangular and three triangular surfaces
- (b) two triangular and three rectangular surfaces
- (c) three rectangular and three triangular surfaces
- (d) none of these

Answer:

- (b) two triangular and three rectangular surfaces

11. When a ray of light passes through an equilateral glass prism :

- (a) it suffers refraction on the first refracting surfaces
- (b) it suffers refraction on both the refracting surfaces
- (c) it bends towards the base on both refracting surfaces
- (d) both (b) and (c)

Answer:

- (d) both (b) and (c)

Numerical Problems on Lenses

Practice Problems 1

Question 1.

A convex lens of focal length 10 cm is placed at a distance of 60 cm from a screen. How far from the lens should be placed an object so as to obtain a real image on the screen? Calculate the magnification of the image and its characteristics.

Answer:

Here $v = 60$ cm

$f = 10$ cm

$$\Rightarrow \frac{1}{v} - \frac{1}{u} = \frac{1}{f} \quad \Rightarrow \frac{1}{60} - \frac{1}{u} = \frac{1}{10}$$

$$\Rightarrow -\frac{1}{u} = \frac{1}{10} - \frac{1}{60} = \frac{6-1}{60} = \frac{5}{60} = \frac{1}{12}$$

$$\Rightarrow -\frac{1}{u} = -\frac{1}{12}$$

$$\therefore u = -12 \text{ cm} \quad \because u \text{ is taken -ve.}$$

Magnification :

$$\Rightarrow m = \frac{v}{u} = \frac{60}{12} = 5$$

$\therefore$ Image is real, inverted and enlarged *i.e.* 5 times that of object

Question 2.

An object of height 3 cm is placed at a distance of 24 cm from a convex lens of focal length 10 cm, when an image is formed on the screen on the other side of the lens. Calculate

- (a) the distance of the screen from the lens
- (b) the size of image
- (c) the characteristics of image.

Answer:

$$h_1 = 3 \text{ cm}$$

$$u = 24 \text{ cm}$$

$$f = 10 \text{ cm}$$

$$\Rightarrow \frac{1}{v} = \frac{1}{u} = \frac{1}{f} \quad \Rightarrow \frac{1}{v} = \frac{1}{f} + \frac{1}{u}$$

$$\Rightarrow \frac{1}{v} = \frac{1}{10} - \frac{1}{24} = \frac{12-5}{120} = \frac{7}{120}$$

$$(a) \quad v = \frac{120}{7} = 17.14 \text{ cm}$$

(b) Size of image h_2

$$m = \frac{v}{u} = \frac{h_2}{h_1}$$

$$\Rightarrow \frac{120}{7} \times 24 = \frac{h_2}{3}$$

$$h_2 = \frac{5}{7} \times 3 = \frac{15}{7} = 2.14 \text{ cm}$$

(c) Characteristics of image

(i) Real (ii) Inverted (iii) Diminished

Practice Problems 2

Question 1.

An object when placed in front of a convex lens forms a real image of 0.5 magnification. If the distance of the image from the lens is 24 cm, calculate focal length of the lens.

Answer:

$$u = ? \quad m = 0.5$$

$$v = 24 \text{ cm}$$

$$f = ?$$

$$\Rightarrow m = \frac{v}{u} = \frac{24}{u}$$

$$\Rightarrow 0.5 = \frac{1}{2} = \frac{24}{u} \quad \therefore u = 48 \text{ cm}$$

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

$$\Rightarrow f = \frac{1}{24} = \frac{1}{48} = \frac{2-1}{48} = \frac{1}{48}$$

$$f = 48 \text{ cm}$$

If in the question 24 cm is distance of object from lens, then

$$m = \frac{v}{u} \quad \Rightarrow \frac{1}{2} = \frac{v}{24} \quad \therefore v = \frac{24}{2} = 12 \text{ cm}$$

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

$$\Rightarrow \frac{1}{f} = \frac{1}{12} - \left(\frac{1}{-24} \right)$$

$$\Rightarrow \frac{1}{f} = \frac{1}{12} + \frac{1}{24} = \frac{2+1}{24} = \frac{3}{24}$$

$$\Rightarrow f = \frac{24}{3} = 8 \text{ cm}$$

Question 2.

A convex lens forms a real image 4 times magnified when placed at a distance of 6 cm from the lens. Calculate the focal length of the lens.

Answer:

$$m = 4$$

$$u = 6 \text{ cm}$$

$$v = ?$$

$$m = \frac{v}{u}$$

$$\Rightarrow u = \frac{v}{6} \qquad \therefore v = 4 \times 6 = 24 \text{ cm}$$

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

$$\Rightarrow \frac{1}{f} = \frac{1}{24} - \left(\frac{1}{-6} \right) = \frac{1}{24} + \frac{1}{6} = \frac{1+4}{24}$$

$$\Rightarrow \frac{1}{f} = \frac{5}{24} \qquad \therefore f = \frac{24}{5} = 4.8 \text{ cm}$$

Practice Problems 3

Question 1.

An object 1.4 cm high when placed in front of a convex lens at a distance of 6 cm, forms a virtual image at a distance of 24 cm from the lens. Calculate

- (a) the focal length of the lens
- (b) the size of the image.

Answer:

$$h_1 = 1.4 \text{ cm}$$

$$u = -6 \text{ cm}$$

$$v = -24$$

($\because$ Image formed is virtual)

$$(a) \quad \frac{1}{f} = \frac{1}{v} - \frac{1}{u}$$

$$\Rightarrow \frac{1}{f} = -\frac{1}{24} - \left(-\frac{1}{6}\right)$$

$$\Rightarrow \frac{1}{f} = -\frac{1}{24} + \frac{1}{6} = \frac{-1+4}{24} = \frac{3}{24} = \frac{1}{8}$$

$$\Rightarrow f = 8 \text{ cm}$$

$$(b) \quad m = \frac{h_2}{h_1} = \frac{v}{u}$$

$$\Rightarrow \frac{h_2}{1.4} = \frac{-24}{-6} = 4$$

$$h_2 = 4 \times 1.4 = 5.6 \text{ cm}$$

Question 2.

A convex lens forms a 2.5 times magnified virtual image when an object is placed at a distance of 8 cm from the lens. Calculate

(a) the distance of the image from the lens

(b) the focal length of lens.

Answer:

$$m = 2.5$$

$$u = -8 \text{ cm}$$

$$(a) \quad m = \frac{v}{u}$$

$$\Rightarrow 2.5 = \frac{v}{-8}$$

$$\Rightarrow v = -20 \text{ cm} \quad \therefore v = 20 \text{ cm}$$

$$(b) \quad \frac{1}{f} = \frac{1}{v} - \frac{1}{u}$$

$$\Rightarrow \frac{1}{f} = -\frac{1}{20} - \left(-\frac{1}{8}\right) = \frac{-1}{20} + \frac{1}{8}$$

$$\frac{1}{f} = \frac{-2+5}{40} = \frac{3}{40} \quad \therefore f = \frac{40}{3} = 13.3 \text{ cm}$$

Question 3.

An object 1 cm high is placed at a distance of 4 cm from a convex lens of focal length 6 cm. Calculate

(a) the position of the image

(b) size of a image. State the characteristics of the image.

Answer:

$$h_1 = 1 \text{ cm}$$

$$u = -4 \text{ cm}$$

$$f = 6 \text{ cm}$$

$$(a) \quad \frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$

$$\Rightarrow \frac{1}{v} = \frac{1}{f} + \frac{1}{u}$$

$$\Rightarrow \frac{1}{v} = \frac{1}{6} + \left(\frac{-1}{4} \right) = \frac{2-3}{12} = \frac{-1}{12}$$

$$\Rightarrow v = -12 \text{ cm}$$

(a) $\therefore$ Distance of image from lens is 12 cm

(b) Size of Image h_2

$$\Rightarrow m = \frac{v}{u} = \frac{h_2}{h_1}$$

$$\Rightarrow \frac{-12}{-4} = \frac{h_2}{1} \quad \Rightarrow h_2 = 3 \text{ cm}$$

Practice Problems 4

Question 1.

An object 2 cm high is placed at a distance of 25 cm from the optical centre of a concave lens of focal length 15 cm. Calculate

(a) the position of the image

(b) the size of the image.

Answer:

$$h_1 = 2 \text{ cm}$$

$$u = -25 \text{ cm}$$

$$f = -15 \text{ cm}$$

(a) Position of image $v = ?$

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

$$\therefore \frac{1}{v} = \frac{1}{f} + \frac{1}{u}$$

$$\Rightarrow \frac{1}{v} = -\frac{1}{15} - \frac{1}{25} = \frac{-5-3}{75} = \frac{-8}{75}$$

$$\Rightarrow v = \frac{-75}{8} = -9.37 \text{ cm}$$

(b) Size of image $h_2 = ?$

$$m = \frac{v}{u} = \frac{h_2}{h_1}$$

$$\Rightarrow \frac{-75}{8 \times -25} = \frac{h_2}{2}$$

$$\Rightarrow \frac{h_2}{2} = \frac{3}{8} \qquad \therefore h_2 = \frac{3}{8} \times 2 = \frac{3}{4} = 0.75 \text{ cm}$$

Question 2.

A concave lens forms 4 times diminished and virtual image when an object is placed at a distance of 80 cm. Calculate

(a) the position of the image

(b) the focal length of the lens.

Answer:

$$m = \frac{1}{4} \quad u = 80 \text{ cm} \quad v = ?$$

$$(a) \quad m = \frac{v}{u}$$

$$\frac{1}{4} = \frac{v}{80} \quad \therefore v = \frac{80}{4} = 20 \text{ cm}$$

(b) Focal length of lens

$$f = ?$$

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

$$\Rightarrow \frac{1}{f} = -\frac{1}{20} - \left(-\frac{1}{80}\right)$$

$$\Rightarrow \frac{1}{f} = -\frac{1}{20} + \frac{1}{80} = \frac{-4+1}{80}$$

$$\Rightarrow \frac{1}{f} = \frac{-3}{80}$$

$$\Rightarrow f = -\frac{80}{3} = -26.67 \text{ cm}$$

Question 3.

A concave lens has focal length 15 cm. At what distance should the object from the lens be placed, so as to form an image at 10 cm from the lens. Also find magnification of the lens.

Answer:

$$f = 15 \text{ cm}$$

$$u = ? \quad v = -10 \text{ cm} \quad \therefore \text{lens is concave.}$$

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

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

$$\Rightarrow \frac{1}{u} = -\frac{1}{10} - \left(\frac{-1}{15}\right)$$

$$\Rightarrow \frac{1}{u} = -\frac{1}{10} + \frac{1}{15} = \frac{-3+2}{30} = \frac{-1}{30}$$

$$(a) \therefore u = -30 \text{ cm}$$

$$(b) m = \frac{v}{u} = \frac{-10}{-30} = \frac{1}{3} = 0.33$$

Practice Problems 5

Question 1.

A converging lens has a focal length 40 cm. Calculate its power.

Answer:

Converging lens means convex lens has focal length +ve

$$f = 40 \text{ cm} = \frac{40}{100} \text{ m}$$

$$\therefore \text{Power of lens} = \frac{1}{f} \text{ expressed in metres}$$

$$P = \frac{100}{40} = + 2.5 \text{ D}$$

Question 2.

A lens which forms a real image has a focal length 8 cm. Calculate its power.

Answer:

$$\text{Focal length} = 8 \text{ cm} = \frac{8}{100} \text{ m}$$

$$\text{Power } P = \frac{1}{f} \text{ expressed in metres}$$

$$P = \frac{1}{\frac{8}{100}} = \frac{100}{8} = +12.5 \text{ D}$$

Practice Problems 6

Question 1.

State the nature of the lens and the focal length if its power is +4D.

Answer:

(a) Power = +4D

(+ve sign shows that lens is convex)

(b) $P = \frac{100}{f}$

$$\Rightarrow 4 = \frac{100}{f}$$

$$\Rightarrow f = \frac{100}{4} = 25 \text{ cm}$$

Question 2.

The number of the glasses of a person is +0.75 D. What is the nature of the lens and what is its focal length ?

Answer:

(a) Number of glasses = Power = + 0.75 D

(+ ve sign shows that lens is convex)

$$(b) P = \frac{100}{f}$$

$$\Rightarrow 0.75 = \frac{100}{f}$$

$$\Rightarrow f = \frac{100}{0.75} = \frac{100 \times 100}{75}$$

$$\Rightarrow f = 133.33 \text{ cm}$$

Practice Problems 7

Question 1.

The focal length of a concave lens is 10 cm. Calculate its power.

Answer:

Concave lens has -ve focal length

$$f = -10 \text{ cm}$$

$$P = \frac{100}{f} = \frac{100}{-10} = -10D$$

Question 2.

The focal length of the lens of a myopic person is 40 cm. What is the power of the lens ?

Answer:

Myopic person uses concave lens

$$f = -40 \text{ cm}$$

$$P = \frac{100}{f} = \frac{100}{-40} = -2.5 D$$

Practice Problems 8

Question 1.

Calculate the focal length of a lens of power -2.75 D.

Answer:

$$\text{Power } P = -2.75 \text{ D}$$

$$P = \frac{100}{f}$$

$$\Rightarrow -2.75 = \frac{100}{f}$$

$$\Rightarrow f = \frac{-100 \times 100}{275} = \frac{-400}{11} = -36.36 \text{ cm}$$

$$\Rightarrow f = -36.36 \text{ cm}$$

Question 2.

The power of a concave lens is -12.5 D. What is the focal length of the lens ?

Answer:

$$\text{Power of concave lens } P = -12.5 \text{ D}$$

$$\Rightarrow P = \frac{100}{f}$$

$$\Rightarrow f = \frac{100}{P}$$

$$\Rightarrow f = \frac{-100}{12.5} = \frac{-1000}{125} = \frac{-40}{5} = -8$$

$$\Rightarrow f = -8 \text{ cm}$$

Exercise – 3**Question 1.**

(a) What do you understand by the term lens ?

(b) What are the various kinds of lenses ? Draw a neat diagram of each kind.

Answer:

(a) Lens : "Is a piece of transparent optical medium material having one or two spherical surfaces."

Or

"A lens is a transparent refracting medium bounded by two curved surfaces which are generally spherical."

(b) There are two types of lenses :

(i) Convex lens or converging lens 

(ii) Concave lens or diverging lens 

Convex lens $\longrightarrow$ (i)  double convex or biconvex 

(ii) plano convex (iii)  concavo-convex

Concave lens $\longrightarrow$ (i) B i o concave

(ii)  plano - concave (ii) plano-concave

(iii)  convex concave

Question 2.

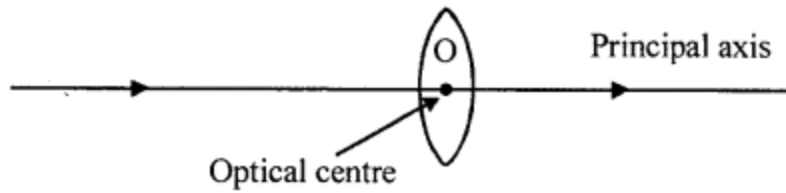
Define the following with respect to converging lens

1. principal axis
2. optical centre
3. first principal focus
4. second principal focus
5. focal length.

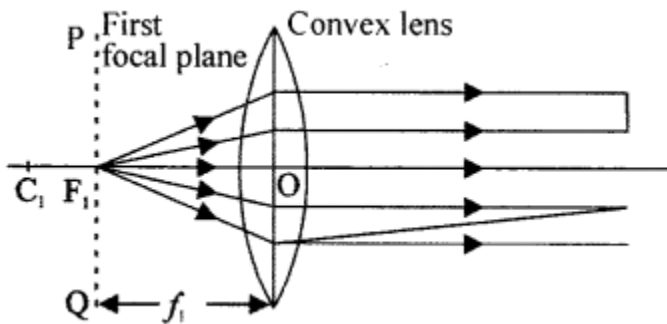
Answer:

(i) Principal axis : "It is the line joining the centres of curvature of the two surfaces of the lens."

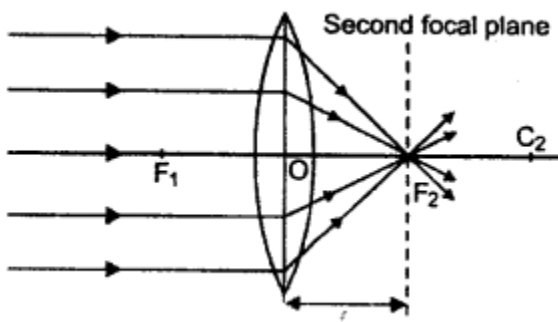
(ii) Optical centre : It is a point on the principal axis of the lens such that a ray of light passing through this point emerges parallel to its direction of incidence."



(iii) **First principal focus** : "Is a point on the principal axis of a convex lens, such that the rays starting from it, after refraction travel parallel to the principal axis."



(iv) **Second Principal focus** : "It is a point on the principal axis, such that rays coming parallel to the principal axis after refraction through the lens actually meet here."



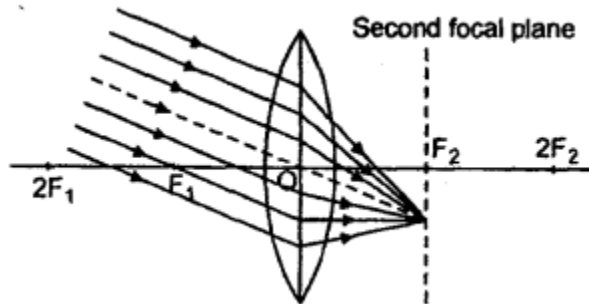
(v) **Focal Length** : "The distance between focus and optical centre of a lens is called focal length."

Question 3.

Draw neat diagrams for the formation of images in case of convex lens and state its characteristics when the object is :

1. at infinity
2. between 2F and infinity
3. at 2F
4. in between F and 2F
5. at F.

Answer:

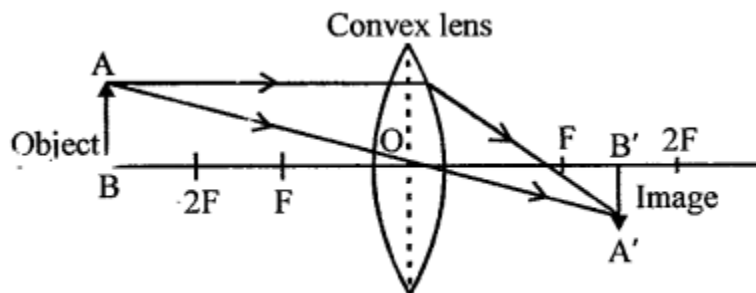


(i) Characteristics of image :

1. Real
2. Inverted
3. Highly diminished
4. at F on right side of lens.

(ii) Object between $2F$ and infinity : Image formed is

1. Real
2. Inverted
3. Diminished
4. Between F and $2F$.



(iii) object at $2F$

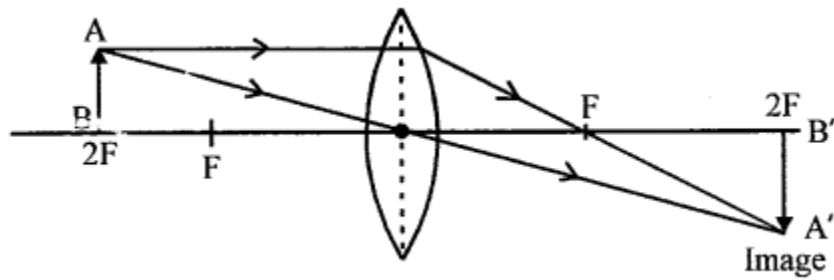


Image formed is :

1. Real
2. Inverted
3. At $2F$ on right side of lens
4. same size of object

(iv) Object lies between F and $2F$:

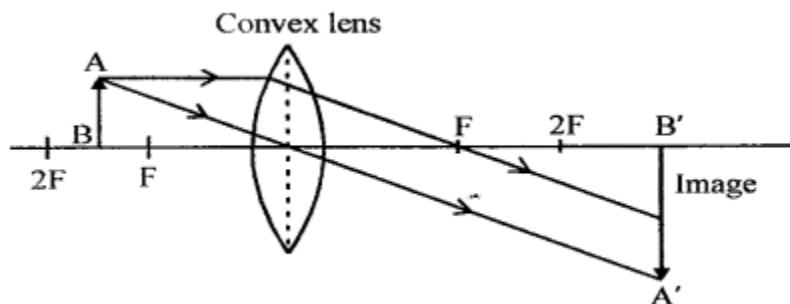
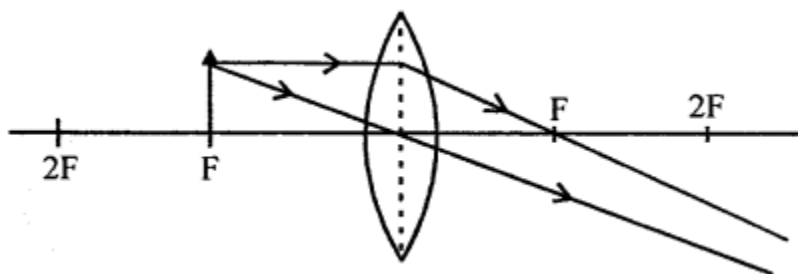


Image formed is :

1. Real
2. Inverted
3. Magnified
4. Beyond $2F$ on Right side of lens.

(v) Object at F :



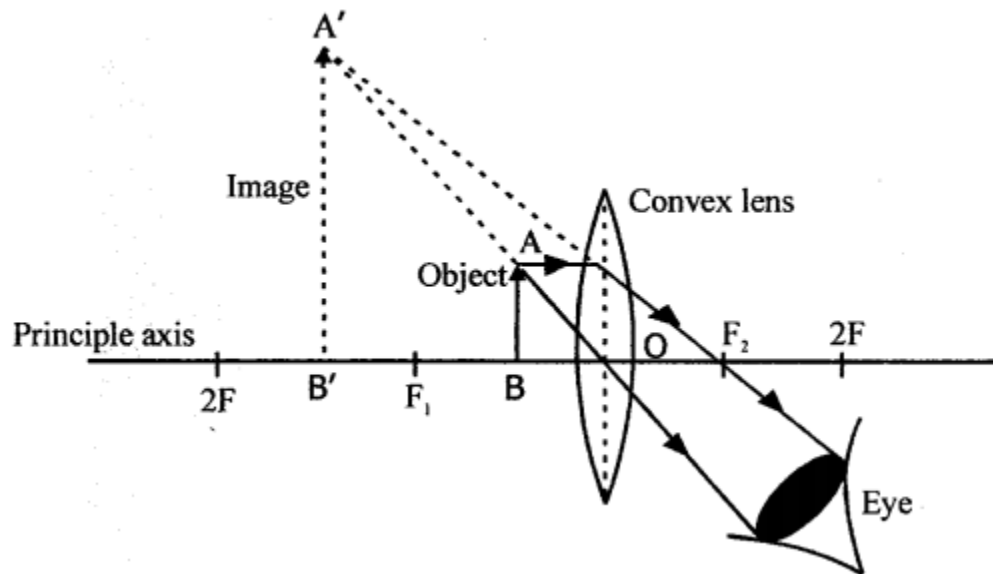
- (i) at infinity (rays after passing lens become)
- (ii) Real
- (iii) Inverted parallel

Question 4.

Draw a neat diagram for a simple microscope.

Answer:

Diagram of simple microscope :



When object lies between F and lens, its image is magnified, erect and on the same side of object which can be seen by eye. Hence this arrangement acts a simple microscope.

Question 5.

Draw neat diagrams for the formation of images in case of concave lens and state their characteristics when the object is :

1. at infinity
2. anywhere between infinity and the optical centre

Answer:

(i) Object at infinity :

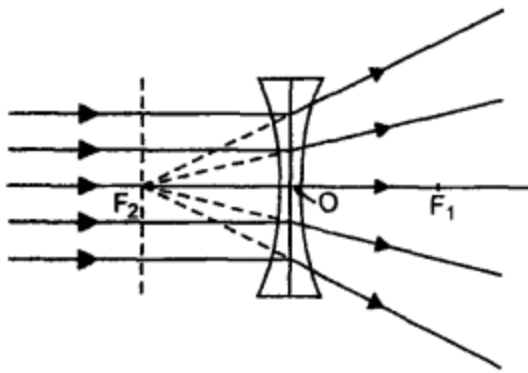
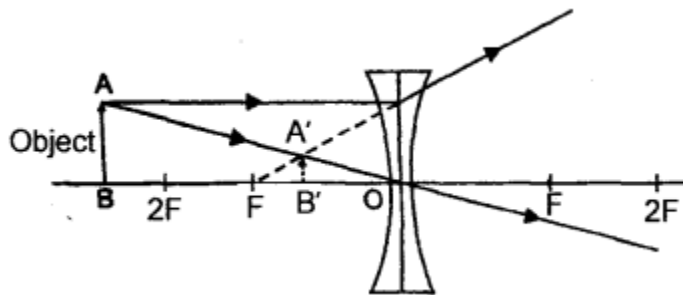


Image formed is

1. at second focus F_2
2. virtual
3. erect
4. highly diminished.

(ii) Object lies anywhere between infinity and optical centre.



The image is formed between F and optical centre is virtual erect and diminished.

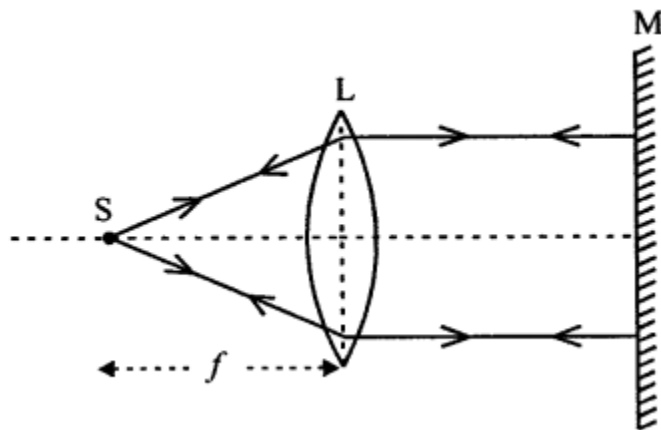
Question 6.

How will you find the focal length of a convex lens, by using a single pin and a plane mirror ?

Answer:

Since rays after refraction through lens become parallel and ray after reflection from mirror meet at original point S , S is the focus and distance between S and lens is focal length. Even if the mirror is moved to any position, here at focal length, the parallel ray

will meet at S (i.e. focus)



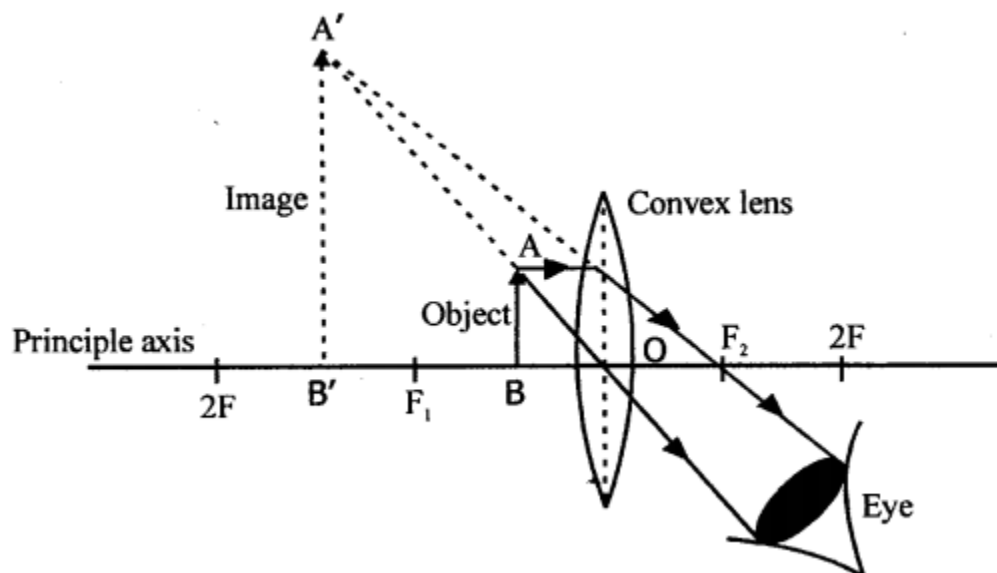
Question 7.

You are required to form an upright image of an object in case of (a) convex lens, (b) concave lens. What will be the position of the object with respect to the lens in each case? Support your answer by diagrams and state the characteristics of the image in each case:

Answer:

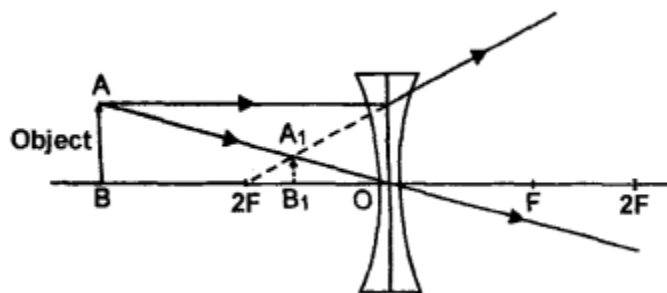
Upright image of an object in case of

(a) Convex lens : The position of object is between and optical centre.



(b) Concave lens : The position of object is anywhere between infinity and optical

centre.



Multiple Choice Questions

Tick (✓) the most appropriate option.

1. The point on the principal axis of a convex lens, such that rays of light starting from it on passing through the lens, move parallel to the principal axis is called :

- (a) first focal point
- (b) second focal point
- (c) optical centre
- (d) aperture of lens

Answer:

- (a) first focal point

2. A convex lens can be regarded as a set of prisms and a glass slab, such that refracting angle of the prisms

- (a) continuously decreases in outward direction
- (b) continuously increases in outward direction
- (c) remains same in outward direction
- (d) none of these

Answer:

- (a) continuously decreases in outward direction

3. A lens forms an inverted image of an object equal to its own size. The object is :

- (a) beyond infinity and $2F_1$
- (b) at $2F_1$
- (c) between $2F_1$ and F_1
- (d) in between F_1 and optical centre

Answer:

- (b) at $2F_1$

4. A convex lens will form a virtual, erect and enlarged image, when the object is :

- (a) between $2F_1$ and F_1
- (b) $2F_1$
- (c) $2F_1$ and infinity
- (d) F_1 and optical centre

Answer:

- (d) F_1 and optical centre

5. A concave lens always forms :

- (a) real, inverted and enlarged image
- (b) virtual, inverted and enlarged image
- (c) virtual, erect and diminished image
- (d) virtual, erect and enlarged image

Answer:

- (c) virtual, erect and diminished image

Questions from ICSE Examination Papers

2003

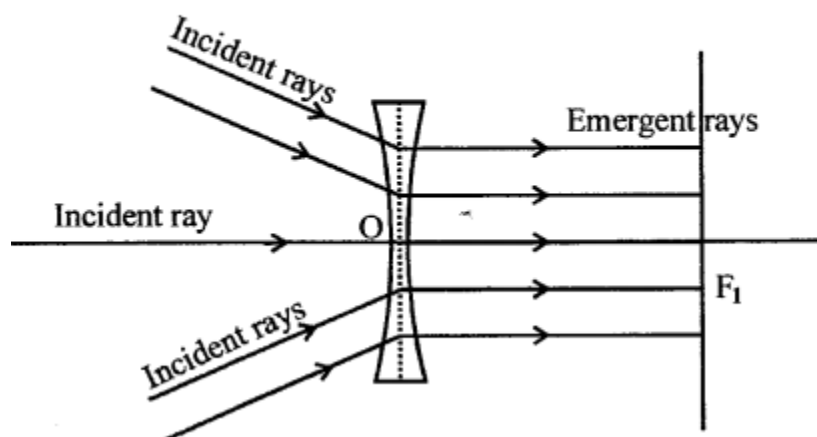
Question 1.

(a) A ray of light, after refraction through a concave lens, emerges parallel to the principal axis. Draw a ray diagram to show the incident ray and its corresponding emergent ray.

(b) The velocity of light in diamond is $21,000 \text{ kms}^{-1}$. What is its refractive index of diamond? (Velocity of light in air $3 \times 10^8 \text{ m/s}$)

Answer:

(a)

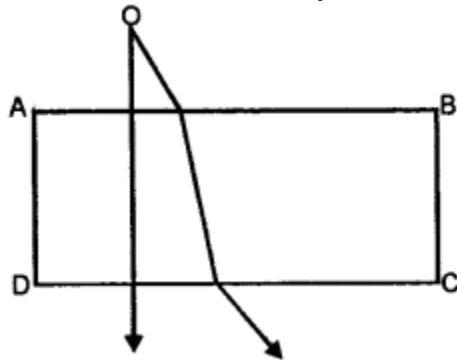


$$(b) \mu = \frac{\text{Speed of light in air}}{\text{Speed of light in medium}}$$

$$\text{Refractive Index} = \frac{3 \times 10^8}{1.21 \times 10^8} = \frac{3}{1.21} = \boxed{2.47} \text{ Ans.}$$

Question 2.

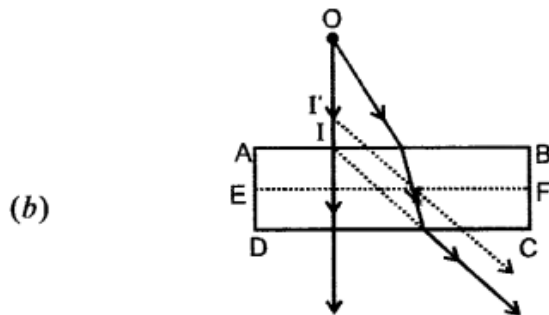
A monochromatic point source of light 'O' is seen through a rectangular glass block ABCD. Paths of two rays, in and outside the block, are shown in figure above.



- Does the source monochromatic source appear to be nearer or farther with respect to the surface AB ?
- How does the shift in (a) depend up on the thickness (AD) of the glass block ?
- Justify your answer in (b) with an appropriate ray diagram.
- For the same rectangular block, which colour from the visible spectrum will produce the maximum shift ?

Answer:

(a) Nearer



Shift is proportional to the thickness of the slab $\therefore$ it increases with increase in thickness of slab.

- With thickness AD, the image is at I while for thickness AE ($< AD$), the image is at I'

and shift $OA' < \text{shift } OI$ when thickness decreases.

(d) The same rectangular glass block will produce Maximum shift is of VIOLET COLOUR LIGHT incident on it for which the refractive index of glass is most.

Question 3.

A postage stamp appears raised by 7.00 mm when placed under a glass block of refractive index 1.5. Find the thickness of the glass block.

Answer:

$$\mu = \frac{\text{Real depth}}{\text{Apparent depth}}$$

$$1.5 = \frac{x}{x-7} \Rightarrow \frac{3}{2} = \frac{x}{x-7} \Rightarrow 3x-21 = 2x \Rightarrow x = 21$$

Thickness of glass block = **21 mm.** Ans.

2004

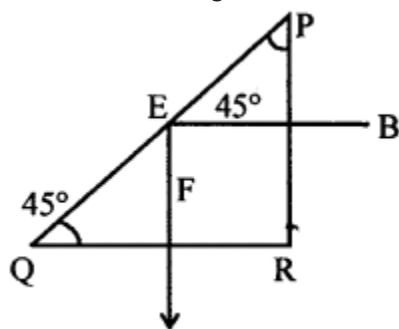
Question 4.

(a) What do you understand by the term critical angle ?

Answer:

It is the angle of incidence of a light ray in a denser medium for which the angle of refraction in a rarer medium is 90° .

(b) Diagram below shows a path of ray AB through an isosceles right angled prism. What is the magnitude of the angle of incidence on (i) face PR (ii) PQ ?



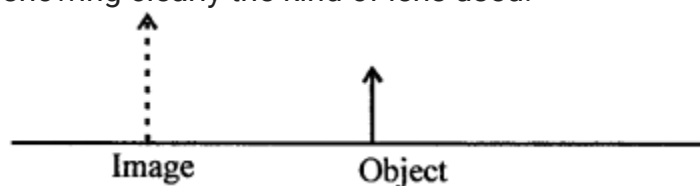
Answer:

Angle of incidence at the face PR is 90°

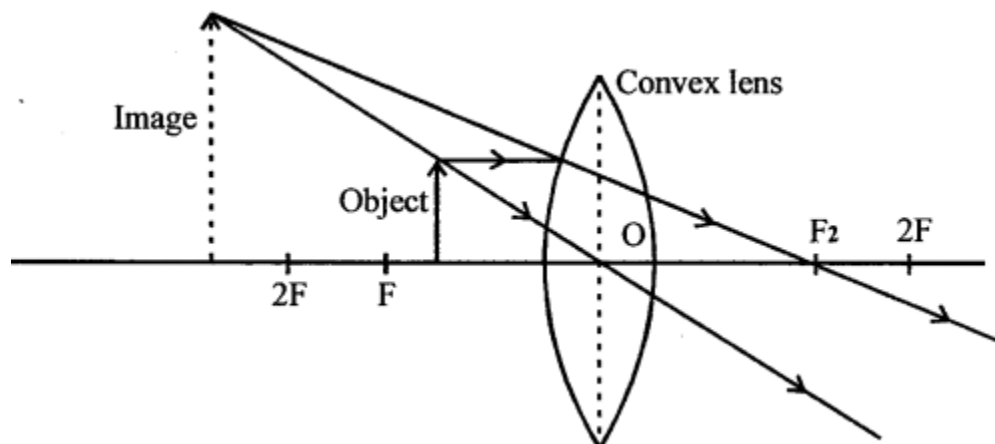
Angle of incidence of the face PQ is 45°

Question 5.

The diagram given below shows the position of an object and its image. Copy the diagram and then by drawing two rays locate the position of the lens and its focus, showing clearly the kind of lens used.



Answer:



As the image is magnified and on the same side of object, the lens must be convex. The object lies within focus and lens.

The lens is convex.

Question 6.

(a) State the Snell's law of refraction.

Answer:

Second law of refraction i.e. $\sin i / \sin r = \mu$ is called Snell's Law.

SNELL'S LAW : which states that "It is the ratio of sine of angle of INCIDENCE to sine of angle of REFRACTION is constant for a pair of media."

$$\frac{\sin i}{\sin r} = \mu = \text{constant} = RI$$

(b) If the velocity of light in air is $3 \times 10^8 \text{ m s}^{-1}$ and refractive index of glass 1.5, calculate the velocity of light in glass.

Answer:

Given, $\mu = 1.5$, $V_{\text{air}} = 3 \times 10^8 \text{ m s}^{-1}$, $V_{\text{glass}} = ?$

$$\text{From } \mu = \frac{V_{\text{air}}}{V_{\text{glass}}}; V_{\text{glass}} = \frac{V_{\text{air}}}{\mu} = \frac{3 \times 10^8}{1.5} \text{ m s}^{-1}$$

$$= \boxed{2 \times 10^8 \text{ ms}^{-1}}$$

2005

Question 7.

Mention two properties of a wave: one property which varies and the other which remains constant when the wave passes from one medium to another.

Answer:

1. Wavelength varies
2. Frequency remains unchanged.

Question 8.

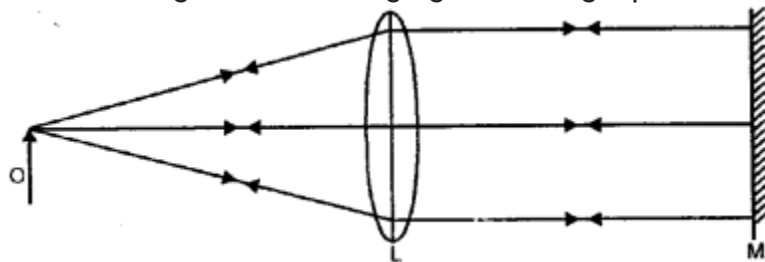
What is meant by the statement 'the critical angle for diamond is 24° '? How is the critical angle of a material related to its refractive index?

Answer:

Critical angle for diamond is 24° means that the angle of incidence of light in diamond is such that the angle of refraction for it in air is 90° . The critical angle is related to the refractive index of the material as $1/\sin i_c = \mu$, where μ = refractive index

Question 9.

The ray diagram given below illustrates the experimental set up for the determination of the focal length of a converging lens using a plane mirror.



- (a) State the magnification of the image formed.
- (b) Write two characteristics of the image formed.
- (c) What name is given to the distance between the object and optical centre in the diagram above?

Answer:

- (a) Magnification of the image formed is of SAME SIZE as that of object.
- (b) The image formed is INVERTED and REAL.
- (c) Focal length.

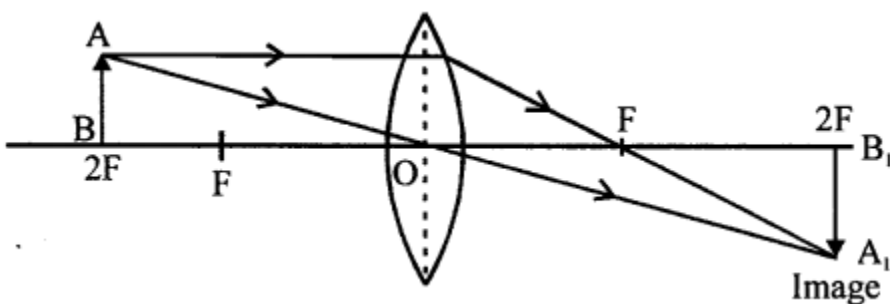
2006

Question 10.

An object is placed in front of a convex lens such that the image formed has the same size as that of the object. Draw a ray diagram to illustrate this.

Answer:

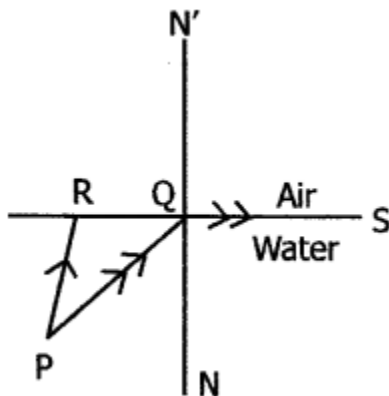
When an object is placed at $2F$, image is formed at $2F$ on other side of lens is of same size as of object.



Question 11.

PQ and PR are two light rays emerging from the object P as shown in the figure

- (a) What is the special name given to the angle of incidence ($\angle PQN$) of ray PQ ?



- (b) Copy the ray diagram and complete it to show the position of the image of the image of the object P when seen obliquely from above.
- (c) Name the phenomenon that occurs if the angle of incidence $\angle PQN$ is increased still further.

Answer:

- (a) Angle of incidence $\angle PQN$ is Critical Angle
- (b) P' is the image of P as seen obliquely from above.
- (c) Total Internal Reflection will take place.

2007

Question 12.

State Snell's Law of Refraction of light.

Answer:

Snell's law of refraction states that for a given pair of media and for a given colour of light the ratio of the sine of the angle of incidence to the sine of angle of refraction is a constant quantity.

i.e.,
$$\frac{\sin i}{\sin r} = \text{constant}$$

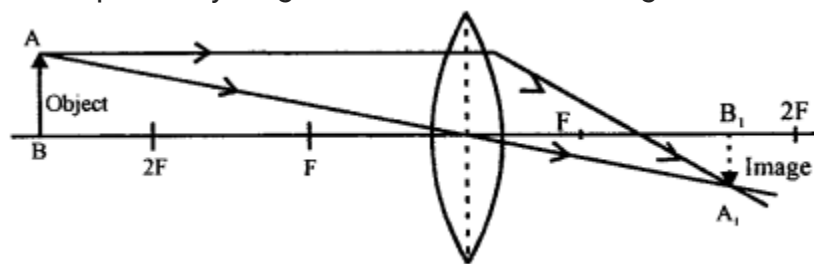
The constant is called refractive index of second media with respect to first media.

Question 13.

An object is placed in front of a converging lens at a distance greater than twice the focal length of the lens. Draw a ray diagram to show the formation of the image.

Answer:

The required ray diagram is as shown in the fig. below.



$A'B'$ is the real, inverted and diminished image of the object AB and is formed between F and $2F$.

Question 14.

Mention one difference between reflection of light from a plane mirror and total internal reflection of light from a prism.

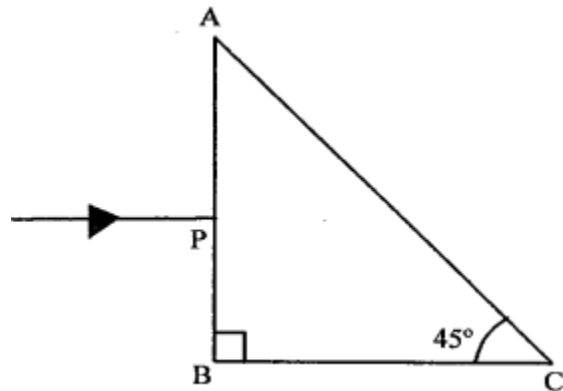
Answer:

In the case of a plane mirror, the reflection of light incident on the mirror takes place for all angles of incidence. In the case of total internal reflection of the light incident on a prism, the incident ray is first refracted and then suffers total reflection from the other face only, if light is incident at an angle greater than the critical angle.

Whereas a lot of light energy is absorbed in ordinary reflection, no light is absorbed during total internal reflection.

Question 15.

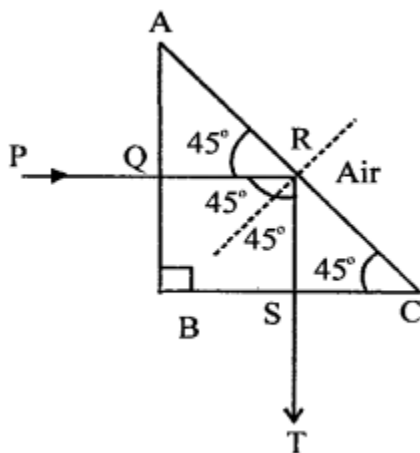
The diagram given below shows a right-angled prism with a ray of light incident on the side AB. (The critical angle for glass is 42°).



1. Copy the diagram and complete the path of the ray of light in and out of the glass prism.
2. What is the value of the angle of deviation shown by the ray ?

Answer:

1. The required diagram is as shown in the fig.
2. The angle of deviation is 90° as shown.

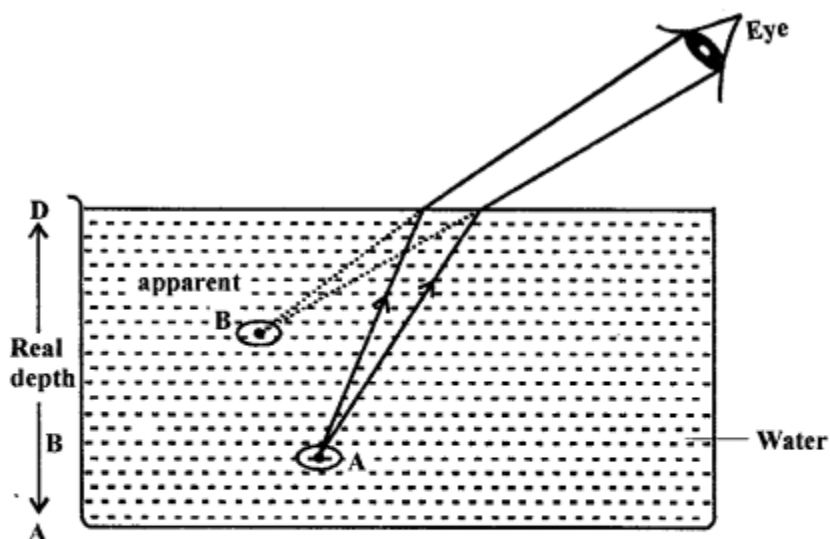


Question 16.

1. With the help of a well-labelled diagram show that the apparent depth of an object, such as a coin, in water is less than its real depth.
2. How is the refractive index of water related to the real depth and the apparent depth of a column of water ?

Answer:

(i) The labelled diagram is as shown. Coin is placed at position A. It appears at a position B.



Here,

AO = real depth

AI = apparent depth

(ii) The required relation is

$$\mu = \frac{\text{real depth}}{\text{apparent depth}}$$

2008

Question 17.

(a) (i) A monochromatic beam of light of wavelength λ passes from air into a glass block. Write an expression to show the relation between the speed of light in air and the speed of light in glass.

(ii) As the ray of light passes from air to glass, state how the wavelength of light changes. Does it increase, decrease or remain constant ?

(b) Draw a ray diagram to illustrate the determination of the focal length of a convex lens using an auxiliary plane mirror.

Answer:

(a) When a ray of light of wavelength λ passes from air into denser medium speed of light in glass decreases

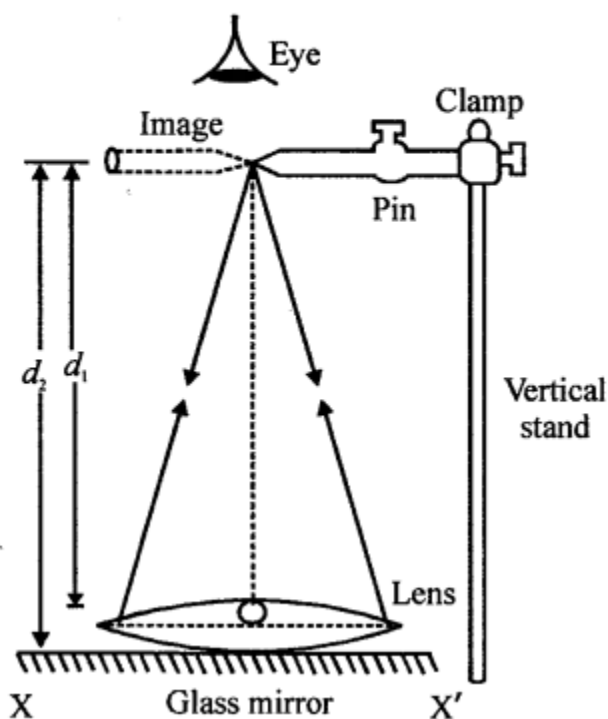
$V = v\lambda$ frequency v remains same wave length ' λ ' decrease

$$\therefore \frac{C}{v} = \frac{\text{vel. of light in air}}{\text{vel. of light in glass}} = \frac{v\lambda}{v\lambda'} = \frac{\lambda}{\lambda'}$$

(ii) Wavelength decrease when a ray of light goes from air to glass

(b) On placing lens L on a plane mirror MM' the pin P is clamped so that its tip is vertically above the centre O of the lens L then height of the pin is adjusted to remove parallax and distance x of the pin from the lens is measured and the distance y of the pin from mirror is measured. The average of the two distances gives the focal length of the lens.

$$f = \frac{x+y}{2}$$

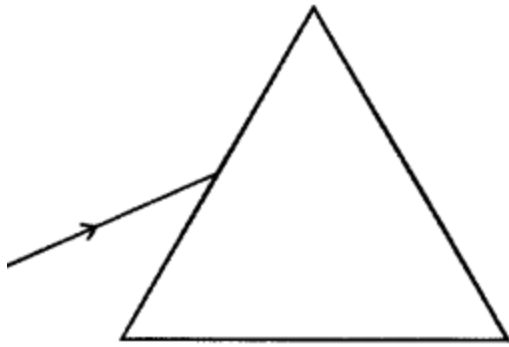


Question 18.

(a) (i) Draw a labelled ray diagram to illustrate (1) critical angle (2) total internal reflection, for a ray of light moving from one medium to another.

(ii) Write a formula to express the relationship between refractive index of the denser medium with respect to rarer medium and its critical angle for that pair of media.

(b) (i) The diagram below shows a ray of light incident on an equilateral glass prism placed in minimum deviation position.

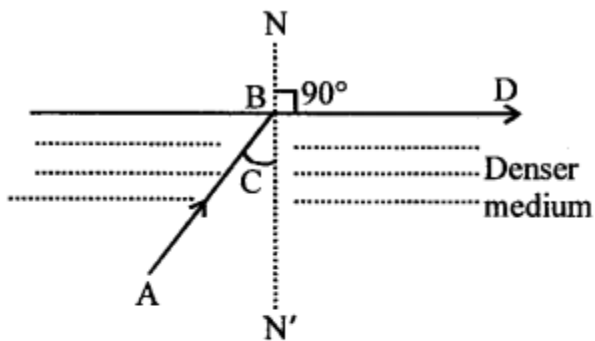


Copy the diagram and complete it to show the path of the refracted ray and the emergent ray.

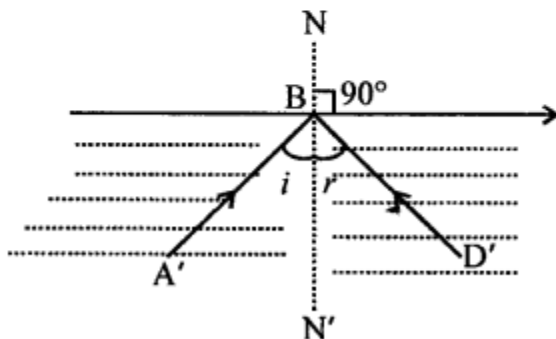
(ii) How are angle of incidence and angle of emergence related to each other in this position of the prism ?

Answer:

(a) (i)



$\angle ABN' = C =$ Critical angle for which angle of refraction $\angle NBD = 90^\circ$ and refracted ray is parallel to the surface.



Angle of incidence $\angle A'BN' > \angle C$

Refraction in the same medium takes place $\angle i = \angle r$

(ii) Refractive index of denser medium (glass) w.r.t. rarer medium (air)

$$= {}^g\mu_a = \frac{\text{velocity of light in glass}}{\text{velocity of light in air}}$$

$${}^g\mu_a = \frac{\sin i_c}{\sin 90^\circ}$$

$$\sin i_c = {}^g\mu_a \quad (\because \sin 90^\circ = 1)$$

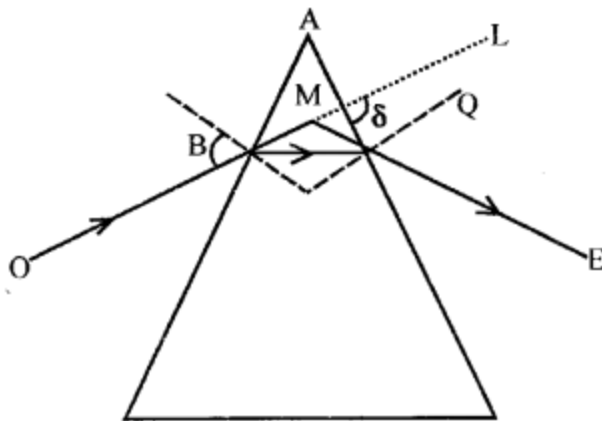
(b) (i) $\angle LMO$ = angle of minimum deviation

OB is incident ray produced to L

QE is emergent ray produced in the backward direction to meet OL at M.

BQ is refracted ray

(ii) Angle of incidence = Angle of emergence.



(ii) In minimum deviation position $\angle i_1 = \angle i_2$ that is angle of incidence = angle of emergence.

Question 19.

A linear object is placed on the axis of a lens. An image is formed by refraction in the lens. For all positions of the object on the axis of the lens, the positions of the image are always between the lens and the object

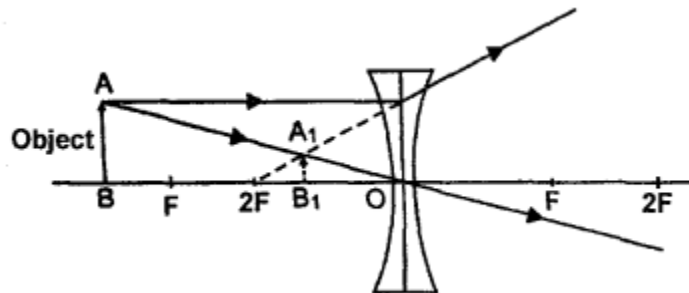
(a) Name the lens.

(b) Draw a ray diagram to show the formation of the image of an object placed in front of the lens at any position of your choice except infinity.

Answer:

(a) As the position of image is always between the lens and the object i.e. on the left of lens it is concave lens.

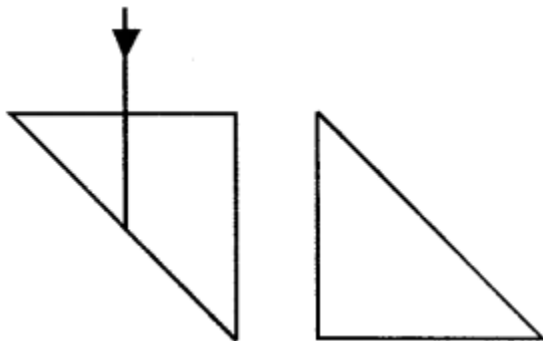
(b) Object lies anywhere between infinity and optical centre.



The image is formed between F and optical centre is virtual erect and diminished.

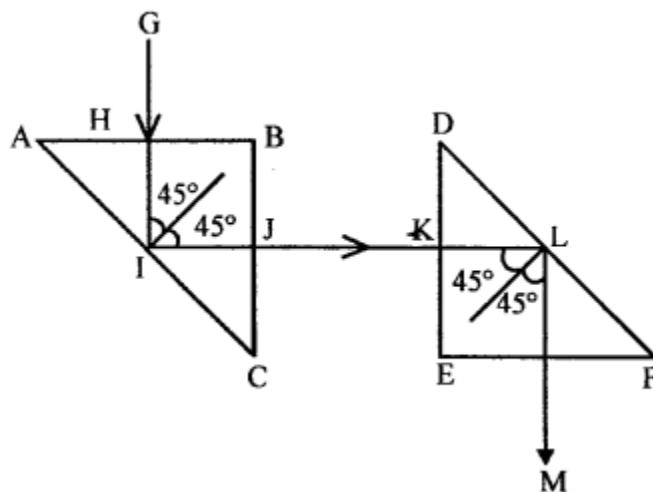
Question 20.

Two isosceles right-angled prisms are placed near each other as shown in the figure.



Complete the path of the light ray entering the first isosceles right-angled glass prism till it emerges from the second identical prism.

Answer:

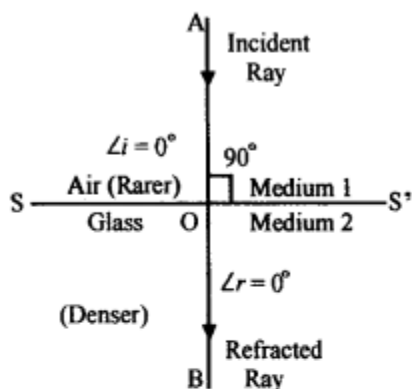


Question 21.

(a) A ray of light strikes the surface of a rectangular glass block such that the angle of incidence is (i) 0° (ii) 42° . Sketch a diagram to show the approximate path taken by the ray in each case as it passes through the glass block and emerges from it.

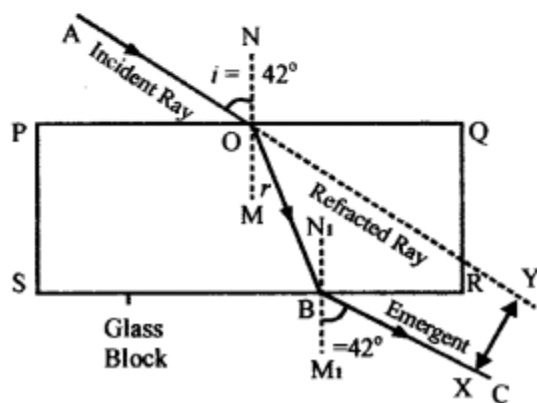
Answer:

(a) (i)



Angle of incidence = 0° . The ray will pass through glass block undeviated and emerge out making angle of refraction.

(ii)



Angle of incidence 42° = critical angle of glass, the refracted ray makes angle of 90° and emerges parallel to the surface along BC.

(b) State the conditions required for total internal reflection of light to take place.

Answer:

Conditions required for total internal reflection to take place :

1. Light must travel from denser to rarer medium.
2. Angle of incidence in denser medium must be greater than critical angle for the pair of media.

(c) Copy and complete the following table :

<i>Types of lens</i>	<i>Position of Object</i>	<i>Nature of Image</i>	<i>Size of Image</i>
<i>Convex</i>	<i>At F</i>		
<i>Concave</i>	<i>At infinity</i>		

Ans.

Types of lens	Position of Object	Nature of Image	Size of Image
Convex	At F	Real, inverted	Highly magnified
Concave	At infinity	Virtual, erect	Diminished

Question 22.

(a) How does the value of angle of deviation produced by a prism change with an increase in the :

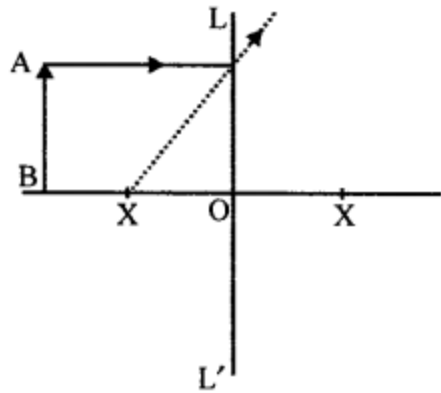
1. value of angle of incidence
2. wavelength of incident light ?

Answer:

1. When the angle of incidence increases angle of deviation first decreases till it reaches the value known as minimum deviation position. After that with the increase in angle of incidence angle of deviation also increases.
2. Angle of deviation decreases with increase in the wavelength of light, so angle of deviation is maximum for violet light and least for red light.

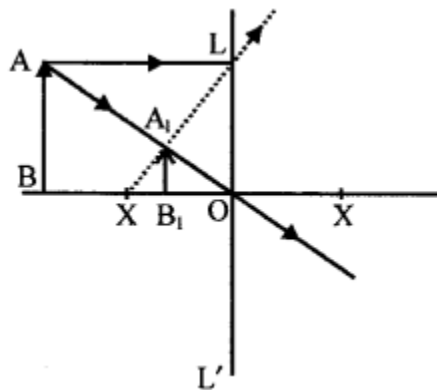
(b) (i) Copy and complete the diagram to show the formation of the image of the subject AB.

(ii) What is the name given to x ?

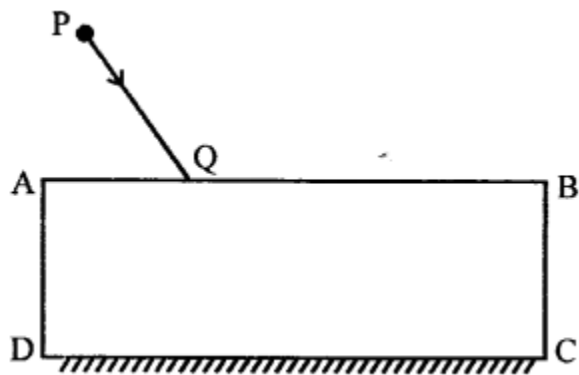


Answer:

X is principal focus of concave lens and OX is focal length



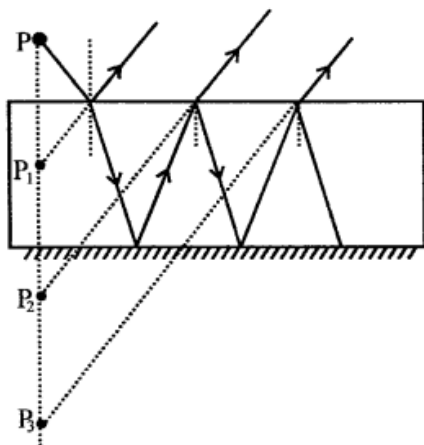
(c) (i) The diagram below shows a ray of white light PQ coming from an object P and incident on the surface of a thick glass plane mirror. Copy the diagram and complete it to show the formation of three images of the object P as formed by the mirror.



(ii) Which image will be the brightest image ?

Answer:

(i)



(ii) Image formed by I_2 is brightest because it is formed by reflection as well as refraction.

2010

Question 23.

(a) (i) What is meant by refraction of light ?

(ii) What is the cause of refraction of light ?

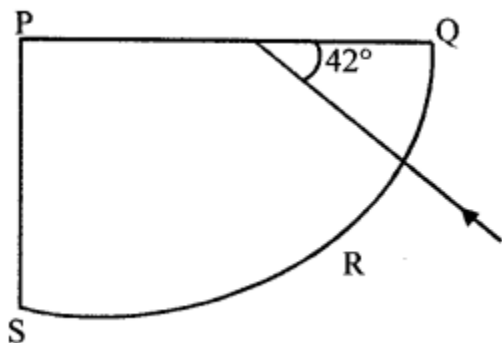
(b) 'The refractive index of diamond is 2.42 ; What is meant by this statement ?

(c) We can burn a piece of paper by focussing the sun rays by using a particular type of lens.

(i) Name the type of lens used for the above purpose.

(ii) Draw a ray diagram to support your answer.

(d) A ray of light enters a glass slab PQRS, as shown in the diagram. The critical angle of the glass is 42° . Copy this diagram and complete the path of the ray till it emerges from the glass slab Mark the angle in the diagram wherever necessary.



Answer:

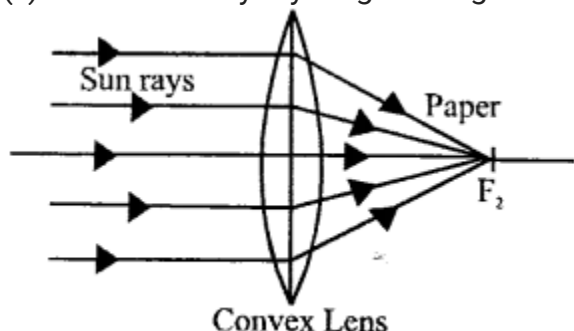
(a) (i) Refraction of Light : “When light travels from one optical medium to other optical medium, it changes its path, . this change in path is called refraction of light.”

(ii) The refraction of light takes place because the velocity of light in different media is different.

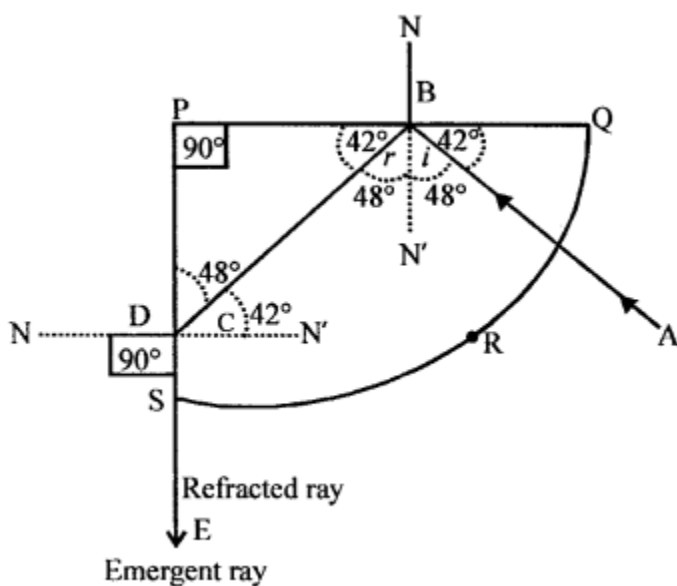
(b) R.I of diamond is 2.42 this means that velocity of light in diamond is $1/2.42$ times the vel. of light in air.

(c) (i) A convex lens is used to focus the sun rays on a piece of paper to burn it. A large amount of heat gets concentrated at a point and is sufficient to burn the piece of paper.

(ii) The necessary ray diagram is given below.



(d) The copied diagram alongwith the complete path of the ray is as shown below :



The angle of incidence on PQ is 48° which is greater than the critical angle. Hence, total internal reflection takes place at PQ. OT is the totally reflected ray. It is incident on PS at 42° and will be refracted along TS.

Question 24.

(a) A stick partly immersed in water appears to be bent. Draw a ray diagram to show the bending of the stick when placed in water and viewed obliquely from above.

(b) A ray of monochromatic light is incident from air on a glass slab :

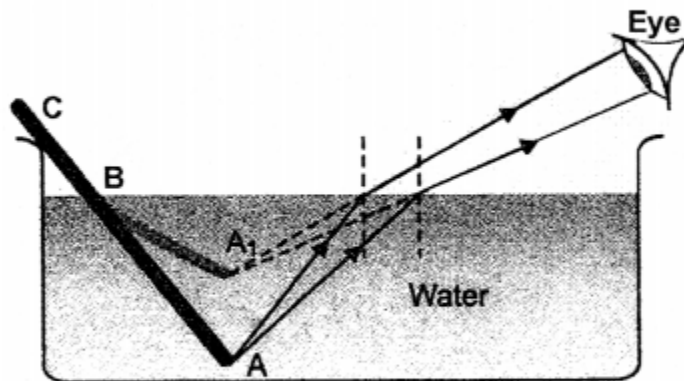
1. Draw a labelled ray diagram showing the change in the path of the ray till it emerges from the glass slab.
2. Name the two rays that are parallel to each other. (Hi) Mark the lateral displacement in your diagram.

(c) An erect, magnified and virtual image is formed, when an object is placed between the optical centre and principal focus of a lens.

1. Name the lens.
2. Draw a ray diagram to show the formation of the image with the above stated characteristics. (4)

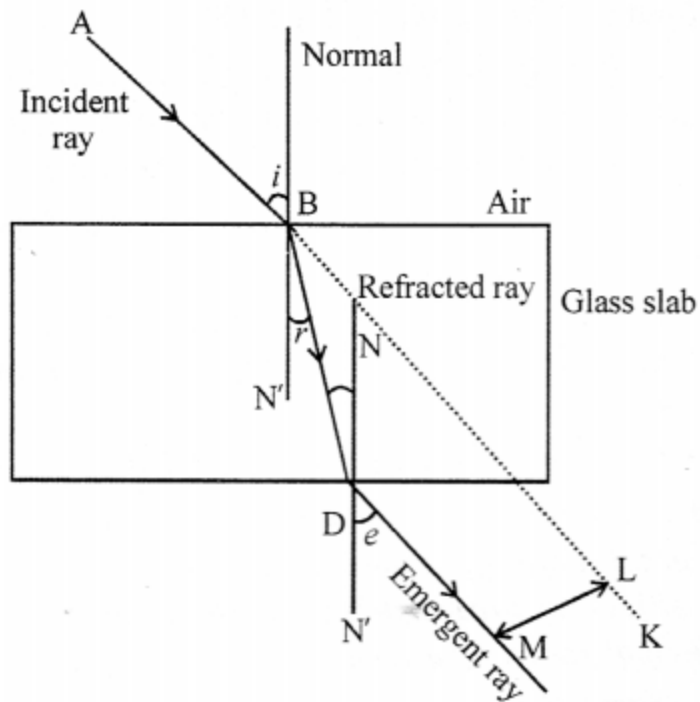
Answer:

(a)



The stick appears to be bent upwards and seems to be shortened. This is due to refraction of light.

(b) (i)

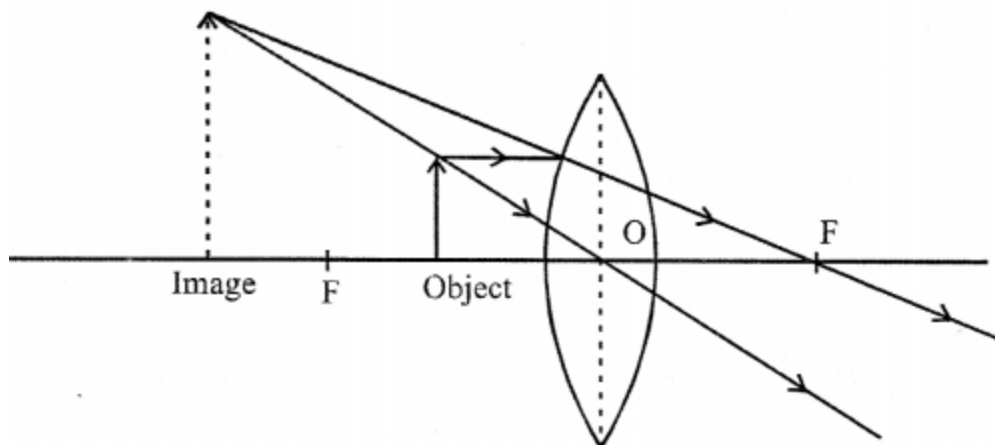


(ii) Incident ray is parallel to emergent ray.

(iii) PQ is the lateral displacement.

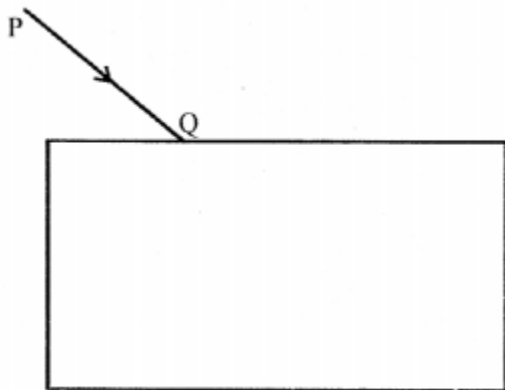
(c) (i) Lens is convex or converging lens.

(ii)



Question 25.

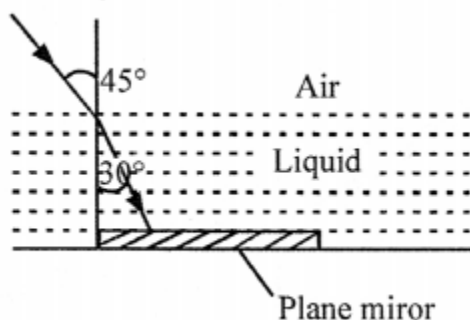
(a) (i) Copy the diagram and complete the path of the ray of light through the glass block. In your diagram, mark the angle of incidence by letter "i" and the angle of emergence by the letter "e"



(ii) How are the angle 'i' and 'e' related to each other?

(b) A ray of monochromatic light enters a liquid from air as shown in the diagram.

(i) Copy the diagram and show in the diagram the path of the ray of light after it strikes the mirror and reenters the medium of air.



(ii) Mark in your diagram the two angles on the surface of separation when the ray of light moves out from the liquid to air.

(c) (i) When does a ray of light falling on a lens pass through it undeviated ?

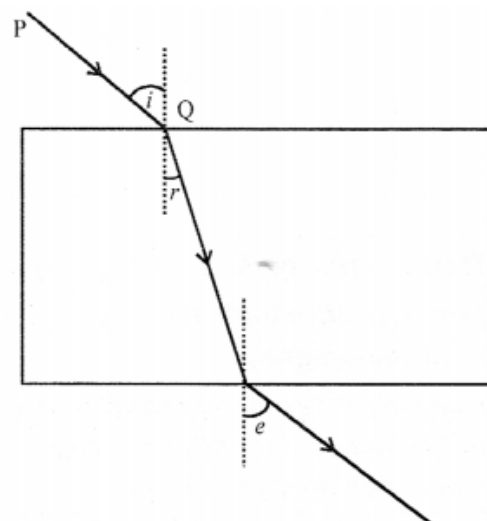
(ii) Which lens can produce a real and inverted image of an object ?

(d) (i) How is the refractive index of a medium related to its real depth and apparent depth?

(ii) Which characteristic property of light is responsible for the blue colour of the sky ?

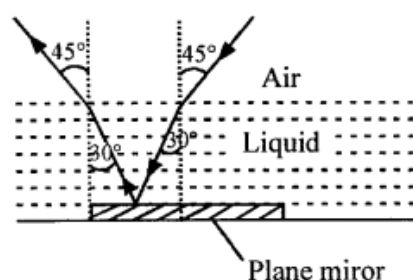
Answer:

(a) (i)



(ii) $\angle i = \angle e$ (Corresponding angles)

(b) (i), $\angle i = 30^\circ$, $\angle r = 45^\circ$



(c) (i) A ray of light passing through the optical centre of the lens passes through it undeviated.

(ii) Convex lens.

(d) (i)
$$\text{Refractive index} = \frac{\text{Real depth}}{\text{Apparent depth}}$$

(ii) Effects of scattering.

The blue or violet light due to its short wavelength is scattered more as compared to red light of long wavelength.

Question 26.

(a) (i) State the laws of refraction of light.

(ii) Write a relation between the angle of incidence (i), angle of emergence (e), angle of prism (A) and angle of deviation (d) for a ray of light passing through an equilateral prism.

(b) An object is placed in front of a lens between its optical centre and the focus and

forms an erect, virtual, and diminished image.

(i) Name the lens which formed this image.

(ii) Draw a ray diagram to show the formation of the image.

Answer:

(a)

(i) Laws of Refraction :

(a) The incident ray, the refracted ray and the normal at the point of incidence, all lie in the same plane.

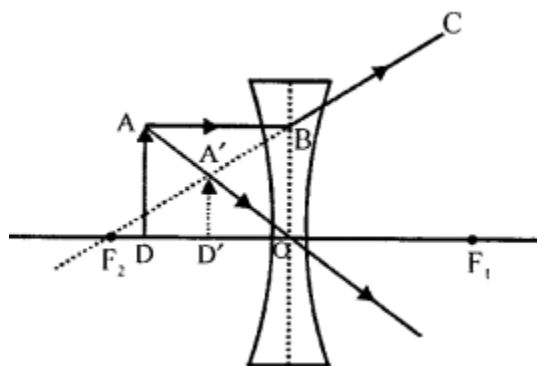
(b) The ratio of the sine of the angle of incidence to the sine of the angle of refraction is constant for the pair of given media.

(ii) $\angle i + \angle e = A + d$

(b)

(i) Lens is concave.

(ii) AD is object between focus and optical centre A'D' is image. The ray diagram is shown.



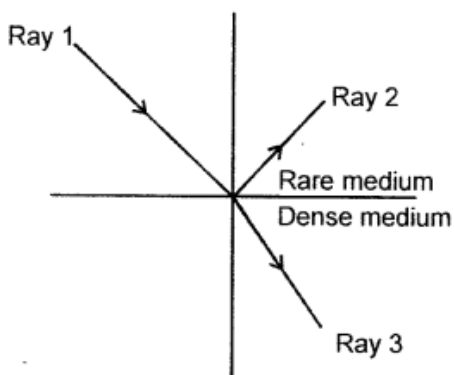
2012

Question 27.

(a)

(i) Define refractive index of a medium in terms of velocity of light.

(ii) A ray of light moves from a rare medium to a dense medium as shown in the diagram below. Write down the number of the ray which represents the partially reflected ray.



- (b) You are provided with a printed piece of paper. Using this paper how will you differentiate between a convex lens and a concave lens ?
- (c) A ray of light incident at an angle of incidence 'V' passes through an equilateral glass prism such that the refracted ray inside the prism is parallel to its base and emerges from the prism at an angle of emergence 'e'
- (i) How is the angle of emergence 'e' related to the angle of incidence 'i' ?
- (ii) What can you say about the value of the angle of deviation in such a situation ?

Answer:

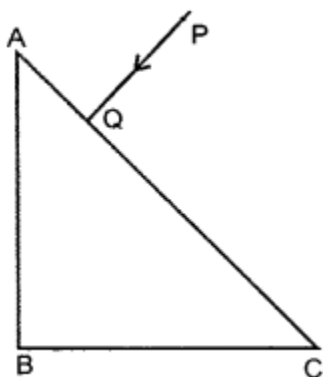
- (a) (i) Refractive index of a medium is the ratio of velocity of light in vacuum or air to the velocity of light in a given medium.

$$R.I. = {}^{air}\mu_{medium}$$

- (ii) Ray 2, represents partially reflected ray.
- (b) Hold each of the lens 5 cm above the printed paper and look for the image. In case of convex lens the print appears enlarged. However, in case of concave lens, the print appears diminished.
- (c) (i) Angle of incidence is equal to the angle of emergence
- (ii) The angle of deviation is minimum in this particular case.

Question 28.

- (a)
- (i) What is meant by the term 'critical angle' ?
- (ii) How is it related to the refractive index of the medium?
- (iii) Does the depth of a tank of water appear to change or remain the same when viewed normally from above ?
- (b) A ray of light PQ is incident normally on the hypotenuse of a right angled prism ABC as shown in the diagram given alongside :



- (i) Copy the diagram and complete the path of the ray PQ till it emerges from the prism.
- (ii) What is the value of the angle of deviation of the ray ?
- (iii) Name an instrument where the action of the prism is used.
- (c) A converging lens is used to obtain an image of an object placed in front of it.

The inverted image is formed between F_2 and $2F_2$ of the lens.

(i) Where is the object placed ?

(ii) Draw a ray diagram to illustrate the formation of the image.

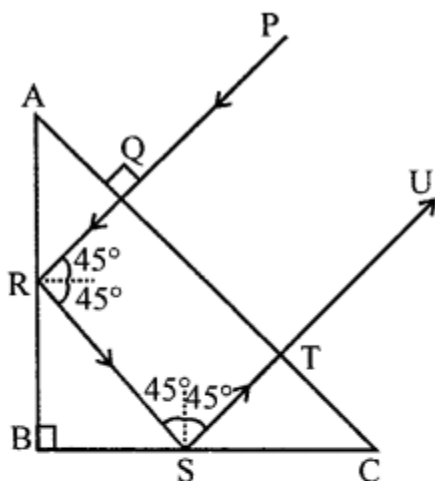
Answer:

(a) (i) The angle of incidence in a denser medium for which angle of refraction in rarer medium is 90° is called critical angle.

(ii) Refractive index (μ) = $1/\sin C$

(iii) The depth of tank remains same when viewed normally from above.

(b) (i)

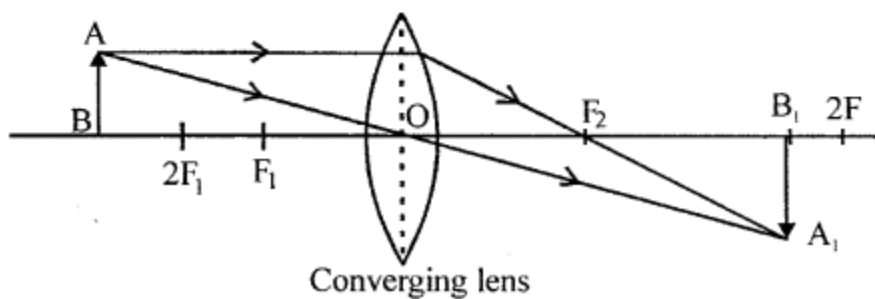


(ii) The ray deviates through 180° .

(iii) This action of prism is used in camera to invert the image.

(c) (i) The object is anywhere between $2F_1$ and infinity.

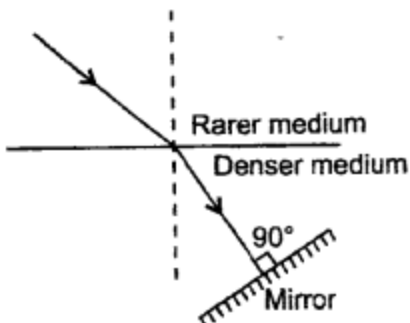
(ii)



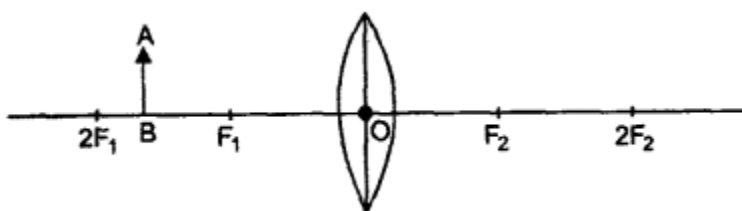
2013

Question 29.

(a) A ray of light is moving from a rarer medium to a denser medium and strikes a plane mirror placed at 90° to the direction of the ray as shown in the diagram.



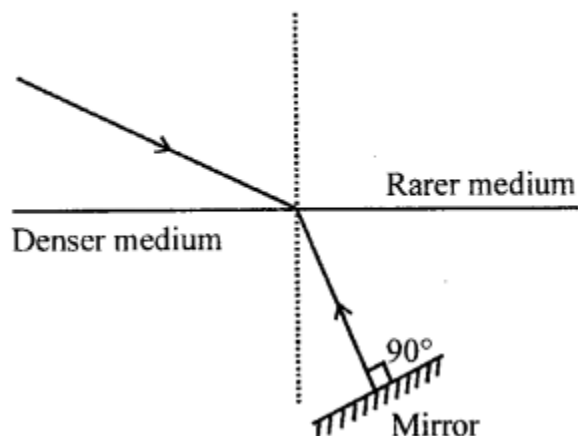
- (i) Copy the diagram and mark arrows to show the path of the ray of light after it is reflected from the mirror.
- (ii) Name the principle you have used to mark the arrows to show the direction of the ray.
- (b)** (i) The refractive index of glass with respect to air is 1.5. What is the value of the refractive index of air with respect to glass ?
- (ii) A ray of light is incident as a normal ray on the surface of separation of two different mediums. What is the value of the angle of incidence in this case ?
- (c)** (i) Can the absolute refractive index of a medium be less than one ?
- (ii) A coin placed at the bottom of a beaker appears to be raised by 4.0 cm. If the refractive index of water is $\frac{4}{3}$, find the depth of the water in the beaker.
- (d)** An object AB is placed between $2F_1$ and F_1 on the principal axis of a convex lens as shown in the diagram.



Copy the diagram and using three rays starting from point A, obtain the image of the object formed by the lens.

Answer:

(a) (i)



(ii) The principle is the law of reversibility of light

(b) (i) R.I. of glass ${}^a\mu_g = 1.5$

$\therefore$ R.I of air with respect to glass

$${}^g\mu_a = \frac{1}{{}^a\mu_g} = \frac{1}{1.5} = \frac{2}{3} = 0.67 \text{ (Approx.)}$$

(ii) Angle of incidence is zero. *i.e.* $\angle i = 0$

(c) (i) Yes, when a ray travels from glass (or any denser medium) to air, the absolute refractive index of air is less than 1.

(ii) Let the real depth of water = x

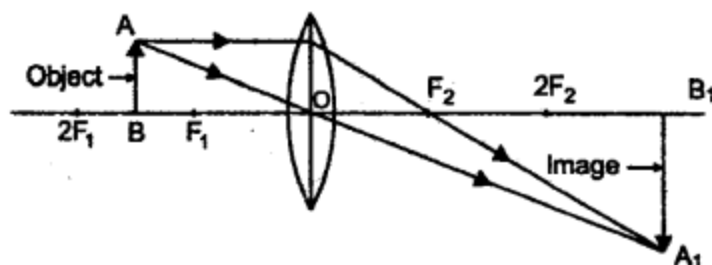
Apparent depth of water = $(x - 4)$ cm.

$$\text{Now, refractive index of water} = \frac{\text{Real depth}}{\text{Apparent depth}} \Rightarrow \frac{4}{3} = \frac{x}{x - 4}$$

$$\text{or } (4x - 16) = 3x$$

$$\therefore \text{Real depth} = x = 16 \text{ cm}$$

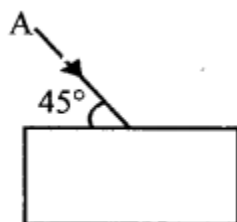
(d)



2014

Question 30.

(a) Draw the diagram given below and clearly show the path taken by the emergent ray.

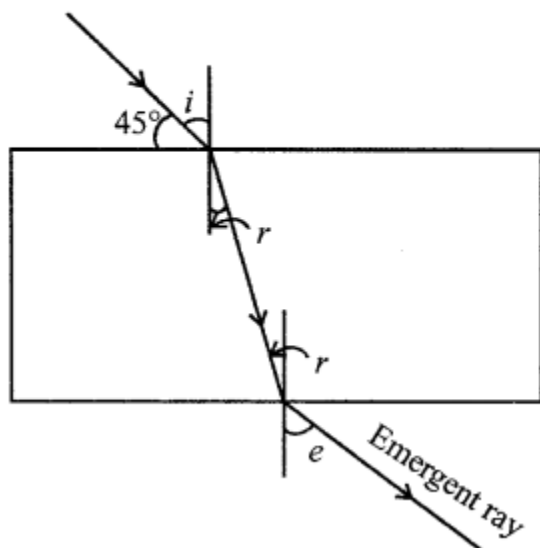


(b) (i) A ray of light passes from water to air. How does the speed of light change?

- (ii) Which colour of light travels fastest in any medium except air? [2]
 (c) Name the factors affecting the critical angle for the pair of media.

Answer:

(a)



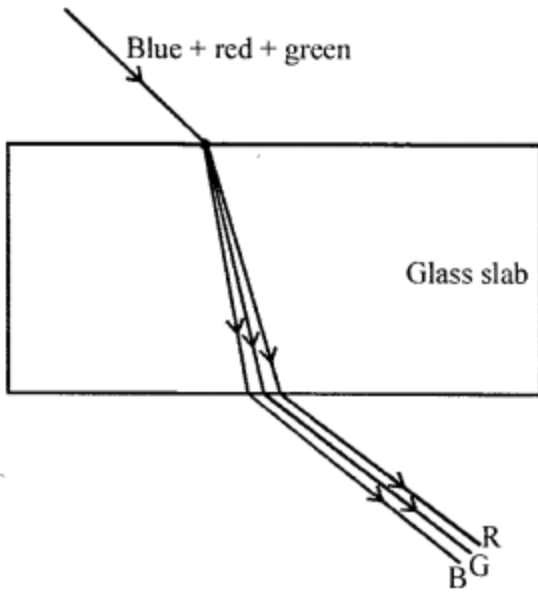
- (b) (i) As the ray of light comes out of water into air (rarer medium) speed of light increases.
 (ii) Red colour of light travels fastest in any medium except air.
 (c) Factors affecting the critical angle for the pair of media are :
 (i) Effect of colour (least for violet, most for red)
 (ii) Effect of Temperature i.e. an increasing the temperature of medium, critical angle increases

Question 31.

- (a) (i) Light passes through a rectangular glass slab and through a triangular glass prism. In what way does the direction of the two emergent beams differ and why?
 (ii) Ranbir claims to have obtained an image twice the size of the object with a concave lens. Is he correct? Give a reason for your answer. [4]
 (b) A lens forms an erect, magnified and virtual image of an object.
 (i) Name the lens.
 (ii) Draw a labelled ray diagram to show the formation of the image.
 (c) (i) Define the power of a lens.
 (ii) The lens mentioned in 2(b) above is of focal length 25 cm. Calculate the power of the lens.

Answer:

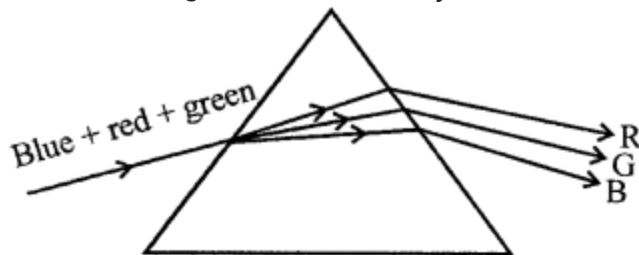
- (a) In case of glass slab the refraction takes place at two parallel surfaces. On the first surface, the colours are separated and dispersion takes place.



On the second surface refraction takes place and emergent ray is parallel to the incident ray on the first surface and emergent ray appears to be almost white. In a prism, refraction takes place at two INCLINED surfaces and causes DISPERSION and DEVIATION of light and spectrum is seen.

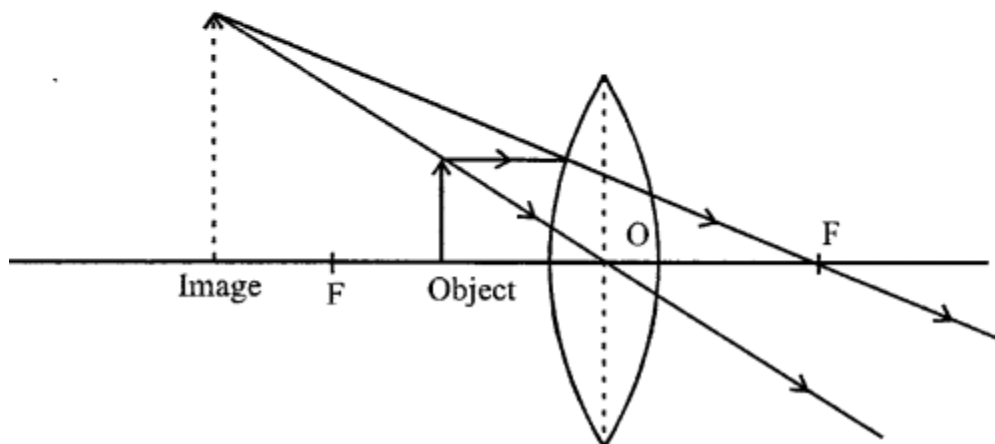
(ii) No, he is not correct.

With concave lens, image formed is always DIMINISHED



(b) (i) Convex lens.

(ii)



(c) (i) The power of a lens is a measure of deviation produced by it in the path of rays refracted through it.

$$(ii) \text{ Power of lens (in D)} = \frac{1}{\text{Focal length (in metre)}}$$

$$= \frac{100}{\text{Focal length (in centimetre)}}$$

$$= \frac{100}{25} = 4D.$$

2015

Question 32.

1. Name one factor that affects the lateral displacement of light as it passes through a rectangular glass block.
2. The speed of light in glass is 2×10^8 km/s. What is the refractive index of glass?

Answer:

1. The thickness of the glass block, angle of incidence and refractive index of glass (any one) are the factors which affect the lateral displacement of light as it passes through a rectangular glass slab.
2. **Given :**
Speed of light in glass = 2×10^8 km/s = 2×10^5 m/s
Refractive index of glass is

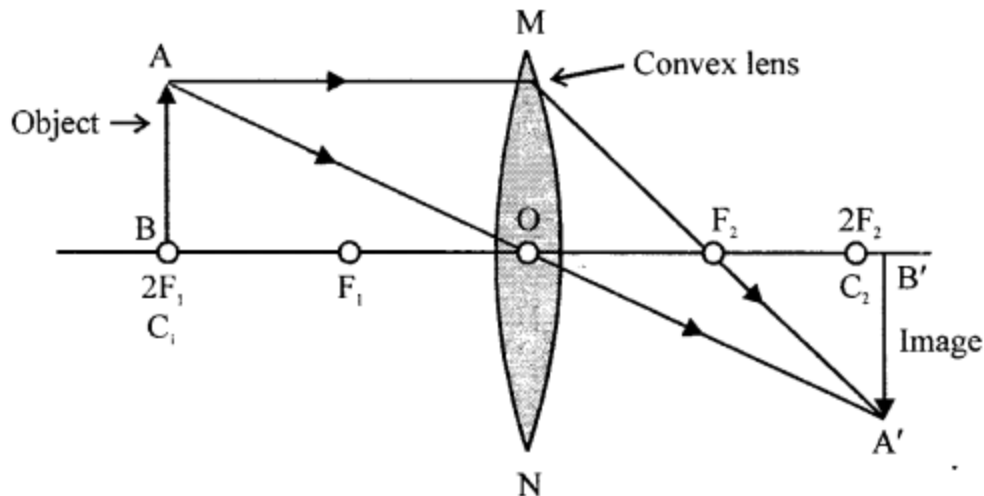
$$\mu_{\text{glass}} = \frac{\text{Speed of light in air}}{\text{Speed of light in glass}} = \frac{3 \times 10^8 \text{ km/s}}{2 \times 10^8 \text{ km/s}} = 1.5$$

Question 33.

- (a) (i) Where should an object be placed so that a real and inverted image of the same size as the object is obtained using a convex lens ?
- (ii) Draw a ray diagram to show the formation of the image as specified in the part a(i).

Answer:

- (i) When an object is placed at $2F_1$ of a convex lens, a real and inverted image of the same size as that of the object is formed at $2F_2$
- (ii) The ray diagram for the same is as shown below :



(b) Jatin puts a pencil into a glass container having water and is surprised to see the pencil in a different state. [4]

- (i) What change is observed in the appearance of the pencil?
- (ii) Name the phenomenon responsible for the change.
- (iii) Draw a ray diagram showing how the eye sees the pencil.

Answer:

1. The pencil appears to be broken at the junction of water, air separation i.e. it also appears shorter and raised.
2. The phenomenon responsible for the above observation is the refraction of light and APPARANT DEPTH in passing from water to air.
3. The ray diagram for the same is as shown below :

2016

Question 34.

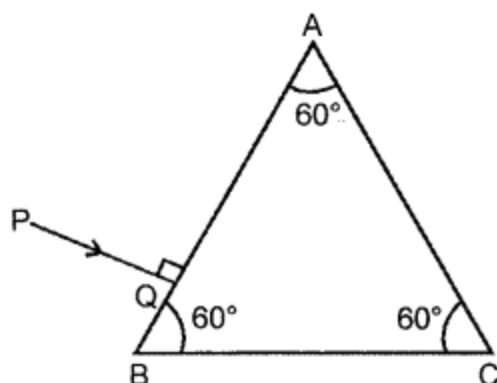
(a) A boy uses blue colour of light to find refractive index of glass. He then repeats experiment using red colour of light. Will the refractive index be same or different in the two cases? Give a reason to support your answer.

Answer:

The refractive index will be different in both cases.

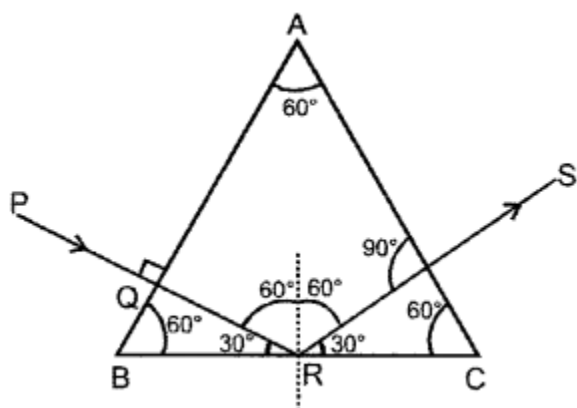
Refractive index of glass is different for different colours. The speed of blue light is less than the speed of red light. So, the wavelength of blue light is less than that of red light. Thus, red light would deviate less than blue light because of difference in wavelength.

(b)



Copy the diagram given above and complete the path of ray till it emerges out of prism. The critical angle of glass is 42° . In your diagram mark the angles wherever necessary.

Answer:



(c) State the dependence of angle of deviation :

1. On refractive index of a material of prism.
2. On the wavelength of light

Answer:

(i) Angle of deviation is directly proportional to the refractive index of the material of prism. For a given angle of incidence, the prism with higher refractive index produces a greater deviation than the prism which has a lower refractive index. Thus, the angle of deviation increases with an increase in the refractive index of the medium.

(ii) Angle of deviation is inversely proportional to the wavelength of the light used. The angle of deviation decreases with an increase in the wavelength of light. Thus, a prism deviates violet light the most and red light the least.

Question 35.

(a)

1. Write a relationship between the angle of incidence and the angle of refraction for a given pair of media.
2. When a ray of light enters from one medium to another medium having different optical densities, it bends, why does this phenomenon occur ?
3. Write a condition where it does not bend when entering a medium of different optical density.

(b) A lens produces a virtual image between the object and the lens.

1. Name the lens
2. Draw a ray diagram to show the formation of image.

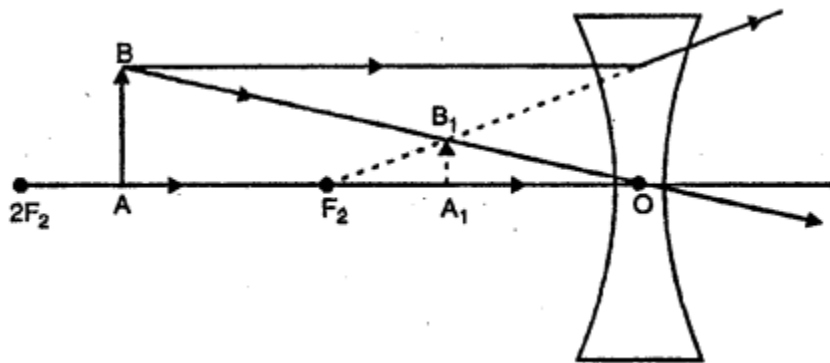
Answer:

- (i) The ratio of the sine of the angle of incidence to the sine of the angle of refraction is constant for a given pair of media called the refractive index $= \sin i / \sin r = \mu$
- (ii) When a ray of light enters from one medium to another with different optical densities, it bends because there is a change in the speed of light in the two media.
- (iii) A ray of light passing from one medium to another does not bend when it is incident normally on the surface.

(b)

(i) The image formed by the lens is virtual and between the object and the lens. Hence, the lens used is a concave lens.

(ii) The following image is of formation of the above image :



Electromagnetic Waves and Spectrum

Exercise – 1

Question 1.

What is the range of wavelength of visible light?

Answer:

Range of wavelength of visible light: $4000 \text{ \AA}$ to $8000 \text{ \AA}$.

Question 2.

What do you understand by the term colour ?

Answer:

Colour : “Is a sensation produced in the brain and is not some thing material.”

Or

“Is a sensation produced in the brain due to excitation of the retina, by an electromagnetic wave of some particular wave length.

Question 3.

(a) Define :

1. monochromatic light,
2. polychromatic light.

(b) Is white light polychromatic or monochromatic ? Explain your answer.

Answer:

(a) (i) **Monochromatic light** : “A light which consists of one colour (or one wave length) only is called monochromatic light)”

(ii) **Polychromatic light** : “A light which consists of a mixture of several colours (wave bands) is called polychromatic light”.

(b) White light is a polychromatic light and has all the seven wavebands present in it.

Question 4.

Define or explain the following terms :

1. dispersion of light
2. spectrum

Answer:

(i) **Dispersion of light** : “The phenomenon of splitting white light into its components (seven colours) when passed through a prism is called dispersion.”

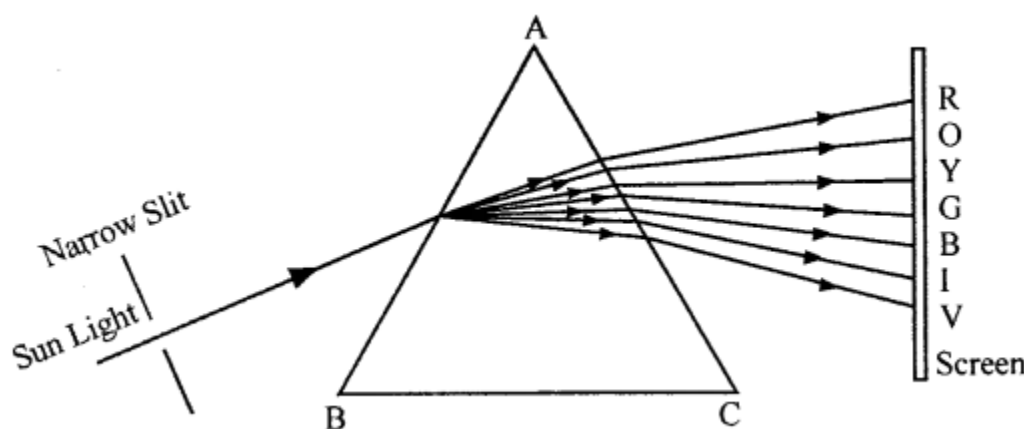
(ii) **Spectrum** : “The band of colours obtained on the screen when a polychromatic (white) light splits into seven colours is called spectrum.”

Question 5.

Draw a neat diagram for the dispersion of white light by a prism and label all the colours of the spectrum.

Answer:

Dispersion of white light by prism:



Question 6.

Is the spectrum obtained by an equilateral glass prism pure or impure ? Explain your answer.

Answer:

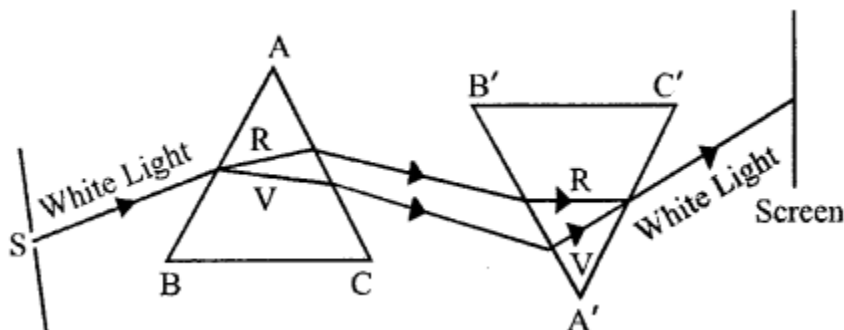
Spectrum obtained is impure as colours overlap each other.

Question 7.

Draw a diagram showing that white light can be dispersed and then recombined by using two similar equilateral prisms.

Answer:

Dispersion and recombination of white light:



Question 8.

- (a) What is ultraviolet spectrum ? What is the range of its wavelength in Å ?
- (b) State four important properties of ultraviolet rays.
- (c) State four uses of ultraviolet rays.

Answer:

(a) **Ultraviolet spectrum :** "The region of spectrum which extends beyond the violet colour of visible spectrum is called ultraviolet spectrum."

(b) **Four properties of ultra violet :**

1. They are electromagnetic waves and are not effected by: Electric Or Magnetic fields.
2. They obey the laws of refraction and reflection.
3. They travel with velocity 3×10^5 km/sec
4. "I'hey produce chemical effect in silver salts.

(c) **Four uses of U.V. :**

1. U.V. arc used to detect adulteration in ghee because of its property of fluorescence.
2. Used to sterilise surgical instruments and drinking water.
3. U.v. absorbed by skin stimulates body to produce vitamin D, which is very good for growth of bones and teeth.
4. U.V. are used to detect original diamonds from fake diamonds.

Question 9.

- (a) What are infrared rays ? What is the range of wavelengths of infrared rays in Å ?
- (b) State four important properties and four uses of infrared rays ?

Answer:

(a) Infrared rays : "The electromagnetic radiations beyond red end of the visible spectrum are called infrared rays : Their range is $8000 \text{ \AA}$ to $10^7 \text{ \AA}$."

(b) Four properties of infra red rays :

1. I.R. rays are least scattered by fog, mist etc. as they have long wavelength.
2. They can be detected by a thermopile or a thermometer with a blackend bulb, as they produce heating effect.
3. They travel with vel. of light i.e. $3 \times 10^8 \text{ ms}^{-1}$
4. They are electromagnetic wave and hence are not affected by electromagnetic fields.

Four uses of infra red rays :

1. They are used to detect diseases in crops which are used to find any change in heat radiation pattern and help in early warning to save crops.
2. Patients with swollen joints, muscles, etc. feel relieved when exposed to these radiations.
3. These are used in night vision devices.
4. They are used in surface to air missiles for tracking and destroying enemy planes.

Question 10.

Write the names of all the components of electromagnetic spectrum in the order of increasing frequency.

Answer:

Components of electromagnetic spectrum in order of increasing frequency :

Radio wave microwave infra-red visible ultra violet, X rays, Gamma rays

→ $3 \times 10^7 \text{ Hz}$ $3 \times 10^{11} \text{ Hz}$ 7.5×10^{14} $3.75 \times 10^{14} - 3 \times 10^{16} \text{ Hz}$ $3 \times 10^{19} \text{ Hz}$

Question 11.

What do you understand by the term "scattering of light"? Which colour of white light is scattered the least and why?

Answer:

Scattering : "When an incident light strikes a particle which has a diameter greater than the wavelength of incident light, then the incident light is absorbed by the particle and transmitted in all possible directions. This phenomenon is called scattering."

Red colour of white light is scattered the least.

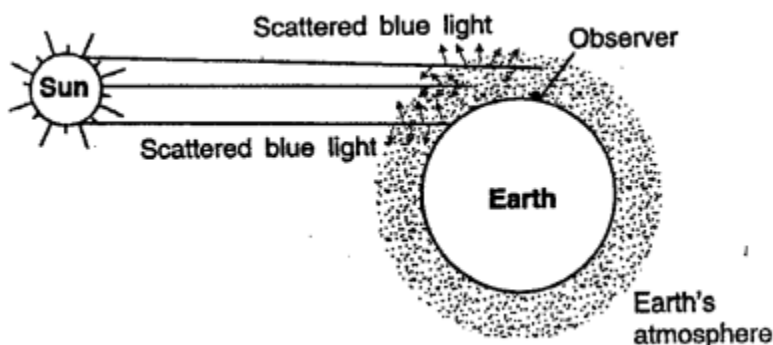
Question 12.

Explain the following :

- (a) Why does the sun appear red during sunrise or sunset?
- (b) Why does the sky appear blue on the earth, but black on the moon ?
- (c) Why are orange or yellow lights used as fog lights in automobiles ?
- (d) Why do the distant hills appear blue ?
- (e) Why does the sky appear blue, instead of violet ?

Answer:

(a) Sun appears red during sun rise or sun set : Blue colour of short wave length scatters the most, while red light of long wave length scatters least (white-blue = red) red light reaches us and sun appears red



- (b) Sky appears blue on earth but black on moon :** Light from sun has to travel longer distance to reach us. Short wave length blue colours scatters more than red colour. Light reaching our eye from all directions is scattered blue, hence sky appears blue. Where as there is no atmosphere on moon, no scattering of light takes place and it appears black on moon.
- (c)** Red colour of longer wave length scatters least by air molecules of atmosphere and red light can be seen from farthest distance (without getting weak) hence are used as fog lights in automobiles.
- (d) Distant hills appear :** Blue because of scattering of blue light by water vapours present in air.
- (e)** As light passes through atmosphere indigo and blue both scatter because size of particles of present in air go on increasing and sky appears blue because blue light reaches us from particles scattering blue colour which are nearest to the eye.

Multiple Choice Questions

Tick (✓) the most appropriate option.

1. Visible light has electromagnetic waves between :

- (a) 8000 Å to 6000 Å
- (b) 8000 Å to 1000 Å

- (c) $8000 \text{ \AA}$ to $4000 \text{ \AA}$
- (d) $8000 \text{ \AA}$ to $2000 \text{ \AA}$

Answer:

- (c) $8000 \text{ \AA}$ to $4000 \text{ \AA}$

2. 1 Angstrom unit ($\text{\AA}$) is equal to :

- (a) 10^{-10} m
- (b) 10^{-12} m
- (c) 10^{-8} m
- (d) 10^6 m

Answer:

- (a) 10^{-10}

3. The most visible colour of visible spectrum is :

- (a) blue
- (b) red
- (c) green
- (d) orange

Answer:

- (b) red

4. The band of seven colours formed, when white light passes through an equilateral prism is called :

- (a) dispersion
- (b) colour band
- (c) spectrum
- (d) none of these

Answer:

(c) spectrum

5. Violet, green, red and yellow are the four colours formed on a white screen when a polychromatic light is dispersed. The arrangement of colours in the decreasing order of wave lengths is :

- (a) green, red, yellow and violet
- (b) red, yellow, green and violet
- (c) violet, green, yellow and red
- (d) violet, green, red and yellow

Answer:

(b) red, yellow, green and violet

6. The angle of deviation is maximum for when the dispersion of polychromatic light takes place

- (a) red
- (b) violet
- (e) green
- (d) blue

Answer:

(b)violet

7. Which is not a source of ultraviolet radiations ?

- (a) Sun
- (b) Arc lamp
- (c) Electric heater
- (d) Star

Answer:

(c) Electric heater

8. The electromagnetic radiation which are useful in night photography is:

- (a) infrared rays
- (b) ultraviolet rays
- (e) visible light
- (d) X-rays

Answer:

- (a) infrared rays

9. The electromagnetic wave associated with high energy is:

- (a) ultraviolet ray
- (b) X-ray
- (e) gamma ray
- (d) infrared ray

Answer:

- (c) gamma ray

10. During the Sunset the colour which scatters closest to the eye of observer is:

- (a) yellow
- (b) red
- (c) blue
- (d) violet

Answer:

- (b) red

11. Infrared rays with very large wavelength are easily reflected by

- (a) air
- (b) glass
- (c) carbon dioxide molecules
- (d) both (b) and (c)

Answer:

(c) carbon dioxide molecules

12. X-rays are produced by

- (a) oscillating circuits in special vacuum tubes
- (b) excitation of outermost electronic shell of an atom
- (c) excitation of inner electron of atom and is sudden annihilation of high energy free electrons.
- (d) nucleus of an atom, by the destruction of high energy particle.

Answer:

(c) excitation of inner electron of atom and is sudden annihilation of high energy free electrons.

Questions from ICSE examination papers 2005

2005

Question 1.

Name any two electromagnetic waves which have a frequency higher than that of violet light. State one use of each.

Answer:

Two ELECTROMAGNETIC WAVES are :

1. **X-rays Use :** are used for medical purposes.
2. **Gamma-rays :** Use : are used to cure cancer.

Question 2.

A glass slab is placed over a page on which the word vibgyor is printed with, each letter in its corresponding colour.

- (a) Will the image of all the letters be in the same place ?
- (b) If not, which letter will be raised to the maximum. Give a reason for your answer.

Answer:

- (a) No, the image of all letters will not be at the same place.
- (b) Letter V will be raised maximum. This is because the refractive index of a material depends inversely upon the wavelength of light. On the other hand the shift in the image depends directly on the refractive index. Since the refractive index of a material is

maximum for violet light, therefore letter V which is written with violet colour is raised the maximum.

2006

Question 3.

Give one use each of the following electromagnetic radiations given below

- (a) Microwaves
- (b) Ultraviolet radiation,
- (c) Infrared radiation.

Answer:

Uses of:

- (a) microwaves _____ for cooking, In radar for communication.
- (b) Ultraviolet radiation _____ for sterilising purposes.
- (c) Infrared radiation _____ used in remote control of T.V. and as signals during war.

2007

Question 4.

Why are infrared radiations preferred over ordinary visible light for taking photographs in fog ?

Answer:

INFRARED RADIATIONS have very long wavelength, they do not easily get scattered in fog or smoke. Thus they can be used for taking infra-red photographs with suitable photographic plates and filters in foggy weather.

Question 5.

- (a) A particular type of high energy invisible electromagnetic rays help us to study the structure of crystals. Name these rays and give another important use of these rays,
- (b) How does the speed of light in glass change on increasing the wavelength of light ?

Answer:

- (a) The high energy invisible electromagnetic rays used in the study of the structure of crystals are X-rays. These X-rays find a wide application in locating the presence of foreign bodies in the human body.
- (b) The speed of the waves of higher wavelength is more i.e., the speed increase with wavelength.

2009

Question 6.

- (a) Why is white light considered to be polychromatic in nature?
(b) Give the range of the wavelength of those electromagnetic waves which are visible to us.

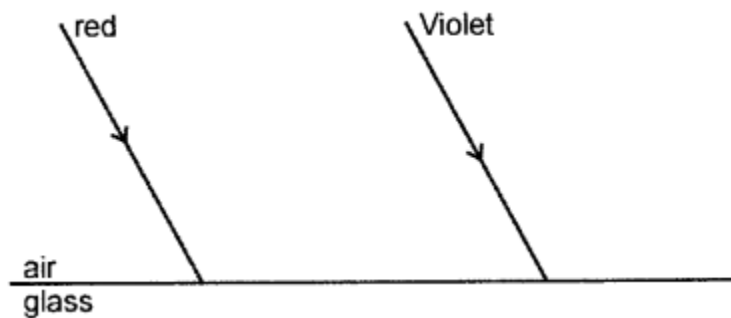
Answer:

- (a) White light is made up of 7 colours viz. As all seen colours have same speed in vacuum/air, so it appears white. Polychromatic means – number of colours combined so white light is actually polychromatic in nature.
(b) Visible waves have wavelength range between $4000 \text{ \AA} - 8000 \text{ \AA}$ (where $1 \text{ \AA} = 10^{-10} \text{ m}$)

2010

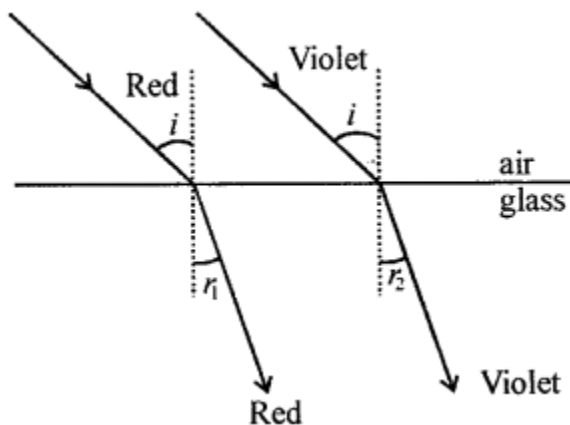
Question 7.

Two parallel rays of Red and Violet travelling through air, meet the air-glass boundary as shown in the figure:



- (a) Will their paths inside the glass be parallel? Give a reason for your answer.
(b) Compare the speeds of the two rays inside the glass.

Answer:



The two refracted rays inside glass are not parallel . Because the refractive index of glass is less for Red light, while it is more for violet light ($\mu_r < \mu_v$), So RED ray is deviated less while the violet is deviated more i.e. angle of refraction r_1 for red is more than angle of refraction r_2 for violet ray.

(a) Since the refractive index of glass for violet colour is more. ($\mu_r < \mu_v$) SO, in glass, the red light travel faster than violet light. The paths inside the glass will not be parallel.

(b) Velocity of red colours will be more than that of the violet colour.

2011

Question 8.

(a) Suggest one way, in each case, by which we can detect the presence of:

1. Infrared radiations.
2. Ultraviolet radiations.

(b) Give one use of Infrared radiations.

Answer:

(a) Way to detect :

1. Infrared radiations : If we move a thermometer with blackend bulb from violet to red end of a visible spectrum, there is a slight rise in temperature and if the bulb is moved in the region beyond red, there is sudden rise in temperature, this proves that the region beyond red is not visible and produces heating effect is Infrared region.

2. Ultraviolet radiations : When a silver chloride (Ag Cl) paper is placed in the region beyond violet, the paper first turns violet, then BROWN and finally black. This proves that there is a region beyond violet which is invisible and produces. Strong chemical effect in silver chloride is known as Ultraviolet regions.

(b) One use of infrared radiation : Used in remote control of t.v. and other gadgets.

2012

Question 9.

(a) What is meant by 'Dispersion of light' ?

(b) In the atmosphere which colour of light gets scattered the least ?

Answer:

- (a) The phenomenon due to which white light splits into component colours on passing through a prism is called dispersion of light.
- (b) Red colour scatters least in the atmosphere.

2013

Question 10.

Name the radiations :

- (a) that are used for photography at night
- (b) used for detection of fracture in bones.
- (c) whose wavelength range is from 100 Å to 4000 Å (or 10 nm to 400 nm).

Answer:

- (a) infrared radiation
- (b) X-rays
- (c) Ultraviolet radiation.

2014

Question 11.

- (a) Name the prism required for obtaining a spectrum of Ultraviolet light.
- (b) Name the radiations which can be detected by a thermopile.

Answer:

- (a) Quartz prism.
- (b) Infrared radiations can be detected by thermopile.

Question 12.

Why is red colour used as a sign of danger?

Answer:

Since the wavelength of red light is maximum in the visible light, the light of red colour is scattered least by the air molecules of the atmosphere and therefore it can reach to a longer distance.

2015

Question 13.

- (a) Why does the Sun appear red at sunrise?
- (b) Name the subjective property of light related to its wave-length.

Answer:

- (a) The Sun appears red at sunrise because of the scattering of light by the atmospheric particles. During sunrise, the light from the Sun has to travel a longer distance through the atmosphere to reach the observer. During this, most of the shorter wave-lengths present in it are scattered away from our line of sight by the molecules of air and other fine particles in the atmosphere. So, the light reaching us directly from the rising Sun consists mainly of longer wavelength red colour due to which the Sun appears red.
- (b) The subjective property of light related to its wavelength is frequency.

Question 14.

- (a) Name the high energetic invisible electromagnetic waves which help in the study of the structure of crystals.
- (b) State an additional use of the waves mentioned in part (a).

Answer:

- (a) X-rays are used in the study of structure of crystals.
- (b) X-rays are used in the detection of fracture in bones and teeth.

2016

Question 15.

What do you understand by the term "Scattering of light"? Which colour of white light is scattered least and why ?

Answer:

Scattering of light is the phenomenon due to which a particle having a diameter greater than the wavelength of light incident on it absorbs the light and then transmits it in all possible directions.

The red colour of the white light is scattered the least because scattering of light depends inversely upon the four power of wavelength. As red colour has the maximum wavelength in the visible region, therefore, it scattered the least.

Sound

Exercise – 1

Question 1.

(a) State the laws of reflection of sound.

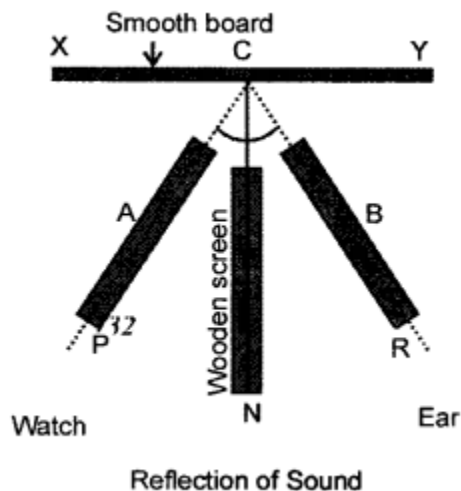
(b) How will you verify laws of reflection of sound experimentally ?

Answer:

(a) **Laws of reflection of sound :**

1. Angle of incidence is equal to the angle of reflection. $\angle i = \angle r$
2. Incident wave, reflected wave and the normal lie in the same plane.

(b) **Verification of laws of reflection :** Take a smooth polished large wooden board and mount it vertically on a table. At right angle to the board fix a wooden screen on each side of the screen place a long, narrow and highly polished tube from inside. Place a watch at the end A. Move the tube B slightly left or right till distinct tick of water is heard. Measure $\angle PKN$ and $\angle BKN$.



It is found that $\angle PKN = \angle BKN$. This verifies the laws of reflection.

Question 2.

Describe any two applications of reflection of sound.

Answer:

(i) **Megaphone :** People use horn shaped metal tubes commonly called megaphones while addressing a group of people in fairs or tourist spots. Sound energy is prevented from spreading out by successive reflections from the horn shaped tubes.

(ii) **Hearing aid :** Its shape is like a trumpet the narrow end is kept in the ear tube of the person who is hard of hearing. Whereas the wider end towards the speaker collects the

waves and reflects into the narrow end. This increases the intensity of sound energy hence the person who is hard of hearing can hear clearly.

Question 3.

(a) What is an echo ?

Answer:

ECHO : "The repeated sound heard after reflection from a distant rigid obstacle (such as cliff, a hill side, wall of a building, edge of forest etc.) after the original sound has ceased is called an ECHO."

(b) State two conditions necessary for the formation of an echo.

Answer:

Two conditions for forming an echo :

1. The minimum distance between the source of sound and the reflecting body should be 17 metres.
2. The intensity of sound should be sufficient so that it can be heard after reflection.

Question 4.

What are reverberation ? Give two examples.

Answer:

Reverberation : "Due to repeated reflections at the reflecting surface (reflector is less than 17 metres from original sound) the sound gets prolonged, This effect is known as reverberation."

Example :

1. Speaking in a large empty room.
2. Clapping in tombs like TajMahal.

Question 5.

How will you determine speed of sound by the method of echos ?

Answer:

In order to determine the speed of sound in air, sound produced from a place at known distance d at least 50 m from the reflecting surface. The time interval t in which the echo reaches the place from where sound was produced is noted by a stop watch. Then speed of sound is calculated

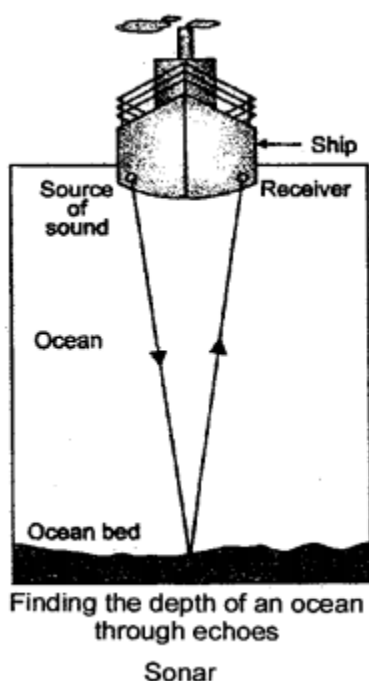
as $v = \text{total distance travelled} / \text{time interval} = 2d / t \text{ ms}^{-1}$

Question 6.

What is sonar ? State its principle. How is it used to find the depth of sea ?

Answer:

SONAR : “Sound Navigation and Ranging.” It is based on the principle of ECHO.



ultra- sonic waves are sent in all directions from the ship and then are received on their return after reflection. Using the formula an obstacle such as enemy submarine, ice berg, a sunken ship etc. The time interval between sending and receiving of wave is noted. The distance (depth) can be calculated by vis speed of ultrasonic waves in water.
 $v = 2d/t$ or $d = Vt/2$

Question 7.

How do bats locate their prey ? Explain in detail.

Answer:

Location of prey by bats :

Bats can produce and detect the sound of very high frequency up to 10 kHz. The sound produced by bats get reflected back from an obstacle in front of it. These echoes tell the bat how they must turn in the air to avoid collision with obstacles. By using their ears, the bats, can fly skilfully at night in the utter darkness of caves. The highly sensitive nose of a bat acts as a recorder and picks up air vibrations set in motion by the movements of other animals. It appears that the nose and ears of the bats are important factors in the radar like operation.

Question 8.

How do the following use echoes ?

1. army,

2. geologists,
3. fishermen.

Answer:

(i) **army** : Echoes are used by army to locate the gun position of enemy. Radar an instrument is used to locate an enemy air-craft ship.

(ii) **geologists** : Echoes are used by geologists for mineral prospecting.

(iii) **fishermen** : for locating fishes ultrasonic waves are sent into water. If these vibrations strike a fish, they are reflected back to the receivers. The time for hearing the echoes recorded. The position of fish is calculated by $d = v \times t/2$ using vel. of sound in water as 1450 ms^{-1} .

Multiple Choice Questions

Tick (✓) the most appropriate option.

Question 1.

The practical application based on the reflection of sound is:

- (a) megaphone
- (b) sounding board
- (c) sonometer
- (d) both (a) and (b)

Answer:

- (d) both (a) and (b)

Question 2.

Which is not the condition for the formation of echoes ?

- (a) Minimum distance between the source of sound and reflecting body should be 17 m.
- (b) The temperature of air should be above 20°C .
- (c) The wavelength of sound should be less than the height of the reflecting body.
- (d) The intensity of sound should be sufficient so that it could be heard after reflection.

Answer:

- (a) Minimum distance between the source of sound and reflecting body should be 17 m.

Question 3.

For hearing an echo, the minimum distance between the source of sound and reflecting body should be

- (a) 12 m
- (b) 24 m
- (c) 17 m
- (d) 51 m

Answer:

- (c) 17m

Question 4.

To locate its prey in the darkness the owl or the bat emits:

- (a) infrasonic waves
- (b) ultrasonic waves
- (c) sonic waves
- (d) infrared waves

Answer:

- (b) ultrasonic waves

Numericals Problems on Echoes

Practice Problems 1

Question 1.

A person fires a gun in front of a building 167 m away. If the speed of sound is 334 ms^{-1} , calculate time in which he hears an echo.

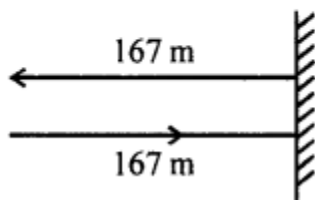
Answer:

$$d = 167 \therefore 2d = 167 \times 2 \text{ m}$$

$$\text{Speed of sound} = 334 \text{ ms}^{-1}$$

$$t \text{ for echo to be heard} = ?$$

$$t = \frac{2d}{\text{speed}} = \frac{167 \times 2}{334} = 1.0 \text{ sec}$$

**Question 2.**

An echo is heard after 0.8 s, when a person fires a cracker, 132.8 m from a high building. Calculate the speed of sound.

Answer:

$$t = 0.8 \text{ s } d = 132.8 \text{ m}$$

$$\text{speed} = \frac{2d}{t} = \frac{2 \times 132.8}{0.8} = \frac{2656}{8} = 332 \text{ ms}^{-1}$$

Question 3.

The speed of sound is 310 ms^{-1} . A person fires a gun. An echo is heard after 1.5 s. Calculate the distance of person from the cliff from which echo is heard.

Answer:

Speed of sound = 310 ms^{-1}

time after which echo is heard $t = 1.5 \text{ s}$ distance from cliff $d = ?$

$2d = \text{Speed} \times t$

Practice Problems 2

Question 1.

An echo is heard by a radar in 0.08 s . If velocity of radio waves is $3 \times 10^8 \text{ ms}^{-1}$, how far is the enemy plane ?

Answer:

$t = 0.08 \text{ s}$ $v = 3 \times 10^8 \text{ ms}^{-1}$

$$\begin{aligned}d &= \frac{vt}{2} = \frac{3 \times 10^8 \times 0.08}{2} = \frac{3 \times 10^8}{2} \times \frac{8}{100} \\&= 12000000 \text{ m} \\&= \frac{12000000}{1000} = 12000 \text{ km}\end{aligned}$$

Question 2.

An enemy plane is at a distance of 300 km from a radar. In how much time the radar will be able to detect the plane ? Take velocity of radiowaves as $3 \times 10^8 \text{ ms}^{-1}$.

Answer:

$d = 300 \text{ km}$ $t = ?$ $v = 3 \times 10^8 \text{ ms}^{-1}$

$t = 2d/v = 2 \times 300 \times 1000 \text{ m} / 3 \times 10^8 \text{ ms}^{-1}$

$= 0.002 \text{ s} = 2 \times 10^{-3} \text{ s}$

Practice Problems 3

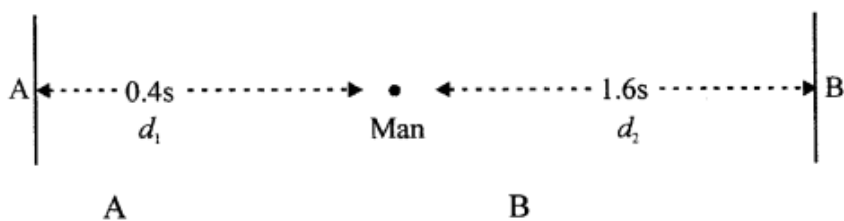
Question 1.

A man stands in between two parallel cliffs and explodes a cracker. He hears the first echo after 0.6 s and second echo after 2.4 s . Calculate the distance between the cliffs.

[Speed of sound is 336 ms^{-1}]

Answer:

Let the 2 buildings A and B situated at a distance d_1 and d_2 from a man's point.



$$t = 0.4 \text{ s} \qquad d_2 = \frac{Vt}{2} = \frac{332 \times 1.6}{2}$$

$$d_1 = \frac{Vt}{2} = \frac{332 \times 0.4}{2} \qquad d_2 = 265.6 \text{ m}$$

$$d_1 = 66.4 \text{ m}$$

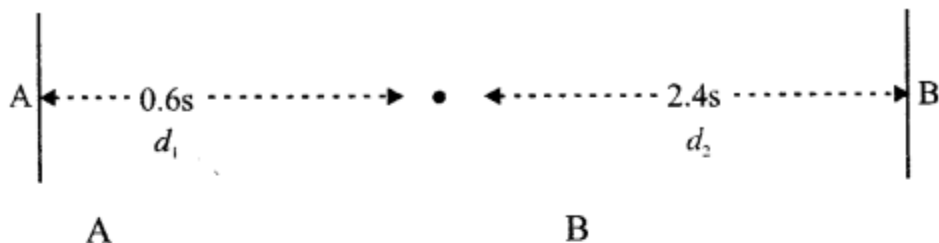
$$\therefore \text{distance AB} = d_1 + d_2 = 66.4 + 265.6 = 332.0 \text{ m}$$

Question 2.

A man stands in between two parallel cliffs and explodes a cracker. He hears the first echo after 0.6 s and second echo after 2.4 s. Calculate the distance between the cliffs. [Speed of sound is 336 ms^{-1}]

Answer:

Let A and B be two cliffs at distance d_1 and d_2 metre from a man.



$$d_1 = \frac{Vt}{2} \qquad d_2 = \frac{Vt}{2}, t = 2.4\text{s} \qquad v = 336 \text{ ms}^{-1}$$

$$t = 0.6\text{s}$$

$$v = 336 \text{ ms}^{-1}$$

$$d_1 = \frac{336 \times 0.6}{2} \qquad d_2 = \frac{336 \times 2.4}{2}$$

$$d_1 = 100.8 \text{ m} \qquad d_2 = 403.2 \text{ m}$$

$$\therefore \text{Distance AB} = d_1 + d_2 \\ = 100.8 + 403.2 = 504.0 \text{ m}$$

Practice Problems : 4

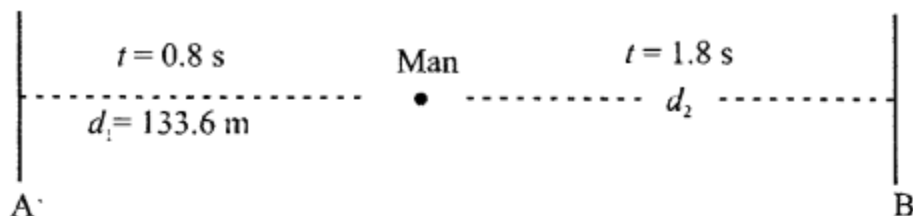
Question 1.

A man stands in between two cliffs, such that he is at a distance of 133.6 m from nearer cliff. He fires a gun and hears first echo after 0.8 s and second echo after 1.8 s.

Calculate :

1. speed of sound
2. distance between two cliffs.

Answer:



For nearer cliff A

$$t = 0.8 \text{ s}$$

$$d_1 = 133.6 \text{ m}$$

$$\text{Speed of sound } v = \frac{2d_1}{t}$$

$$V = \frac{2 \times 133.6}{0.8} = 334 \text{ ms}^{-1}$$

For cliff B

$$t = 1.8 \text{ s}$$

$$v = 334 \text{ ms}^{-1}$$

$$d_2 = \frac{Vt}{2}$$

$$= \frac{334 \times 1.8}{2}$$

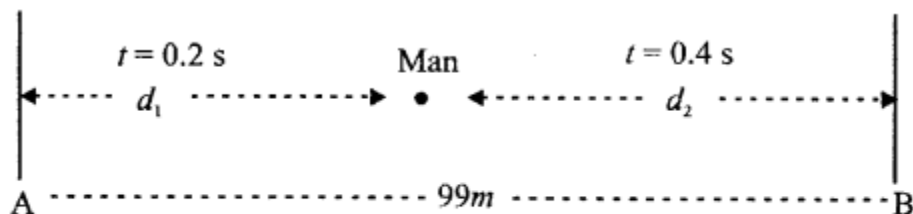
$$\begin{aligned} \therefore \text{distance between two cliffs} &= d_1 + d_2 \\ &= 133.6 + 300.6 = 434.2 \text{ m} \end{aligned}$$

Question 2.

A person stands in between two parallel cliffs which are 99 m apart. He fires a gun and hears two successive echoes after 0.2 s and 0.4 s. Calculate :

1. the distance of the person from the nearer cliff
2. speed of sound.

Answer:



For cliff A

$$t = 0.25$$

For cliff B

$$t = 0.4 \text{ s}$$

Let speed of sound = V

Speed = V

$$\therefore d_1 = \frac{Vt}{2} = \frac{V \times 2}{2 \times 10} = \frac{V}{10} \text{ m} \quad d_2 = \frac{v \times 4}{2 \times 10} = \frac{v}{5}$$

$$\text{But } d_1 + d_2 = 99 \text{ m}$$

$$\frac{v}{10} + \frac{v}{5} = 99$$

$$\frac{3v}{10} = 99$$

$$v = \frac{990}{3} = 330 \text{ ms}^{-1}$$

distance of person from nearer cliff

$$d_1 = \frac{v}{10} = \frac{330}{10} = 33 \text{ m}$$

$$(ii) \quad \text{We know that } V = \frac{2d_1}{t} = \frac{2 \times 33}{.2} = 330 \text{ ms}^{-1}$$

Practice Problems : 5

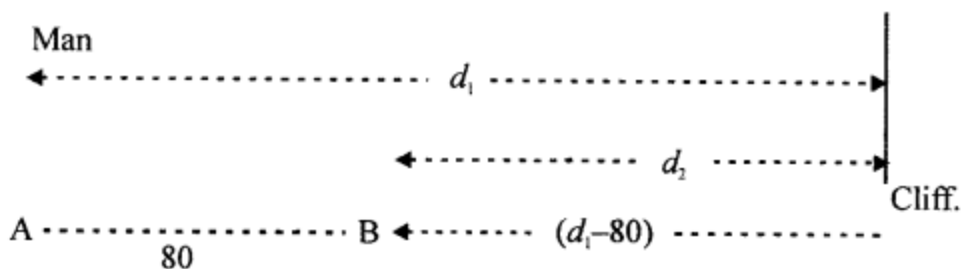
Question 1.

A man stands in front of a vertical cliff and fires a gun. He hears an echo after 2.5 s. On moving 80 m closer to the cliff he again fires the gun and he hears an echo after 2 s. Calculate:

(a) distance of man from cliff to his initial position

(b) speed of sound.

Answer:



Let speed of sound = $v \text{ ms}^{-1}$

When man is at A at a distance d_1 from cliff.

$$t = 2.5 \text{ s}$$

$$v = \frac{2d_1}{t} = \frac{2 \times d_1}{2.5} = \frac{4}{5} d_1 \quad \dots(i)$$

when man is at B, distance from cliff = $(d_1 - 80) \text{ m}$

$$t = 2 \text{ s}$$

$$\therefore v = \frac{2(d_1 - 80)}{2} = (d_1 - 80) \quad \dots(ii)$$

$$(i) = (ii)$$

$$(a) \quad \frac{4}{5} d_1 = (d_1 - 80) \quad \therefore 4d_1 = 5d_1 - 400$$

$$d_1 = 400 \text{ m}$$

Put $d_1 = 400$ in (i)

$$(b) \quad v = \text{speed of sound} = \frac{4d_1}{5}$$

$$= \frac{4 \times 400}{5} = 320 \text{ ms}^{-1}$$

Question 2.

A boy stands in front of a cliff, on the other side of a river. He fires a gun and hears an echo after 6 seconds. The boy then moves 170 m backwards and again fires the gun. He hears an echo after 7 seconds. Calculate :

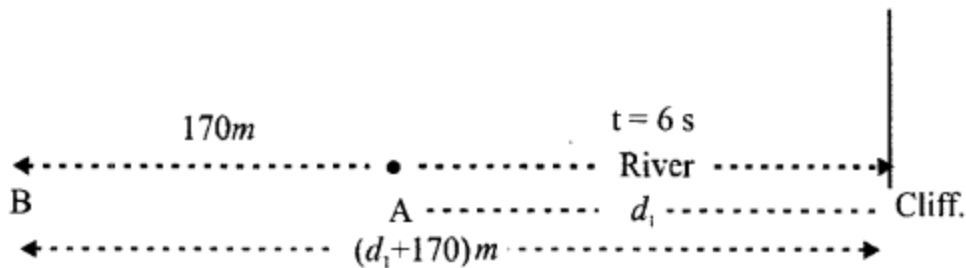
(a) width of river

(b) speed of sound.

Answer:

Let speed of sound = $V \text{ ms}^{-1}$

Width of river = d_1



When man is at A

$t = 6 \text{ s}$

$$V = \frac{2d_1}{6} = \frac{d_1}{3} \quad \dots(i)$$

When he moves 170 m away i.e. At B

distance from cliff = $(d_1 + 170) \text{ m}$

$t = 7 \text{ s}$

$$\therefore v = \frac{2(d_1 + 170)}{7} \quad \dots(ii)$$

Equating (i) and (ii)

$$\frac{2d_1 + 340}{7} = \frac{d_1}{3}$$

$$7d_1 = 6d_1 + 1020$$

$$(i) \quad 7d_1 - 6d_1 = 1020 \quad \therefore d_1 = 1020 \text{ m}$$

(ii) Put $d_1 = 1020$ in (i)

$$\text{Speed of sound } v = \frac{1020}{3} = 340 \text{ ms}^{-1}$$

Exercise – 2

Question 1.

Define the following :

1. natural vibrations

2. forced vibrations
3. damped vibrations
4. natural frequency

Answer:

(i) Natural vibrations : "The vibrations produced in a body, on being slightly disturbed from its mean position are called natural vibrations."

(ii) Forced vibrations : "The vibrations which take place under the influence of an external periodic force are called forced vibrations."

(iii) Damped vibrations : "The periodic vibrations of continuously decreasing amplitude in the presence of resistive force are called damped vibrations."

(iv) Natural frequency : "The number of vibrations executed per second by a freely vibrating body is called natural frequency."

Question 2.

State four characteristics of forced vibrations.

Answer:

Characteristics of forced vibrations :

1. The body acquires the frequency of external periodic force.
2. The amplitude of forced vibration is very small, if the frequency of external force is much different from natural frequency of the body.
3. The amplitude of vibration remains constant with time, but magnitude depends upon the frequency of the driving force.
4. If the frequency of external force is exactly equal or is an integral multiple vibrating body, the amplitude of oscillation is very large.

Question 3.

Give two examples of forced vibrations.

Answer:

Examples:

1. When a guitar is played, the artist forces the strings of the guitar to execute forced vibrations.
2. The vibrations produced in hollow sound box containing air are forced vibrations.

Question 4.

Why are the stringed instruments provided with large wind box?

Answer:

So that on plucking the strings, forced vibrations of the air send greater energy and cause a loud sound.

Question 5.

What do you understand by the term resonance ? Give two conditions for producing resonance.

Answer:

Resonance : “is a special case of forced vibrations. When the frequency of an externally applied periodic force on a body is equal to its natural frequency, the body readily begins to vibrate with an increased amplitude. This phenomenon is called resonance.”

Two conditions of resonance :

1. The natural frequency of the given body (non-vibrating body) must be equal to (or its integral multiple) the frequency of the vibrating body.
2. The vibrating body must have sufficient force, so as to set the other body into vibrations.

Question 6.

Explain the following :

(a) Why does the frame of a motorbike vibrate violently at some particular speed ?

Answer:

The vibrations caused by the movement of the piston, the frame of motorbike may have frequency (natural) be equal to the frequency of piston and due to resonance, it vibrates violently at that particular speed.

(b) Why does an odd piece of cutlery start vibrating violently when a note of some particular frequency is played ?

Answer:

When note of some particular frequency is played its frequency may have matched the natural frequency of odd piece of cutlery and due to resonance the piece starts vibrating.

(c) Why are the soldiers instructed to march out of step while crossing a bridge ?

Answer:

While crossing the bridge when soldiers march in steps, each soldier exerts a periodic force in same phase and therefore the bridge executes the forced vibrations of frequency equal to the frequency of their steps. Now the natural frequency of the bridge happens to be equal to the frequency of the steps, the bridge will vibrate with a large amplitude due to resonance and bridge may collapse. So, the soldiers are advised to break their steps while crossing the bridge.

Multiple Choice Questions

Tick (✓) the most appropriate option.

Question 1.

A string is stretched between two nails fixed in the opposite walls and plucked from middle. The vibrations produced by the string are : –

- (a) forced vibrations
- (b) free vibrations
- (c) damped vibrations
- (d) resonant vibrations

Answer:

- (b) free vibrations

Question 2.

Water from a tap is allowed to fall in a vessel with a thin neck. The pitch of sound produced by falling water with the volume of water in the vessel.

- (a) decreases
- (b) increases
- (c) remains same
- (d) none of these

Answer:

- (b) increases

Question 3.

The amplitude of forced vibrations is generally than the amplitude of applied external force.

- (a) more
- (b) less
- (c) equal to
- (d) none of these

Answer:

- (b) less

Question 4.

A tuning fork has a frequency of 212 Hz. It will produce resonance in a wooden board of frequency

- (a) 106 Hz
- (b) 318 Hz
- (c) 212 Hz
- (d) 448 Hz

Answer:

- (c) 212 Hz

Question 1.

Define the following

1. musical sound,
2. noise

Answer:

(i) **Musical sounds** : "Sound waves which produce pleasant sensation in our ears and are acceptable, are called musical sounds."

(ii) **Noise** : "Sound waves which produce trouble-some sensation and are unacceptable are known as noise."

Question 2.

Give three differences between musical sound and noise.

Answer:

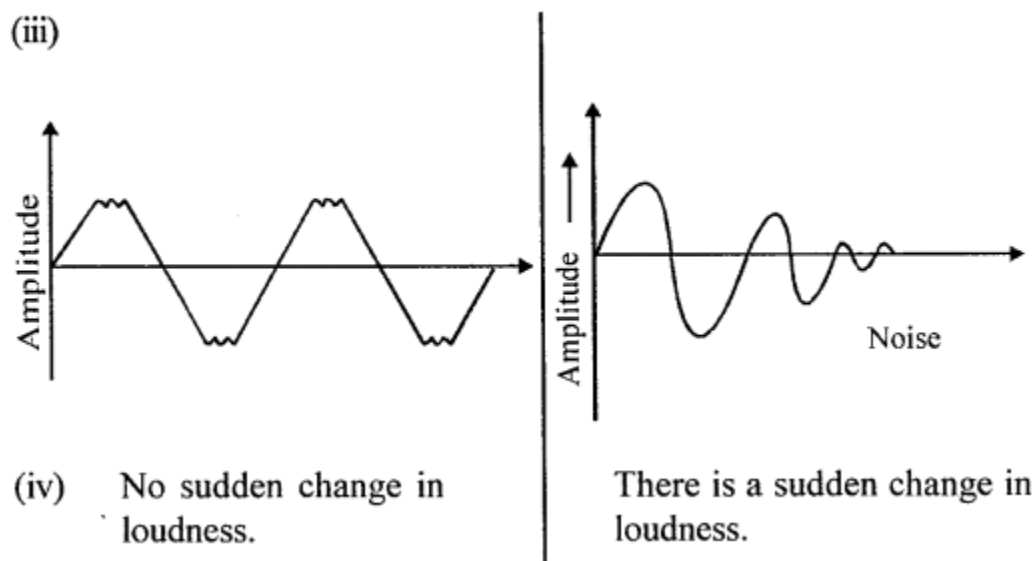
Difference between musical sound and noise

Musical sound:

1. Produce pleasant effect on the ear
2. Proceeds at regular intervals in quick succession.

Noise:

1. Produce displeasing effect on ear. .
2. Proceed at irregular intervals.



Question 3.

State three characteristics of musical sound.

Answer:

Three characteristics of musical sound :

1. Pitch
2. Loudness or intensity of sound
3. Quality or timbre.

Question 4.

(a) What do you understand by the term pitch of sound ?

(b) How is the pitch of sound related to the frequency of a vibrating body ?

Answer:

(a) **Pitch** : "This characteristic enables us to differentiate between two sounds with equal loudness, coming from different sources and having different frequencies."

Sounds with equal loudness can be produced by pressing different keys of the harmonium, but they are easily distinguished due to different pitches.

(b) The higher the frequency of a note the higher is its pitch.

Question 5.

(a) What do you understand by the term loudness of sound ?

(b) How is the loudness of sound related to :

1. amplitude of the vibrating body,
2. distance of the observer from the vibrating body,
3. density of the medium producing sound,
4. frequency of sound.

Answer:

(a) **Loudness** : "Is the time rate at which the sound energy flows through a unit area."

Different bodies of same frequency have different loudness due to different amplitude. More the amplitude louder it is.

(b) :

1. More the amplitude, louder it is.
2. Loudness or intensity of sound $I \propto 1/(\text{Distance})$ Loudness decreases with increase in distance.
3. Loudness is directly proportional to density of medium.
4. Sound waves of the same Intensity but of different frequencies usually have different loudness.

Question 6.

(a) What do you understand by the term intensity of sound?

(b) Name the unit in which intensity of sound (loudness) is measured.

(c) What is the normal range of loudness ?

(d) What is the range of loudness when sound becomes painful?

Answer:

(a) **Intensity of sound or Loudness** : "Is the time rate at which the sound energy flows through a unit area." Different bodies of same frequency have different loudness due to different amplitude. More the amplitude louder it is.

(b) Unit of Intensity of loudness is (dB) decibels.

(c) Normal range of loudness is 50 (dB) to 80 (dB).

(d) above 80 dB it becomes painful.

Question 7.

List one source of noise in :

(a) transportation,

(b) homes,

(c) factories,

(d) surroundings.

Answer:

Source of noise in

(a) **Transportation** : Petrol and diesel vehicles.

(b) **Homes** : Power music system, desert cooler.

(c) **Factories** : Running of machines, grinding.

(d) **Surroundings** : Loud speakers used in marriages and religious places.

Question 8.

List four harmful effects of sound pollution.

Answer:

Harmful effects of sound pollution :

1. Noise produces headaches, irritability and nervous tension.
2. A long exposure to noise pollution may result in the loss of hearing to deafness.
3. Noise in the surroundings interferes with the conversation with another.
4. It causes anger, tension and interferes with the sleep pattern of individuals.

Question 9.

List four ways of reducing noise pollution.

Answer:

Ways of reducing noise pollution :

1. Factories should be located far away from residential areas.
2. Heavy vehicles should not be allowed in residential areas.
3. At homes T.V. radio, power music system, should be played at a low volume.
4. Machines should be designed in such a way, so that they produce minimum noise.

Question 10.

What do you understand by the term quality of sound ?

Answer:

Quality of sound : "The notes of different instruments having the same frequencies and same loudness are distinguished by this characteristics." It is because different waveforms are produced by different musical instruments.

Multiple Choice Questions

Tick (✓) the most appropriate option.

Question 1.

The amplitude of a sound wave is increased from 1 mm to 2 mm. The loudness of the sound will:

- (a) increase two time
- (b) increase four times
- (c) same
- (d) decrease

Answer:

- (b) Increase four times $\because$ IOC (amp)²

Question 2.

By decreasing the amplitude of a pure note its :

- (a) speed decreases
- (b) wavelength decreases
- (c) quality changes
- (d) loudness decreases

Answer:

- (d) loudness decreases

Question 3.

Two notes are produced from a flute and piano, such that they have same loudness and same pitch. The notes so produced differ in their :

- (a) waveform
- (b) wavelength
- (c) frequency
- (d) speed

Answer:

- (a) waveform

Question 4.

The voice of women is shrill as compared to men because of the difference in their :

- (a) speed
- (b) loudness
- (c) frequency
- (d) all these

Answer:

- (c) frequency

Question 5.

The sound produced by two tuning forks A and B have same amplitude and same waveform, but the frequency of A is three times more than B. In such a case :

- (a) quality of sound of A differs from B
- (b) the note produced by A is shriller than B
- (c) the note produced by B is shriller than A
- (d) the note produced by A has more speed than B.

Answer:

- (b) the note produced by A is shriller than B

Questions from ICSE Examination Papers

2006

Question 1.

Explain why musical instruments like a guitar are provided with a hollow box.

Answer:

Hollow box is so constructed that the air column inside it has a natural frequency which is same as that of strings stretched on it. So that when the strings are made to vibrate, the air column inside the box is set into vibrations and its reinforces the sound.

Question 2.

A tuning fork, struck by a rubber pad, is held over a length of air column in a tube. It produces a loud sound for a fixed length of the air column.

- (a) Name the above phenomenon.
- (b) How does the frequency of the loud sound compare with that of the tuning fork ?
- (c) State the unit for measuring loudness.

Answer:

Phenomenon is resonance

(b) The frequency of the loud sound is increased compared to frequency of tuning fork.

(c) Unit of loudness is decibel dB which signifies sound PRESSURE LEVEL.

$IdB = 10 \log_{10} 1/10$

2007

Question 3.

Define the terms :

- (a) Amplitude
- (b) Frequency (as applied to sound waves).

Answer:

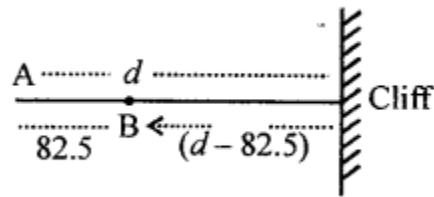
- (a) Amplitude of a wave is the maximum displacement of a particle about its mean position.
- (b) Frequency of a wave is defined as the number of vibrations made per second about the mean position. It is measured in Hz.

Question 4.

A man standing in front of a vertical cliff fires a gun. He hears the echo after 3 seconds. On moving closer to the cliff by 82.5 m, he fires again. This time, he hears the echo after 2.5 seconds. Calculate :

- (a) the distance of the cliff from the initial position of the man.
- (b) the velocity of sound.

Answer:



- (a) Let the cliff be at a distance d from the man, then the time t

after which the first echo is heard

$$t = \frac{2d}{v} \quad \dots(i)$$

Where v is the velocity of sound.

(b) In the second case, the time P will be given by

$$P = \frac{2(d - 82.5)}{v}$$

dividing (ii) by (i) $\frac{P}{t} = \frac{d - 82.5}{d}$

$$\frac{2.5}{3} = 1 - \frac{82.5}{d}$$

$$\text{or } \frac{82.5}{d} = 1 - \frac{2.5}{3} = \frac{0.5}{3} = \frac{1}{6}$$

$$d = 82.5 \times 6 \\ = 495 \text{ m}$$

$$v = \frac{2d}{t}$$

$$= \frac{2 \times 495}{3} = \frac{990}{3} \\ = 330 \text{ ms}^{-1}$$

2008

Question 5.

A radar sends a signal to an aeroplane at a distance 45 km away with a speed of $3 \times 10^8 \text{ ms}^{-1}$. After how long is the signal received back from the aeroplane ?

Answer:

As sound comes back so it is echo.

t is calculated by the formula

$$t = \text{Total distance travelled} / \text{Speed} = 2d/V$$

$$\text{Here } d = 45000 \text{ m, } V = 3 \times 10^8 \text{ ms}^{-1}, t = 2 \times 45000 / 3 \times 10^8 = 3 \times 10^{-4} \text{ s.}$$

Question 6.

(a) :

1. What is meant by an echo ? Mention one important condition that is necessary for an echo to be heard distinctly.
2. Mention one important use of echo.

Answer:

1. The sound heard after reflection from a rigid obstacle (such as a cliff, a hillside, wall of building, edge of a forest etc.) is called an echo.
An echo is heard only if the distance between the person producing the sound and the rigid obstacle is long enough to allow the reflected sound to reach the person atleast 0.1 second after the original sound is heard.
2. Sound ranging and echo depth sounding. Echos are also . used by geologists for mineral prospecting.

(b) :

1. Sometimes when a vehicle is driven at a particular speed, a rattling sound is heard. Explain briefly, why this happens and give the name of the phenomenon taking place.
2. Suggest one way by which the rattling sound can be stopped.

Answer:

1. It happens due to resonance. When a vehicle is driven, the piston of the engine makes in and out motion at a frequency depending upon its speed. The vibrations caused by the movement of piston are transmitted to all parts of the vehicle. It is just possible that some parts of the vehicle (or its frame), may have natural frequency of to and fro movement of piston at the certain speed of the vehicle. When this happens, then at this particular speed of the vehicle that part starts vibrating vigorously due to resonance.
2. To stop the rattling sound. The speed of vehicle is changed, so that the condition of resonance will not then hold.

2009

Question 7.

An ultrasonic wave is sent from a ship towards the bottom of the sea. It is found that the time interval between the sending and the receiving of the wave, is 1.5 second. Calculate the depth of the sea if the velocity of sound in sea water is 1400 ms^{-1} .

Answer:

$$t = 1.5 \text{ s}$$

$$s = ?$$

$$v = 1400 \text{ ms}^{-1}$$

$$2s = vt$$

$$s = vt/2 = 1400 \times 1.5/2$$

$$= 1050 \text{ m}$$

Question 8.

(a) A stringed musical instrument, such as the Sitar, is provided with a number of wires of different thicknesses. Explain the reason for this.

Answer:

In stringed instruments, frequency depends on thickness or radius of string. So to produce different frequencies different strings of different thicknesses are provided.

(b) What is meant by noise pollution ? Write the name of one source of sound that causes noise pollution.

Answer:

The disturbance produced in the environment by undesirable, loud and harsh sound from various sources. Also a constant hearing of sound of level above 120 dB can cause headache and permanent damage to the ears of the listener. This is called noise pollution, e.g., police car siren concert, jet at take off produce noise pollution.

Question 9.

(a) (i) What is the principle on which sonar is based?

(ii) Calculate the minimum distance at which a person should stand in front of a reflecting surface so that he can hear a distinct echo. (Take speed of sound in air = 350 ms⁻¹.)

Answer:

1. Sonar is based on echo.
2. The sensation of sound persists in our ears for about 1/10th, of a second after exciting stimulus ceases to act. If d is the distance between the observer and obstacle and v the speed of sound, the time taken to hear the echo is
 $t = \text{Distance travelled in going and coming back} / \text{speed of Sound of } v = 340 \text{ ms}^{-1}$
 $\therefore$ Minimum distance of 17.5 m from the listener, to hear. echo distinctly.

(b) :

1. Name the characteristic of sound which enables a person to differentiate between two sounds with equal loudness but having different frequencies.
2. Define the characteristic named by you in (i).
3. Name the characteristic of sound which enables a person to differentiate between two sounds of the same loudness and frequency but produced by different instruments.

Answer:

Characteristic having

1. Two sounds with equal loudness but having different frequencies is Pitch.
2. PITCH : "is that characteristic of sound by which an acute (or shrill) note can be distinguished from a grave or flat note."
3. Characteristic is quality.

(c) :

1. A person is tuning his radio set to a particular station. What is the person trying to do to tune it ?
2. Name the phenomenon involved, in tuning the radio set.
3. Define the phenomenon named by you in part (ii).

Answer:

1. He is trying to match the frequency of the radio components with the broadcasting station he wants to receive and hence to produce resonance (make the sound louder).
2. Resonance is the phenomenon.
3. Resonance "is a special case of forced vibrations. When the frequency of an externally applied periodic force on a body is equal to its natural frequency, the body readily begins to vibrate with an increased amplitude. This phenomenon is known as Resonance."

2010

Question 10.

(a) State two differences between light waves and sound waves.

(b) The waves of the same pitch have their amplitudes in the ratio 2 : 3.

1. What will be the ratio of their loudness ?
2. What will be the ratio of their frequencies ?

(c) Name the subjective property

1. of sound related to its frequency.
2. of light related to its wavelength

Answer:

(a) The two main differences are :
Light Waves:

1. They are electromagnetic waves and their velocity is $3 \times 10^8 \text{ ms}^{-1}$.
2. They have very small wavelength.

Sound Waves:

1. These are mechanical waves and their velocity is 340 ms^{-1} .
2. The wavelength of sound waves is quite large compared with that of light waves.

(b) :

1. Since loudness is inversely proportional to the square of the amplitude, $I = \text{loudness} \propto 1/(\text{amp})^2$ therefore loudness will be in ratio of $(2)^2 : (3)^2$ i.e., 4 : 9.
2. Since their pitch is the same, therefore their frequencies will be same i.e., their ratio is 1 : 1.

(c) :

1. Loudness
2. Colour

Question 11.

(a) A man stands at a distance of 68 m from a cliff and fires a gun. After what time interval will he hear the echo, if the speed of sound in air is 340 ms^{-1} .

(b) If the man had been standing at a distance of 12 m from the cliff would he have heard the clear echo ?

Answer:

(a) The time t after which an echo is heard is given by, $t = 0.07 \text{ s}$ which is less than 0.1 s .

2011

Question 12.

(a) When acoustic resonance takes place, a loud sound is heard. Why does this happen ? Explain.

(b) :

1. Three musical instruments give notes of the frequencies listed below. Flute : 400 Hz; Guitar : 200 Hz; Trumpet: 500 Hz. Which of these has the highest pitch?
2. Which of the following frequencies does a tuning fork of 256 Hz resonate ? 288 Hz, 333 Hz, 512 Hz.

Answer:

(a) At acoustic resonance, the amplitude of the vibration of the body becomes very large. Since loudness is proportional to the square of the amplitude, therefore, we hear a loud sound under this condition.

(b) :

1. Trumpet: 500 Hz.
2. 512 Hz. Second resonance will take place.

Question 13.

(a) :

1. Name the type of waves which are used for sound ranging.
2. Why are these sound waves mentioned in (i) above are not audible to us ?
3. Give one use of sound ranging.

(b) A man is standing 25 m away from a wall produces a sound and receives the reflected sound.

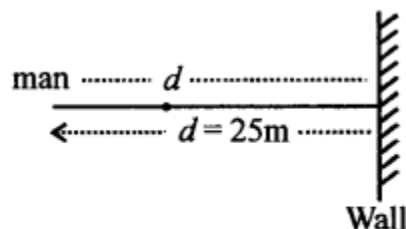
1. Calculate the time after which he receives reflected sound if the speed of sound is 350 ms⁻¹
2. Will the man be able to hear a distinct echo ? Give a reason for your answer.

Answer:

(a):

1. Ultrasonic waves.
2. Because their frequency lies beyond the limits of audibility (20 Hz–20,000 Hz).
3. To locate the position of the object under water and to find the depth of sea.

(b):



$$\text{Time} = \frac{2d}{v} = \frac{2 \times 25}{350} = 0.14 \text{ sec}$$

- 1.
2. Yes, because distance is more than 17 m and time period is 0.14 sec.

2012

Question 14.

(a) Which characteristic of sound will change, if there is a change in

1. its amplitude
2. its waveform.

(b) :

1. Name one factor which affects the frequency of sound emitted due to vibrations in an air column.
2. Name the unit used for measuring the sound level.

Answer:

(a) :

1. With the change in amplitude, the loudness of sound changes.
2. With the change in waveform the quality of sound changes.

(b) :

1. The length of vibrating air column affects its frequency. More the length of vibrating air column, lesser is its frequency.
2. Decibel (dB) is the unit used for measuring sound level.

Question 15.

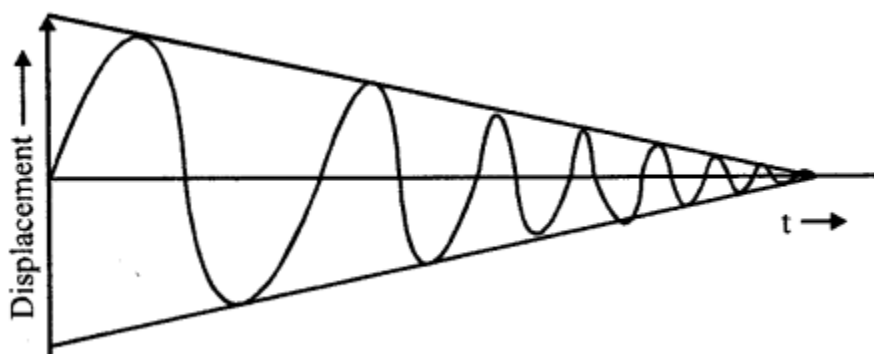
(a):

1. What is meant by Resonance ?
2. State two ways in which Resonance differs from Forced vibrations.

(b):

1. A man standing between two cliffs produces a sound and hears two successive echoes at intervals of 3 s and 4 s respectively. Calculate the distance between the two cliffs. The speed of sound in the air is 330 ms^{-1} .
2. Why will an echo not be heard when the distance between the source of sound and the reflecting surface is 10 m?

(c) The diagram below shows the displacement-time graph for a vibrating body.



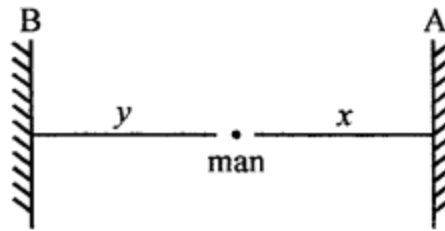
1. Name the type of vibrations produced by the vibrating body.
2. Give one example of a body producing such vibrations.
3. Why is the amplitude of the wave gradually decreasing?
4. What will happen to the vibrations of the body after some time ?

Answer:

(a) :

1. The phenomenon due to which the natural frequency of a given body corresponds to the frequency of sound impressed on it, such that it rapidly starts vibrating is called resonance.
2. **(a).** The resonance takes place only when the natural frequency of a given body is equal to the frequency of sound impressed on it, whereas during forced vibration a body is forced to vibrate with the frequency of sound impressed on it.
(b). Loud sound is produced during resonance, but not in case of forced vibrations.

(b) (i)



$$V = 330 \text{ ms}^{-1}$$

$$d \text{ of A} = x$$

$$t = 3 \text{ sec}$$

$$\therefore \frac{2d}{t} = V$$

$$\frac{2x}{3} = 330$$

$$x = \frac{330 \times 3}{2} = 495 \text{ m}$$

$$\text{Now } \frac{2y}{4} = 330$$

$$y = 330 \times 2 = 660 \text{ m}$$

Distance between AB = $x + y = 495 + 660 = 1155 \text{ m}$

3. The persistence of sound on ear drum is $1/10$ of a second. The echo can be heard if the minimum distance of the source of sound from the vibrating body is 17 m. As the distance is only 10 m, therefore, no echo is produced.

(c) :

1. Transverse vibrations are produced which are gradually damped.
2. A stretched string of a guitar.
3. As the energy of wave is dissipated its amplitude decreases.
4. The body will stop vibrating. It will come to rest.

2013

Question 16.

(a) : A bucket kept under a running tap is getting filled with water. A person sitting at a distance is able to get an idea when the bucket is about to be filled.

1. What changes take place in the sound to give this idea?
2. What causes the change in the sound ?

(b): A sound made on the surface of a lake takes 3 s to reach a boatman. How much time will it take to reach a diver inside the water at the same depth ?

[Velocity of sound in air = 330 ms^{-1} ; Velocity of sound in water = 1450 ms^{-1}]

Answer:

(a):

1. The sharp pitched sound slowly changes to low pitched sound as the bucket gets filled. The sound almost dies when the bucket is completely filled.
2. As the length of vibrating air column decreases due to the water, the frequency of the sound changes.

(b) : Distance covered by the sound to reach boatman = $330 \text{ ms}^{-1} \times 3 \text{ s} = 990 \text{ m}$

∴ Distance of diver from the source of sound = 990 m 990 m 990 _

∴ Time taken by the sound to reach diver = $1450 \text{ ms}^{-1} \text{ " } 145 \text{ s} = 0.68 \text{ s}$ (Appox.).

Question 17.

(a) :

1. What is the principle on which SONAR is based.
2. An observer stands at a certain distance away from a cliff and produces a loud sound. He hears the echo of the sound after 1.8 s. Calculate the distance between the cliff and the observer if the velocity of sound in air is 340 ms^{-1} .

(b) : A vibrating tuning fork is placed over the mouth of a burette filled with water: The tap of the burette is opened and the water level gradually starts falling. It is found that the sound from the tuning fork becomes very loud for a particular length of the water column.

1. Name the phenomenon taking place when this happens.
2. Why does the sound become very loud for this length of the water column ?

(c) :

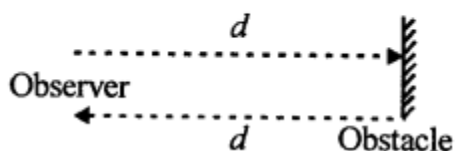
1. What is meant by the terms (a) amplitude (b) frequency of a wave ?
2. Explain why stringed musical instruments, like the guitar, are provided with a hollow box.

Answer:

(a) :

1. SONAR is based on Echo of Sound.
2. Distance between cliff and source of sound

$$= \frac{\text{Velocity of sound} \times \text{time}}{2} = \frac{340\text{ms}^{-1} \times 1.8\text{s}}{2} = 306 \text{ m}$$



(b) :

1. The phenomenon is called 'resonance of sound'.
2. At some particular length of air column the natural frequency of air column corresponds to the frequency of tuning fork. At this moment the sound waves reinforce to produce loud sound.

(c) :

1. The maximum displacement of vibrating particle about its mean position is called its amplitude. The number of waves which pass through a point in a medium in one second is called frequency.
2. Stringed musical instruments are provided with hollow box so that when the vibrations are produced by strings are impressed on the enclosed air, they produce forced vibrations and a loud sound is produced.

2014

Question 18.

(a) :

1. What are mechanical waves ?
2. Name one property of waves that do not change when the wave passes from one medium to another.



The diagram above shows three different modes of vibrations P, Q and R of the same string.

1. Which vibrations will produce a louder sound and why?
2. The sound of which vibration will have maximum shrillness?
3. State the ratio of wavelengths P and R.

Answer:

(a) :

1. Mechanical Waves : "Sound waves which require medium to travel are called Mechanical Waves."
2. Frequency of wave does not change as it passes from one medium to other medium.

(b) :

1. R will produce louder sound because its amplitude is more than P and Q.
2. The sound of P string will have maximum
3. The ratio of wavelength of P and R is $\lambda_P/\lambda_R = f_R/f_P = 1/3 \therefore \lambda_P : \lambda_R = 1 : 3$



Question 19.

(a) : A type of electromagnetic wave has wavelength 50A.

1. Name the wave.
2. What is the speed of this wave in vacuum?
3. State one use of this type of wave.

(b) :

1. State one important property of waves used for echo depth sounding.
2. A radar sends a signal to an aircraft at a distance of 30 km away and receives it back after 2×10^{-4} second. What is the speed of the signal?

Answer:

(a) :

1. X-Ray.
2. 3×10^8 m/s.
3. X-Ray are used for detection of fracture in bones.

(b) :

1. The depth of sea can be found by echo depth sounding process and waves used are ULTRA SONIC and these can travel undeviated through a long distance, can be confined to narrow beam and are not absorbed by medium.
2. Distance of aircraft = 30 km = 30×1000 m = 30,000 m
Total distance = $2 \times 30,000$ = 60,000 m
Time taken = 2×10^{-4} second

$$\text{Hence, Speed of sound } V = \frac{\text{distance travelled } (2d)}{\text{time taken } (t)}$$

$$= \frac{60,000}{2 \times 10^{-4}} = 30,000 \times 10^4 \text{ m/s}$$

$$= 3 \times 10^8 \text{ m/s} = 3 \times 10^5 \text{ km sssss}^{-1}$$

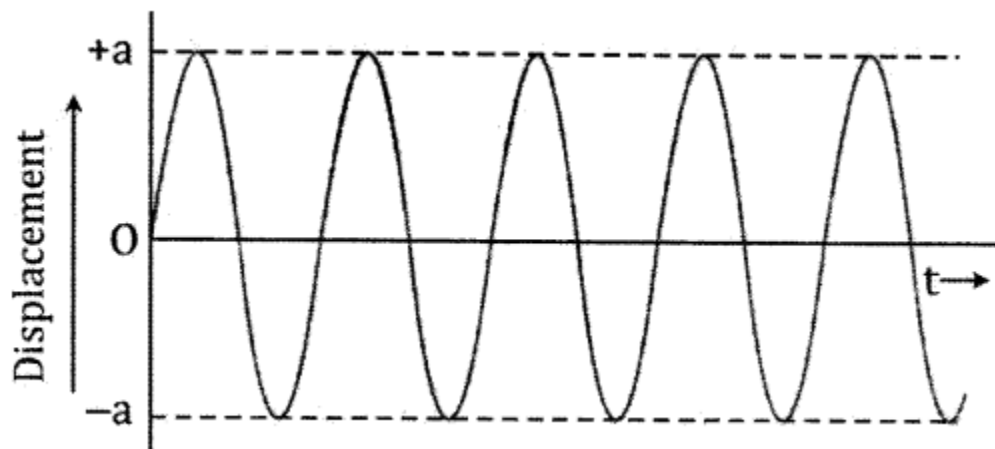
2015

Question 20.

1. Draw a graph between displacement and the time for a body executing free vibrations.
2. Where can a body execute free vibrations?

Answer:

1. The displacement–time graph for a body executing free vibrations is given below:



2. The free vibrations of a body actually occur only in vacuum because the presence of a medium offers some resistance due to which the amplitude of vibration does not remain constant and decreases continuously. Thus, we define free vibrations as the periodic vibrations of a body of constant amplitude in the absence of any external force on it.

(b) :

1. State the safe limit of sound level in terms of decibel for human hearing.
2. Name the characteristic of sound in relation to its waveform.

Answer:

1. The safe limit of sound level for human hearing is 60 dB to 85 dB.
2. The characteristic of sound in relation to its waveform is quality or timbre.

Question 21.

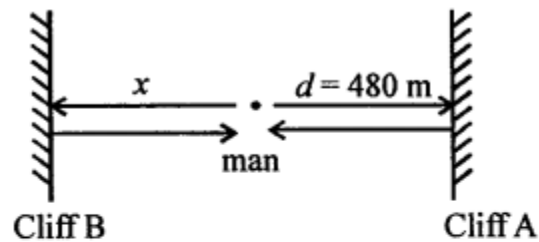
(a) : A person standing between two vertical cliffs and 480 m from the nearest cliff shouts. He hears the first echo after 3s and the second echo 2s later. Calculate:

1. The speed of sound.
2. The distance of the other cliff from the person.

Answer:

1. Let d_1 be the distance of the nearest cliff and d_2 be the distance of the farther cliff. The time for the first echo is $t_1 = 3$ s The first echo will be heard from the nearest

cliff. The total distance travelled by sound before reaching the person is $2d_1$



We know that

$$\text{Speed of sound} = v = \frac{2d}{t} = \frac{2d_1}{t_1}$$

$$v = \frac{2 \times 480}{3} = 320 \text{ m/s}$$

Hence, the speed of sound is 320 m/s.

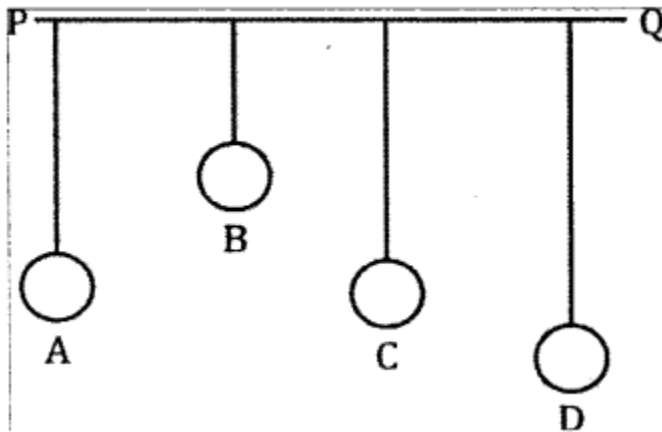
2. The second echo is heard 2 s after the first one. Hence, $t_2 = 3 + 2 = 5$ s Again the sound travels a total distance $2d_2$ before reaching the person. So, we get

$$v = \frac{2d_2}{t_2}$$

$$\therefore d_2 = \frac{vt_2}{2} = \frac{320 \times 5}{2} = 800 \text{ m}$$

Hence, the distance between the other cliff and the person is 800 m.

(b) : In the diagram below, A, B, C, D are four pendulums suspended from the same elastic string PQ. The length of A and C are equal to each other while the length of pendulum B is smaller than that of D. Pendulum A is set in to a mode of vibrations.



1. Name the type of vibrations taking place in pendulums B and D?
2. What is the state of pendulum C?
3. State the reason for the type of vibrations in pendulums B and C.

Answer:

1. The vibrations which occur in pendulums B and D are called forced vibrations.
2. Pendulum C is in the state of resonance with pendulum A as it is of the same length.
3. The pendulums vibrate because the forced vibration from A is transferred due to string PQ.
Pendulum B is of a different length as compared to pendulum A. Hence, it will continuously vibrate with a frequency which is different from that of pendulum A. Its amplitude will also be very small. Pendulum C is of the same length as compared to pendulum A. Hence, it will vibrate in phase with pendulum A. Its amplitude will be equal to that of pendulum A as it will attain resonance.

2016

Question 22.

(a) : The ratio of amplitude of two waves is 3:4. What is the ratio of their :

1. loudness
2. frequencies?

Answer:

1. Let a_1 and a_2 be the amplitudes and I_1 and I_2 be the intensities of the two waves.

$$\therefore \frac{I_1}{I_2} = \frac{a_1^2}{a_2^2} = \frac{3^2}{4^2}$$

$$\therefore \frac{I_1}{I_2} = \frac{9}{16}$$

2. Frequency is the number of waves formed per second. It only depends on time period. Thus, the ratio of their frequencies is 1:1.

(b) : State two ways by which the frequency of transverse vibrations of a stretch string can be increases.

Answer:

The frequency of transverse vibration is given by

$$f = \frac{1}{2l} \sqrt{\frac{T}{\pi r^2 d}}$$

$$\text{or } f = \frac{1}{2l} \sqrt{\frac{T}{m}}$$

where l = length of the vibrating string

T = tension in the string

m = mass per unit length of the string

Therefore, the frequency of transverse vibration of a stretched string can be increased by

1. decreasing the length of the string
2. decreasing the radius of the string
3. increasing the tension T in the string

(c) : What is meant by noise pollution? Name one source of sound causing noise pollution.

Answer:

The disturbance produced in the environment by undesirable and loud sound from the various sources is called noise pollution. Loudspeaker, noise produced by heavy duty vehicles or railways trains, etc.

Question 23.

(a) :

1. Name the waves used for echo depth sounding.
2. Give one reason for their use for the above purpose.
3. Why are the waves mentioned by you not audible to us?

Answer:

1. (i) The waves used for echo depth sounding are ultrasound waves.
 (ii) Ultrasound waves are used for echo depth ranging because they can travel undeviated through a long distance.
 (iii) Ultrasonic waves have frequency larger than 20000 Hz. Hence, these waves are not audible to us as the audible range for the human ear is 20 Hz to 20000 Hz.

(b) :

1. What is an echo
2. State two conditions for an echo to take place.

Answer:

1. The sound heard after reflection from a distant obstacle after the original sound has ceased is called an echo,
2. The conditions for an echo to take place are
 - a. The minimum distance between the source of sound and the reflector in air must be 17 m.
 - b. The size of the reflector must be large enough as compared to the wavelength of sound wave.

(c) :

1. Name the phenomenon involved in tuning a radio set to a particular station.
2. Define the phenomenon named by you in part (i) above.
3. What do you understand by loudness of sound ?
4. In which units is the loudness of sound measured ?

Answer:

1. The phenomenon involved in tuning a radio set to a particular station is called resonance.
2. Resonance : When the frequency of an externally applied periodic force on a body is equal to its natural frequency, the body readily begins to vibrate with an increased amplitude. This phenomenon is known as resonance.
3. Loudness is the property by virtue of which a loud sound can be distinguished from a faint one, both having the same pitch and quality.
4. The loudness of sound is measured in decibel (dB).

Electric Circuits, Resistance & Ohm's Law

Exercise – 1

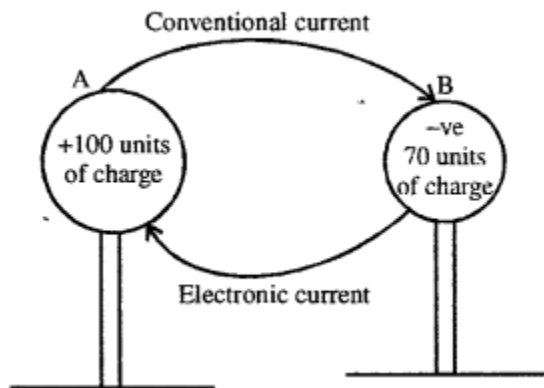
Question 1.

In which direction conventional current and electronic current flow from a source of electricity ?

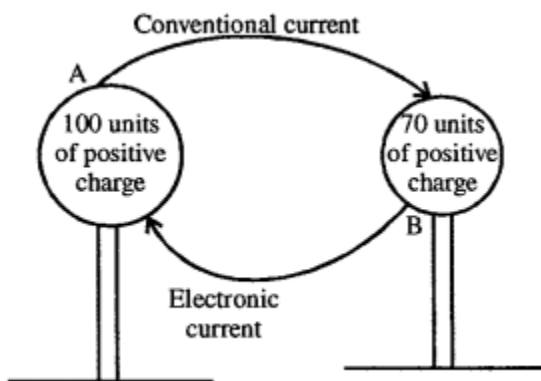
Answer:

Electronic current is always in opposite direction to conventional current.

1. When both the bodies are positively charged and are in contact the body having more +ve charge is at higher potential conventional current from A to B $+100 > +70$ from higher potential to lower potential.
∴ Electronic current from B to A.

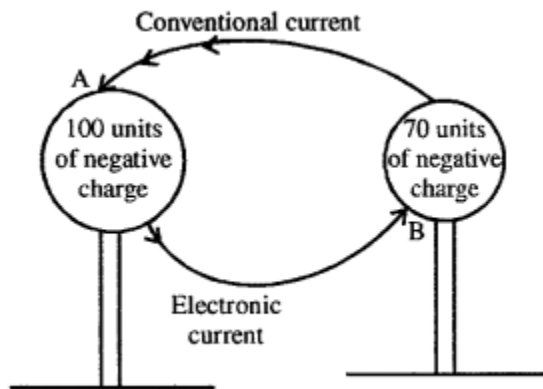


2. When both A and B negative charge conventional current: from higher potential (– 70) to lower potential (–100) i.e. from B to A electronic current: from A to B.



3. When A has +ve charge of 100 units and B has –ve charge of 70 units
Conventional Current: from A to B Higher potential to lower potential a electronic

current from b to A.



Question 2.

Define electric potential. State its practical unit and define it.

Answer:

Electric Potential : "Is the electrical state of a conductor which determines the direction of flow of charge when two conductors are either in contact or joined by a metallic wire."

Or

ELECTRIC POTENTIAL "at a point is the work done in moving unit positive charge from infinity to that point in an electric field.

S.I. unit is volt.

VOLT : "If work done in moving 1 coulomb of charge from one point to other is 1 joule, the potential-difference between two points is said to be 1 volt."

Question 3.

Define quantity of charge. States its practical unit and define it

Answer:

Quantity of charge is "The number of charges (electrons) which drift from a higher to a lower potential is called quantity of charge."

Particle unit of charge is coulomb.

Coulomb: "Flow of 6.25×10^{18} electrons through a conductor constitute 1 coulomb."

Or

"Charge carried by 6.25×10^{18} electrons is called 1 coulomb."

Question 4.

Define electric current State its practical unit and define it

Answer:

Electric current: "Rate of flow of charge". $I = Q/t = ne/t$

S.I. Unit $\rightarrow$ Ampere (A)

Ampere : "When a charge of 1 coulomb passes in 1 second current flowing is one ampere."

Question 5.

State two multiples and two submultiples of the unit of electric potential and electric current

Answer:

Multiple units of :

Electric potential is

1. (Kv) kilovolt = 10^3 V
2. Megavolt (Mv) = 10^6 V

Electric current :

1. KA (kilo-ampere) = 1000 A
2. MA (Mega-ampere) = 10^6

Sub multiple units of:

Electric potential:

1. mV millivolt = 10^{-3} V
2. μ v = microvolt = 10^{-6} V

Electric current :

1. mA = milliampere = 10^{-3} A
2. μ A = micro-ampere = 10^{-6} A

Question 6.

What do you understand by the terms potential difference? State its practical unit

Answer:

Potential difference: "Is the amount of work done in moving a unit positive charge from one point to other." Practical unit – volt.

Question 7.

Define

(a) open electric circuit

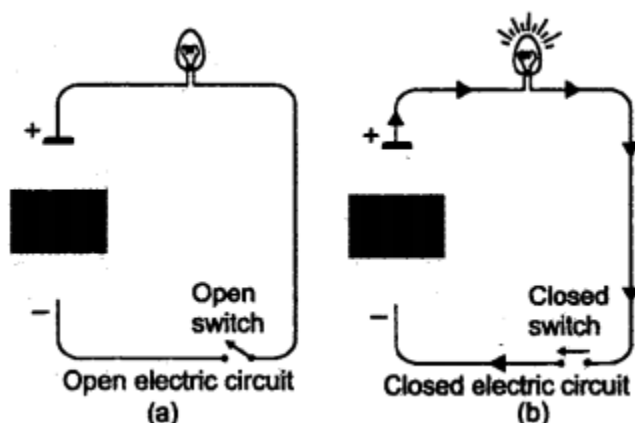
(b) closed electric circuit.

Answer:

(a) **Open electric circuit :** "An electric circuit in which flow of current stops, because of an open switch is called an open electric circuit.

(b) **Closed electric circuit :** "An electric circuit in which a current flows continuously,

because the switch is closed is called a closed electric .



Question 8.

What do you understand by the term electric resistance? state its practical unit.

Answer:

"The obstruction offered to the flow of current by a conductor (wire) is called its RESISTANCE."

S.I. UNIT – is $1/\text{OHM}$ or $(\text{Ohm})^{-1}$

Question 9.

What do you understand by the term electric conductance? State its practical unit

Answer:

"The reciprocal of resistance is called electric CONDUCTANCE". i.e.

Conductance = $1/\text{Resistance}$

S.I. Unit of Conductance Ω^{-1} or OHM^{-1}

Question 10.

What is a superconductor ? Name two materials and the temperature at which they become superconductors.

Answer:

SUPER CONDUCTOR : "The substances which lose resistance when they are cooled to very low temperature (nearly absolute zero) are called super conductors, e.g. mercury at 4.12 k, LEAD, TIN, VANADIUM etc. and this phenomenon is called SUPER CONDUCTIVITY. The temperature at which they become super-conductors is called CRITICAL TEMPERATURE.

Question 11.

State the laws of resistance.

Answer:

Laws of resistance :

1. Resistance of a conductor is directly proportional to its length $R \propto l$
2. Resistance of a conductor is Inversely proportional to its area of cross-section $R \propto 1/a$
3. Resistance of a conductor depend upon its nature i.e. copper has less resistance than iron.
4. Resistance of a conductor increases with increase in temperature i.e. resistance of filament of a bulb is more when lighted as compared to when it is not lighted.

Question 12.

Define specific resistance and state its unit in CGS and SI system.

Answer:

Specific resistance: "Is the resistance of a wire of that material of unit length and unit area of cross-section."

Unit:

In C.G.S. system $\rightarrow [\Omega - \text{cm}]$ ohm – cm

In S.I. system $\rightarrow [\Omega - \text{m}]$ ohm – metre.

Question 13.

Name two materials in each case whose resistance

- (a) increases,
- (b) remains the same and
- (c) decreases with the rise in temperature.

Answer:

Two materials:

1. Cu, iron, sp. resistance increases Tungston with increase in temp.
2. Metallic alloys like eureka, Manganin and German silver The sp. resistance remains the same with rise in temp.
3. Carbon and Rubber. Resistance decrease with increase in temperature.

Question 14.

Give two differences between the electric resistance and electric specific resistance of a material

Answer:

Two differences between resistance and sp. resistance.

Resistance :

1. S.I. unit is ohm (Ω)
2. It is measured as ratio of pot. difference at the ends of a conductor to the current flowing through the conductor.

Resistivity or sp. Resistance :

S.I. unit $[\Omega\text{-m}]$ ohm. metre. It is measured as the resistance offered by a conductor of unit length and unit area of cross-section.

Multiple choice questions

Tick (✓) the most appropriate option.

Question 1.

The graph between V/I for a conductor is a straight line. The slope of the graph represents :

- (a) resistivity
- (b) resistance
- (c) electric potential
- (d) none of these

Answer:

- (b) resistance

Question 2.

Two conductors A and B have 500 and 100 units of . negative charge when the conductors are connected by an electric wire the conventional current flows from :

- (a) A to B
- (b) B to A
- (c) Current does not flow
- (d) none of these

Answer:

- (b) B to A

Question 3.

A conductor at 4.2 K is found to offer no resistance. Such a conductor is called

- (a) zero conductor
- (b) superconductor
- (c) absolute conductor
- (d) none of these

Answer:

- (b) superconductor

Question 4.

Which of the following is non-ohmic resistance ?

- (a) Copper wire
- (b) Brass wire
- (c) Copper wire wound on an electromagnet
- (d) Constantan wire

Answer:

- (b) Brass wire

Question 5.

Which of the following an ohmic resistance ?

- (a) Diode valve
- (b) Filament of a bulb
- (c) Carbon are light
- (d) Manganin wire

Answer:

- (d) Manganin wire

Question 6.

A conductor has a resistivity of $2.63 \times 10^{-8} \Omega \text{ m}$ at 20° C . If the temperature of conductor is raised to 200° C , its resistivity will :

- (a) increase
- (b) decrease
- (c) remain unaffected
- (d) none of these

Answer:

- (a) increase

Question 7.

Amongst the following substance, the resistance will decrease with the increase in temperature in case of:

- (a) copper
- (b) carbon
- (c) brass
- (d) nichrome

Answer:

- (b) carbon

Numericals on Specific Resistance

Practice Problems : 1

Question 1.

A wire of resistance 4.5Ω and length 150 cm , has an area of cross-section of 0.04 cm^2 . Calculate sp. resistance of the wire.

Answer:

$$R = 4.5\Omega, l = 150 \text{ cm}, a = .04 \text{ cm}^2$$

$$\therefore \text{ sp. resistance of wire } \rho = \frac{Ra}{l}$$

$$\rho = \frac{4.5 \times 0.04}{150} = \frac{180}{150000} = 0.0012\Omega - \text{cm}$$

$$a_2 = \frac{a}{3}$$

Question 2.

A wire of length 40 cm and area of cross-section 0.1 mm² has a resistance of 0.8 fl
Calculate sp. resistance of the wire.

Answer:

$l = 40 \text{ cm}$, area of cross-section $a = 0.1 \text{ m m}^2 = 0.1/100 \text{ c m}^2$ $R = 0.8 \Omega$

$$\text{Specific resistance of wire } \rho = \frac{Ra}{l} = \frac{0.8}{40} \times \frac{1}{1000}$$

$$\rho = 0.00002\Omega - \text{cm}$$

Practice Problems : 2

Question 1.

Resistance of a conductor of length 75 cm is 3.25 Ω . Calculate the length of a similar conductor, whose resistance is 13.25 Ω .

Answer:

$$l_2 = ? \quad R_2 = 13.25\Omega$$

$$l_1 = 75 \text{ cm} \quad R_1 = 3.25\Omega$$

$$\frac{l_2}{l_1} = \frac{R_2}{R_1} \quad \therefore l_2 = \frac{R_2 l_1}{R_1} = \frac{13.25 \times 75}{3.25}$$

$$l_2 = 305.76 \text{ cm}$$

Question 2.

A conductor of length 85 cm has a resistance of 3.750. Calculate the resistance of a similar conductor of length 540 cm.

Answer:

$$l_1 = 85 \text{ cm} \quad R_1 = 3.75 \Omega$$

$$l_2 = 540 \text{ cm} \quad R_2 = ?$$

$$\frac{R_2}{R_1} = \frac{l_2}{l_1} \quad \therefore R_2 = \frac{l_2 R_1}{l_1} = \frac{540 \times 3.75}{85}$$

$$R_2 = 23.82 \Omega$$

Practice Problems : 3

Question 1.

A resistance wire made from German silver has a resistance of 4.250. Calculate the resistance of another wire, made from same material, such that its length increases by 4 times and area of cross-section decreases by three times.

Answer:

$$R_1 = 4.25 \quad l_1 = l \text{ (say)}$$

$$a_1 = a \text{ (say)}$$

$$R_2 = ? \quad l_2 = 4l$$

$$a_2 = \frac{a}{3}$$

As both the wires are made of the same material, have same sp. resistance

$$\therefore \rho = \frac{R_1 a_1}{l_1} = \frac{R_2 a_2}{l_2} \quad \text{or} \quad R_2 = \frac{R_1 a}{l} \times \frac{4l}{\frac{a}{3}}$$

$$\therefore R_2 = 12 R_1 = 12 \times 4.25 = 51.00 \Omega$$

Question 2.

A nichrome wire of length l and area of cross-section $a/4$ has a resistance R . Another nichrome wire of length $3l$ and area of cross-section $a/2$ has a resistance of R_1 . Find the ratio of $R_1 : R$.

Answer:

As both the wire are made of same material, have same sp. resistance

$$\therefore \rho = \frac{R \frac{a}{4}}{l} = \frac{R_1 \frac{a}{2}}{3l} \quad \text{or} \quad \frac{R}{4} = \frac{R_1}{6}$$

$$\therefore \frac{R_1}{R} = \frac{6}{4} = \frac{3}{2} \quad \therefore R_1 : R = 3 : 2$$

Exercise – 2

Question 1.

(a) Define series circuit.

Answer:

(a) **Series circuit:** “Resistances are said to be connected in series if same current flows through them and the resistance are connected end to end.

(b) State three characteristics of a series circuit Ans. Characteristics of series circuit:

Answer:

1. Same current flows through each resistance.
2. $V = V_1 + V_2 + V_3 \dots$ i.e. total potential drop is the sum of individual resistances.
3. When we want higher resistance, connect them in series. (Resistance is more than individual resistances).

Question 2.

(a) Define parallel circuit.

Answer:

Parallel circuit : “Resistances are said to be connected in parallel if one end of each is connected at a common terminal and other end of each at other common terminal and they have a common pot. difference.”

(b) State three characteristics of a parallel circuit.

Answer:

Characteristics of parallel circuit:

1. Pot. difference of each resistance is same.
2. Current divides [$I = I_1 + I_2 + I_3 \dots$]
3. $1/R = 1/R_1 + 1/R_2 + 1/R_3$ reciprocal of total resistance is the sum of reciprocals of individual resistances.
4. Total resistance is less than the least of individual resistances.

Question 3.

(a) State Ohm's law.

Answer:

Ohm's Law : "Physical conditions like temp. remaining the same potential across the ends of a conductor is directly proportional to the current flowing".

(b) What are the limitations of Ohm's law?

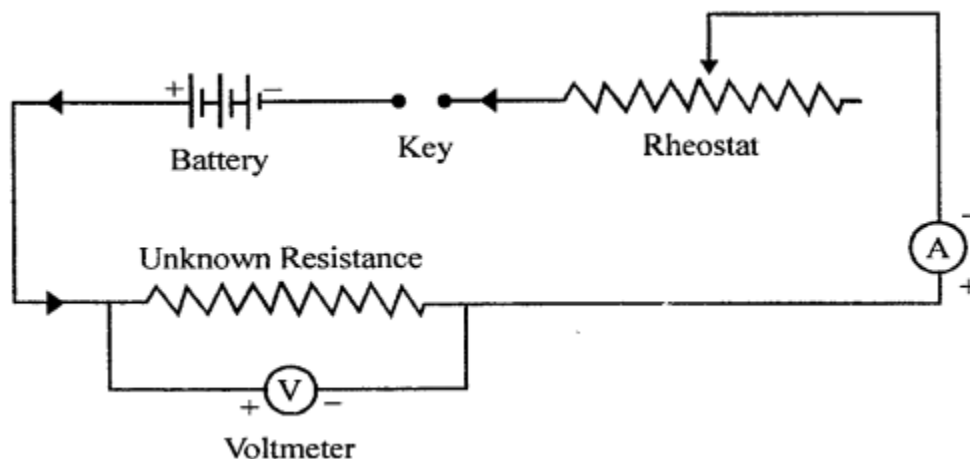
Answer:

Ohm's Law is obeyed only when temperature remains constant.

Question 4.

How will you verify Ohm's law by voltmeter, ammeter method?

Answer:



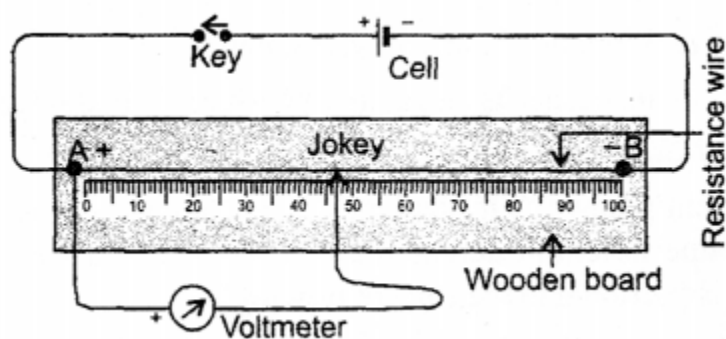
Verification of Ohm's Law: Use the circuit as shown taking care the +ve of voltmeter and +ve of Ammeter should be connected to the +ve of battery and voltmeter in parallel. Key is closed and Rheostat is set to get the minimum reading in Ammeter and voltmeter. The rheostat is then gradually moved and each time value of A and V are noted. The ratio of V/I is always found constant. This verifies Ohm's law.

Question 5.

How will you verify Ohm's law by potentiometer method?

Answer:

Potentiometer method to verify



Connect the potentiometer as shown, close the key and record the potential difference by pressing the jockey at 10 cm intervals of length of the potentiometer wire. Repeat the experiment for six different lengths of potentiometer wire and record the corresponding pot. differences.

potential diff. (in volts)	V_1	V_2	V_3	V_4	V_5	V_6
Length (in cm)	l_1	l_2	l_3	l_4	l_5	l_6

Find the ratio between potential difference and length. It is found.

$$\frac{V_1}{l_1} = \frac{V_2}{l_2} = \frac{V_3}{l_3} = \frac{V_4}{l_4} = \frac{V_5}{l_5} = \frac{V_6}{l_6} = \text{constant}$$

$V/I = \text{constant (} l \text{)}$ (where I is current and the current in series circuit is constant quantity)

But $I \propto R$ {By law of resistance}

$V/R = I$ or $I = V/R$

Hence ohm's law is verified.

Question 6.

What are ohmic resistances ? Given two examples.

Answer:

Ohmic resistances : "Conductors which obey ohm's law are called ohmic resistances."

Two examples : Vanadium, all pure metals like Cu, Al, etc.

Question 7.

What are non-ohmic resistances ? Give two examples.

Answer:

Non-ohmic resistances: "The resistances which do not obey ohm's law are called non-ohmic resistances."

Two examples : Diode valve, triode valve, transistors, filament of a bulb.

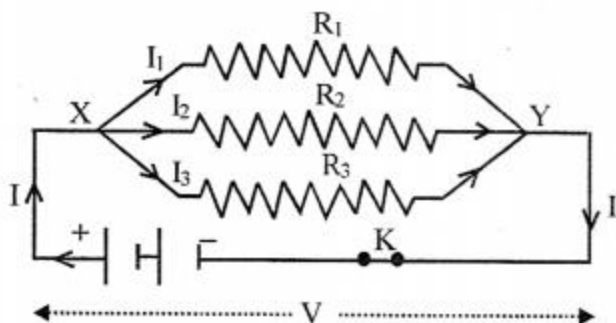
Question 8.

Derive an expression for three resistances connected in series.

Answer:

EQUIVALENT RESISTANCE OF RESISTORS

(i) in **PARALLEL** :



Let three resistors are connect in such away that one end of each R_1, R_2, R_3 is connected at a common terminal (X) and the other end of each at common terminal (Y) through a battery. So that potential difference of each resistor is V and current I at X divides itself and I_1, I_2 and I_3 flows through R_1, R_2 and R_3 respectively and again combine at y and current I flows further.

$I = I_1 + I_2 + I_3 \dots (i)$ we know that

$$I = \frac{V}{R} \quad \therefore I_1 = \frac{V}{R_1}$$

$$\frac{V}{R} = \frac{V}{R_1} + \frac{V}{R_2} + \frac{V}{R_3}$$

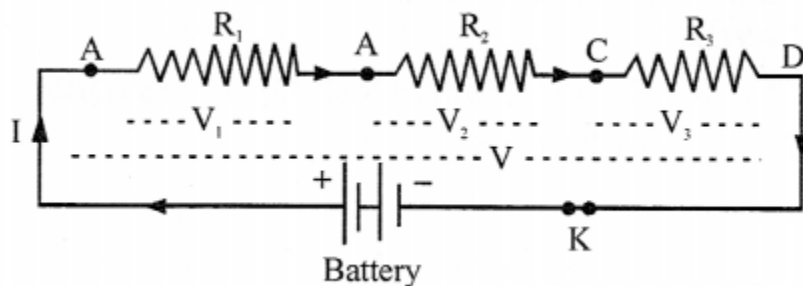
$$\therefore \frac{V}{R} = V \left[\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \right] \quad \begin{matrix} I_2 = \frac{V}{R_2} \\ I_3 = \frac{V}{R_3} \end{matrix} \quad \text{put in (i)}$$

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

EQUIVALENT or RESULTANT resistance of parallel conductors

The reciprocal of EQUIVALENT RESISTANCE is equal to the sum of the reciprocals of individual resistors.

EQUIVALENT RESISTANCE OF RESISTORS In (ii)



Let three resistors R_1, R_2 , and R_3 , be connected in series i.e. resistors are joined one after the other as shown and same current I passes through each and each resistors has potential difference say V_1, V_2 and V_3 so that total p.d. between A and D terminals is V

$$V = V_1 + V_2 + V_3 \dots (i) \quad V = IR$$

$$IR = I R_1 + I R_2 + I R_3 \quad V_1 = I R_1$$

$$IR = I [R_1 + R_2 + R_3] \quad V_2 = I R_2$$

$$V_3 = I R_3 \quad \text{put in (i)}$$

$$R = R_1 + R_2 + R_3$$

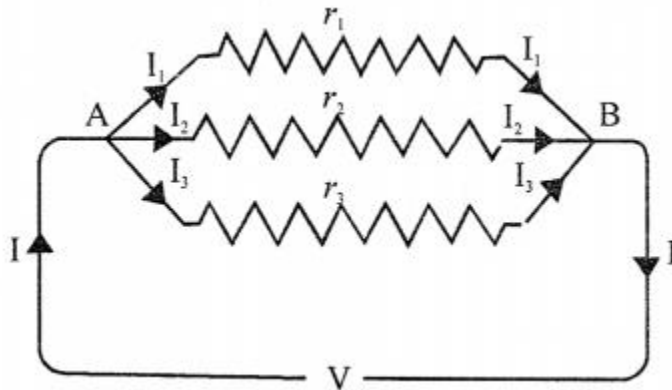
i. e. EQUIVALENT RESISTANCE of resistors in series is the sum of their individual resistance.

Question 9.

Derive an expression for three resistances connected in parallel.

Answer:

To derive relation for resultant resistance of three resistances in parallel, consider three resistances



1. r_1, r_2, r_3 One end of each is connected to common terminal X and other end of each at common terminal Y.
2. Here current I divides into I_1, I_2, I_3 , flowing through r_1, r_2, r_3 and potential difference is v for all resistances.

We know that $I = \frac{V}{R}$

$$\therefore I_1 = \frac{V}{r_1}$$

$$I_2 = \frac{V}{r_2}$$

$$I_3 = \frac{V}{r_3}$$

put in (i)

$$I = I_1 + I_2 + I_3$$

$$\frac{V}{R} = \frac{V}{r_1} + \frac{V}{r_2} + \frac{V}{r_3}$$

$$\frac{V}{R} = V \left[\frac{1}{r_1} + \frac{1}{r_2} + \frac{1}{r_3} \right]$$

$$\frac{1}{R} = \frac{1}{r_1} + \frac{1}{r_2} + \frac{1}{r_3}$$

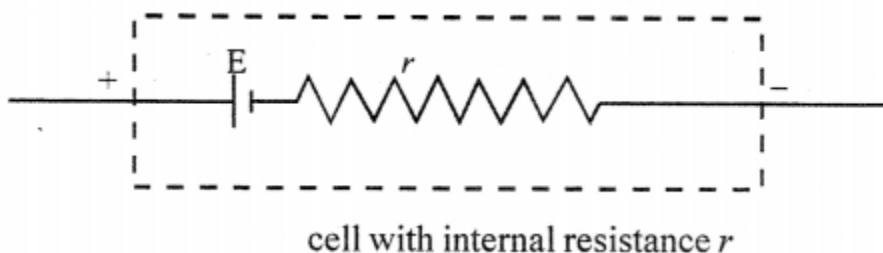
Question 10.

What do you understand by the term internal resistance of a cell ?

Answer:

INTERNAL RESISTANCE OF A CELL :

"The resistance offered by the electrolyte inside the cell to the flow of current is called the internal resistance of cell.



Question 11.

State the factors on which internal resistance of a cell depends.

Answer:

Factors effecting the internal resistance of a cell :

1. Surface area of electrodes larger surface area, lesser is the internal resistance.
2. Distance between electrodes : more the distance, more is the internal resistance.
3. Temp, of electrolyte $r \propto 1/T$
4. Higher the concentration of electrolyte greater is internal resistance.

Question 12.

What is the difference between emf and terminal voltage of a cell ?

Answer:

Difference between e.m.f. and terminal voltage :

Terminal voltage : When current is drawn from a cell i.e. the cell is in a closed circuit, the potential differences between the electrodes (terminals) of a cell is called terminal voltage,

e.m.f. : "when no current is drawn from a cell i.e. when the cell is in open circuit, the pot. difference between the terminals of the cell is called electromotive force, (e.m.f.).

Multiple choice questions

Tick (✓) the most appropriate option.

Question 1.

In a series circuit:

- (a) p.d. across all resistors is same
- (b) current flowing through all resistors is same
- (c) The combined resistance of all resistors is less than individual resistors.
- (d) none of the above

Answer:

- (b) current flowing through all resistors is same

Question 2.

In a parallel circuit:

- (a) p.d. across all resistors is same
- (b) current flowing through all resistors is same
- (c) the equivalent resistance of all resistors is more than any of the individual resistors
- (d) none of the above

Answer:

- (a) p.d. across all resistors is same

Question 3.

Two resistors of $2\ \Omega$. each are connected in a parallel. The equivalent resistance is :

- (a) less than $2\ \Omega$ but more than $1\ \Omega$
- (b) one ohm
- (c) four ohm
- (d) between $4\ \Omega$ and $2\ \Omega$

Answer:

- (b) one ohm

Question 4.

A new cell is marked 1.5 V. When connected to an external resistance, the voltmeter connected to its terminals reads 1.2 V. The drop in potential across the terminals of the cell is due to the :

- (a) internal resistance of cell
- (b) external resistance .
- (c) both (a) and (b)
- (d) none of these

Answer:

- (a) internal resistance of cell

Question 5.

A potentiometer is connected to a cell through switch in series. To one end of the potentiometer is attached a voltmeter with the help of connecting wire and a jockey. When the jockey is moved over the potentiometer wire from zero end to 100 cm the reading shown by voltmeter is likely to :

- (a) decrease
- (b) increase
- (c) does not change
- (d) none of these

Answer:

- (b) increase

Question 6.

When the current is drawn from a cell in a closed circuit, the potential difference between the terminals of cell is called :

- (a) e.m.f.
- (b) p.d.
- (c) terminal voltage
- (d) both (a) and (b)

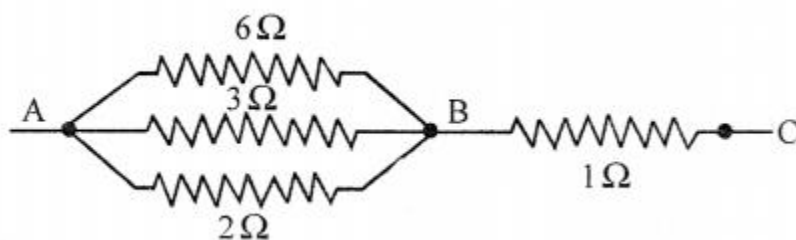
Answer:

- (c) terminal voltage

Numerical Problems on Resistance

Practice Problems : 1

Question 1.



Calculate the equivalent resistance

1. between points A and B
2. between points A and C.

Answer:

Resistance 6Ω , 3Ω and 2Ω are in parallel between A and B

1. Equivalent resistance between AB is R_1 . $R_1 = 1\Omega$ Now combination R_1 and 1Ω of BC are in series
2. Now between points A and C $R = R_1 + 1 = 1 + 1 = 2\Omega$

Question 2.

In figure, calculate equivalent resistance between points

1. A and B
2. B and C
3. A and C.

Answer:

Equivalent resistance between AB 4Ω and 12Ω are in parallel

$$\therefore R_1 = \frac{1}{\frac{1}{4} + \frac{1}{12}} = \frac{3+1}{12} = \frac{1}{3}$$

$$\therefore R_1 = 3\Omega$$

(ii) Between B and C

Equivalent resistance R_2 between BC

$$\frac{1}{R_2} = \frac{1}{12} + \frac{1}{24} + \frac{1}{8} = \frac{2+1+3}{24} = \frac{1}{4}$$

$$\therefore R_2 = 4\Omega$$

2. Between B and C

Equivalent Resistance R_2 between BC

3. Between A and CD

Now R_1 and R_2 are in series

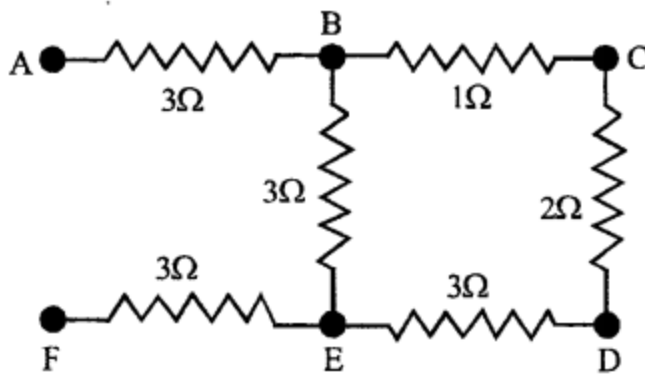
Equivalent Resistance between A and C

$$R = R_1 + R_2 = 3 + 4 = 7\Omega$$

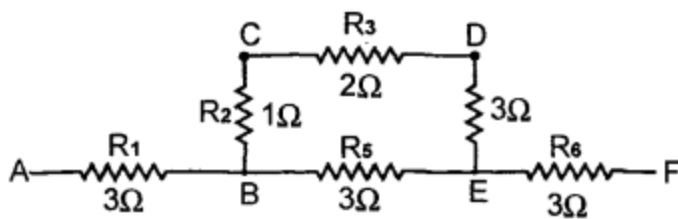
Practice Problems : 2**Question 1.**

Calculate the equivalent resistance between points

1. B and E (ii) A and F.



2.



1. Equivalent Resistance between BE, (1Ω , 2Ω , 3Ω are in series) is R_1

$$R_1 = 1 + 2 + 3 = 6\Omega$$

R_1 is in parallel to $R_2 = 3\Omega$

their resultant R_3

$$1/r_3 = 1/r_1 + 1/r_2 = 1/6 + 1/3 = 1+2/6 = 1/6 \text{ Between BE}$$

$$\therefore R_3 = 2\Omega$$

(ii) Equivalent resistance between A and F

i.e. R_4 , R_2 , R_5 are in series

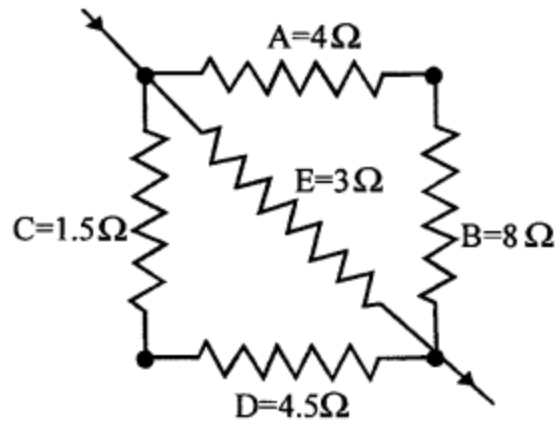
3Ω , 2Ω and 3Ω are in series

$$R = 3 + 2 + 3 = 8\Omega$$

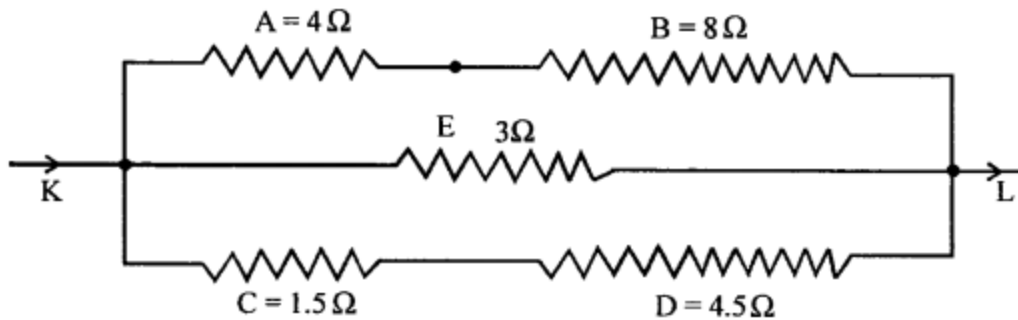
Answer:

Question 2.

Calculate the equivalent resistance of circuit diagram shown in Fig. below.



Ans.



Resistances A and B are in series

$$R_1 = 4 + 8 = 12\Omega$$

Resistance C and D are in series

$$R_2 = 1.5 + 4.5 = 6\Omega$$

Now R_1 , E and R_2 are in parallel

$\therefore$ Equivalent resistance between F and G

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{E} + \frac{1}{R_2}$$

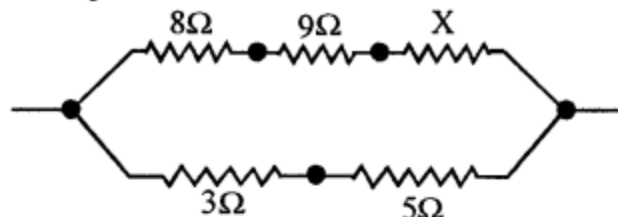
$$\frac{1}{R} = \frac{1}{12} + \frac{1}{3} + \frac{1}{6} = \frac{1+4+2}{12} = \frac{7}{12}$$

$$\therefore R = \frac{12}{7} = 1.71\Omega$$

Practice Problems : 3

Question 1.

Equivalent resistance of circuit diagram is 6Ω . Calculate the value of x .



Ans. 8Ω , 9Ω , $x\Omega$ are in series

$$\therefore R_1 = 8 + 9 + x = (17 + x) \Omega \quad \dots(i)$$

3Ω and 5Ω are in series

$$\therefore R_2 = 3 + 5 = 8\Omega \quad \dots(ii)$$

Now Equivalent resistance of R_1 and R_2 which are in parallel is $R_3 = 6\Omega$

$$\therefore \frac{1}{R_3} = \frac{1}{R_1} + \frac{1}{R_2}$$

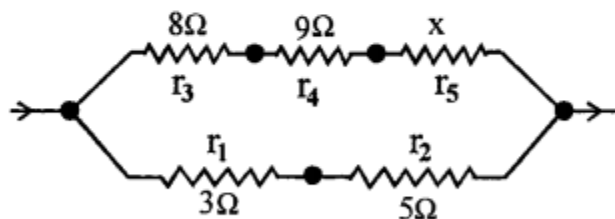
$$\therefore \frac{1}{6} = \frac{1}{(17+x)} + \frac{1}{8}$$

$$\text{or } \frac{1}{17+x} = \frac{1}{6} - \frac{1}{8} = \frac{1}{24}$$

$$\therefore 17 + x = 24$$

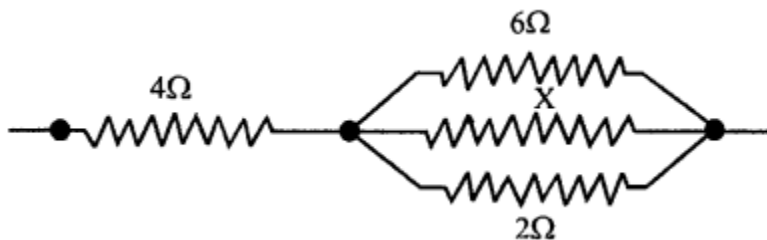
$$x = 24 - 17 = 7$$

$$x = 7\Omega$$



Question 2.

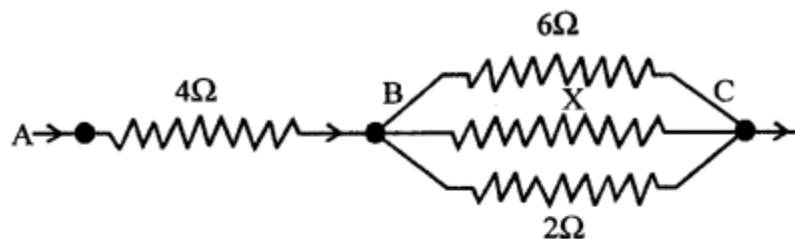
Equivalent resistance of circuit diagram is 5Ω . Calculate the value of x .



Answer:

Since Equivalent resistance of 4Ω and parallel combination is 5Ω and 4Ω and parallel combination are in series.

Resistance of parallel combination is = 5 – 4 = 1Ω



$$\therefore \frac{1}{1} = \frac{1}{2} + \frac{1}{6} + \frac{1}{x}$$

$$\text{or } \frac{1}{x} = \frac{1}{1} - \frac{1}{2} - \frac{1}{6} = \frac{6-3-1}{6} = \frac{1}{3}$$

$$\therefore x = 3\Omega$$

Numerical Problems on Ohm's Law

Practice Problems : 1

Question 1.

A current of 0.2 A flows through a conductor of resistance 4.50. Calculate p.d. at the ends of conductor.

Answer:

Here $I = 0.2 \text{ A}$, $R = 4.5\Omega$

p.d. at the ends of conductor $V = IR$

$$V = 0.2 \times 4.5 = 0.9 \text{ V}$$

Question 2.

A bulb of resistance 4000 is connected to 200 V mains. Calculate the magnitude of current.

Answer:

$R = 400\Omega$, $V = 200 \text{ V}$

$$I = V/R \text{ } 200/400 = 0.5 \text{ A}$$

Question 3.

An electric heater draws a current of 5 A, when connected to 220 V mains. Calculate the resistance of its filament.

Answer:

$I = 5 \text{ A}$, $V = 220 \text{ V}$, $R = ?$

$$R = v/I = 220/5 = 44\Omega$$

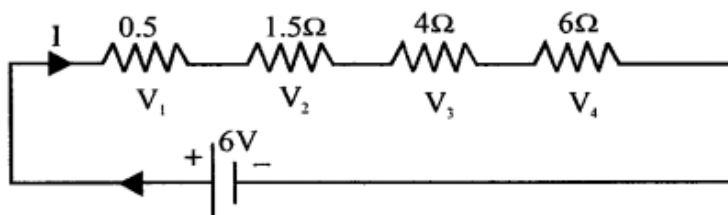
Practice Problems : 2

Question 1.

Four resistors of resistance $0.5\ \Omega$, $1.5\ \Omega$, $4\ \Omega$ and $6\ \Omega$ are connected in series to a battery of e.m.f. $6\ \text{V}$ and negligible internal resistance. Calculate :

1. current drawn from the cell
2. p.d. at the ends of each resistor.

Answer:



Equivalent resistance of four resistors in series

$$R = 0.5\ \Omega + 1.5\ \Omega + 4\ \Omega + 6\ \Omega = 12\ \Omega$$

e.m.f. of battery $V = 6\text{V}$

$$(i) \quad \therefore I = \frac{V}{R} = \frac{6}{12} = \frac{1}{2} = 0.5\ \text{A}$$

$$(ii) \quad \text{P.d. across } 0.5\ \Omega, V_1 = Ir_1 = \frac{1}{2} \times .5 = 0.25$$

$$V_1 = 0.25\ \text{V}$$

$$\text{Similarly } V_2 = 1.5 \times 0.5 = 0.75\ \text{V}$$

$$V_3 = 4 \times 0.5 = 2\ \text{V}$$

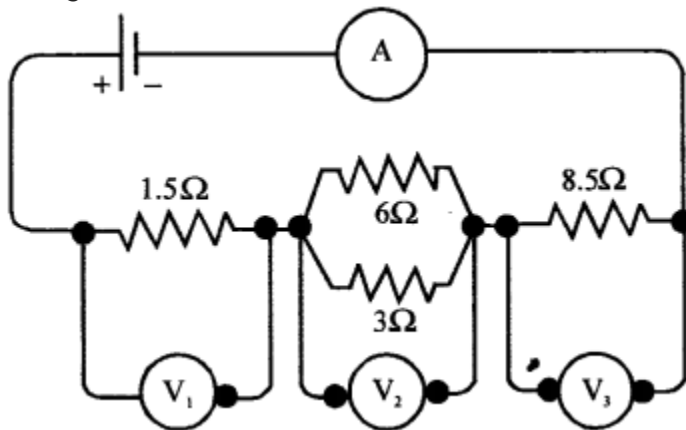
$$V_4 = 6 \times 0.5 = 3\ \text{V}$$

Question 2.

Figure shows a circuit diagram having a battery of $24\ \text{V}$ and negligible internal resistance. Calculate :

1. reading of the ammeter,

2. reading of V_1 , V_2 and V_3 .



Answer:

As 6Ω and 3Ω are in parallel

$$\therefore \frac{1}{R_1} = \frac{1}{6} + \frac{1}{3} = \frac{1}{2} \quad \therefore R_1 = 2\Omega$$

Now total resistance of the circuit = $[1.5 + 2 + 8.5] = 12\Omega$

V of battery = 24 volt.

$$\therefore \text{(i) Reading of ammeter } I = \frac{V}{R} = \frac{24}{12}$$

$$I = 2A$$

$$\text{(ii) Reading of } V_1 = Ir_1 = 2 \times 1.5 = 3V$$

$$\text{Similarly } V_2 = Ir_2 = 2 \times 2 = 4V$$

$$\text{and } V_3 = Ir_3 = 2 \times 8.5 = 17V$$

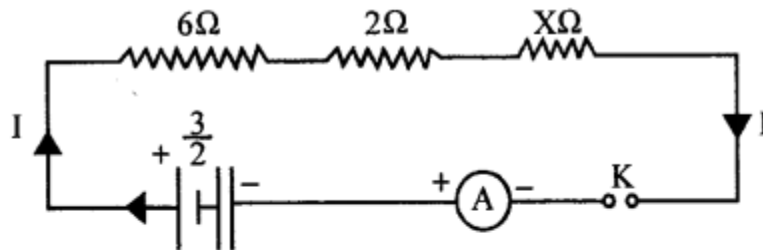
Practice Problems : 3

Question 1.

Three resistors of 6Ω , 2Ω and x are connected in series to a cell of e.m.f $3/2$ V, when the current registered in circuit is $1/6$ A. Draw the circuit diagram and calculate value of x

Answer:

Circuit diagram:



Here $V = \frac{3}{2}$ V, $I = \frac{1}{6}$ A

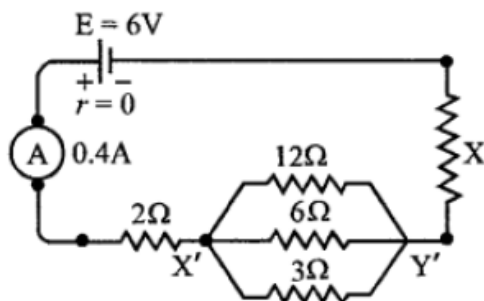
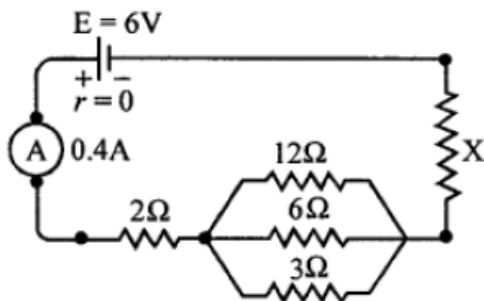
$\therefore$ Resistance of circuit $= R = \frac{V}{I} = \frac{\frac{3}{2}}{\frac{1}{6}} = 9\Omega$

But 6Ω , 2Ω , $X\Omega$ are in series

$\therefore 6 + 2 + X = 9$
 $X = 9 - 8 = 1\Omega$

Question 2.

Carefully study the circuit diagram in figure and calculate the value of resistor x.



Answer:

Effective resistance between X'Y' which are in parallel

$$\frac{1}{R_1} = \frac{1}{12} + \frac{1}{6} + \frac{1}{3} = \frac{1+2+4}{12} = \frac{7}{12}$$

$$R_1 = \frac{12}{7} \Omega$$

$$V = 6V$$

$$I = 0.4 \text{ A}$$

$$\text{Total resistance in circuit} = R = \frac{V}{I} = \frac{6}{0.4}$$

$$R = \frac{60}{4} = 15 \Omega$$

$$\therefore 2\Omega + \frac{12}{7}\Omega + X = 15$$

$$X = 15 - 2 - \frac{12}{7} = \frac{91-12}{7} = \frac{79}{7} = 11.28$$

$$X = 11.28 \Omega$$

Practice Problems : 4

Question 1.

Three resistors of 4Ω , 6Ω . and 12Ω are connected in parallel The combination of these resistors is connected in series to a resistance of 2Ω and then to a battery of e.m.f 6 V and negligible internal resistance.

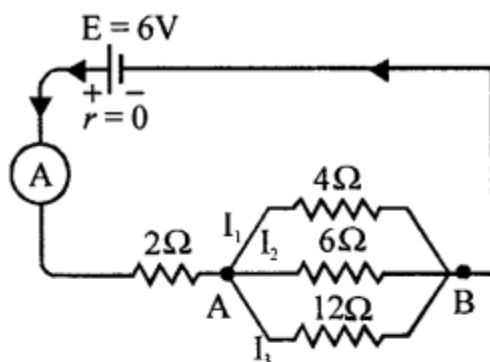
(a) Draw the circuit diagram

(b) Calculate the current in main circuit

(c) Calculate the current in each of the resistors in parallel

Answer:

(a) Circuit diagram



Effective resistance between AB

$$\frac{1}{R_1} = \frac{1}{4} + \frac{1}{6} + \frac{1}{12} = \frac{1}{2} \quad \therefore R_1 = 2\Omega$$

Now $R = 2\Omega + 2\Omega = 4\Omega$ (as in series)

(b) Current in circuit $I = \frac{V}{R} = \frac{6}{4} = 1.5 \text{ A}$

(c) Now p.d. across AB $= V = IR_1 = \frac{3}{2} \times 2 = 3\text{V}$

(i) I_1 through $4\Omega = \frac{V}{R} = \frac{3}{4} = 0.75 \text{ A}$

(ii) $I_2 = \frac{3}{6} = 0.5 \text{ A}$

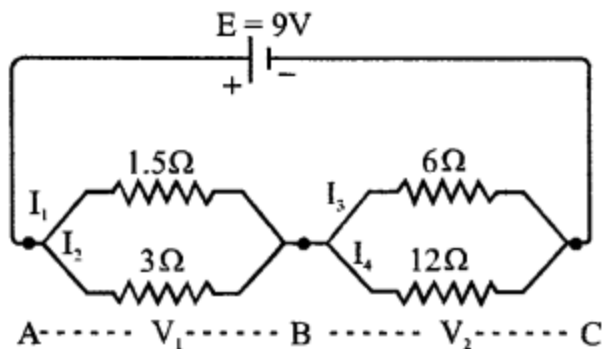
(iii) $I_3 = \frac{3}{12} = 0.25 \text{ A}$

Question 2.

Study the circuit diagram in figure carefully and calculate:

(a) current in main circuit

(b) current in each of the resistors in parallel circuit.



Ans. Effective resistance between AB and BC

$$\frac{1}{R_1} = \frac{1}{1.5} + \frac{1}{3} = \frac{1}{1} \quad \text{and} \quad \frac{1}{R_2} = \frac{1}{6} + \frac{1}{12} = \frac{1}{4}$$

$$R_1 = 1\Omega \quad \therefore \quad R_2 = 4\Omega$$

But $R = R_1 + R_2$ being in series

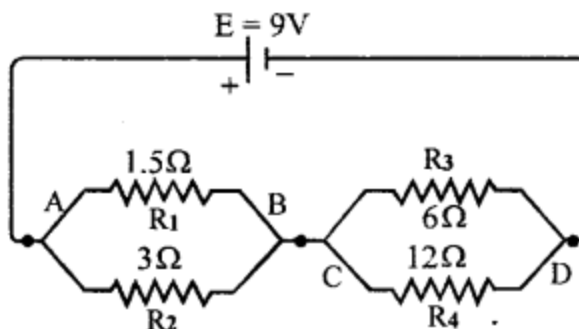
$$R = 1 + 4 = 5\Omega, \quad V = 9V$$

$$\therefore \text{(a) current in main circuit} = I = \frac{V}{R} = \frac{9}{5} = 1.8 A$$

$$\text{(b) P.d. across AB, } V_1 = IR_1 = 1.8 \times 1 = 1.8 V$$

$$\therefore I_1 = \frac{V_1}{1.5} = \frac{1.8}{1.5} = 1.2 A$$

$$\text{and } I_2 = \frac{1.8}{3} = 0.6 A$$



$$\text{P.d. across BC, } V_2 = IR_2 = 1.8 \times 4 = 7.2 V$$

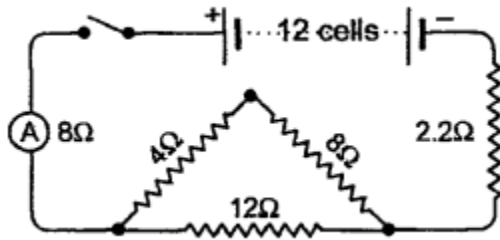
$$\therefore I_3 = \frac{V_2}{6} = \frac{7.2}{6} = 1.2 A$$

$$\text{and } I_4 = \frac{7.2}{12} = 0.6 A$$

Practice Problems : 5

Question 1.

Figure shows a circuit diagram containing 12 cells, each of e.m.f 1.5 V and internal resistance 0.25Ω . Calculate:



- (a) Total internal resistance
- (b) Total e.m.f.
- (c) Total external resistance
- (d) Reading shown by the ammeter
- (e) Current in 12Ω and 8Ω resistors
- (f) p.d. across 2.2Ω resistor
- (g) Drop in potential across the terminals of the cell

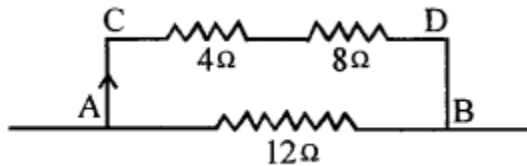
Answer:

Number cells in series = $n = 12$

(a) Total internal resistance of 12 cells = $n r = 12 \times 0.25 = 3\Omega$

(b) Total e.m.f. = $12 \times 1.5 = 18\text{ V}$

(c) Total external resistance : $4 + 8 = 12\Omega$ in series



$$\text{Resistance between AB} = \frac{12 \times 12}{(12+12)} = 6 \Omega$$

as are in parallel.

$$\therefore \text{Total external resistance} = 0.8 + 6 + 2.2 = 9 \Omega$$

(d) Reading shown by the ammeter

$$I = \frac{E}{R+r} = \frac{18}{(9+3)} = \frac{18}{12} = 1.5 \text{ A}$$

(e) To find Current in 12Ω and 8Ω

$$V = IR$$

$$I_1 \text{ through CD} = 1.5 \times 6 = 9 \text{ V}$$

$$I_1 \text{ through } 8\Omega = \frac{V}{R} = \frac{9}{(8+4)} = \frac{9}{12} = 0.75 \text{ A}$$

$$I_2 \text{ through } 12\Omega = \frac{V}{R} = \frac{9}{12} = 0.75 \text{ A}$$

(f) p.d. across 2.2 resistor

$$\begin{aligned} \text{p.d. across } 2.2 \text{ resistor} &= I \times R \\ &= 1.5 \times 2.2 \\ &= 3.30 \text{ V} \end{aligned}$$

(g) Drop in potential across the terminals of the cell.

$$= E - V$$

$$(12 \times 1.5) - IR \quad \text{Or} \quad Ir$$

$$18 - (1.5 \times 9) \quad 1.5 \times 3$$

$$18 - 13.5 = 4.5 \text{ V} \quad = 4.5 \text{ V}$$

Question 2.

Four cells, each of e.m.f 2 V and internal resistance 0.2Ω each are connected in series to form a battery. This battery is connected to an ammeter, a resistance 1.2 and then to a set of resistance of 4Ω , 6Ω and 12Ω in parallel to complete the overall circuit in series.

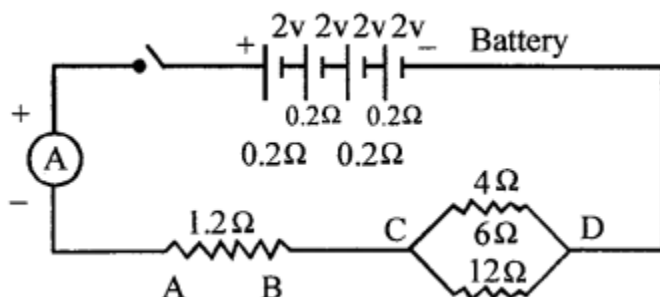
(a) Draw circuit diagram of arrangement.

(b) Calculate total internal resistance

- (c) Total e.m.f.
- (d) Current recorded by ammeter.
- (e) Current flowing through 6 wire in parallel.
- (f) Drop in potential across the terminals of the battery.

Answer:

- (a) Circuit diagram :



- (b) Total internal resistance $r = 4 \times 0.2 = 0.8 \Omega$
- (c) Total e.m.f. $= 4 \times 2 = 8 \text{ V}$
- (d) Current recorded by ammeter ?
 R_1 across CD $1/R_1 = 1/4 + 1/6 + 1/12 = R_1 = 2 \Omega$
 Total resistance $(0.8 + 1.2 + 2) = 4 \Omega$
 $I = V/R = 8/4 = 2 \text{ A}$
- (e) V across CD $= I R_1 = 2 \times 2 = 4 \text{ V}$
 Current through $6 \Omega = V/R = 4/6 = 0.67 \text{ A}$
- (f) drop in potential across the terminals of the battery $E - V = Ir = 2 \times 0.8 = 1.6 \text{ V}$

Practice Problems : 6

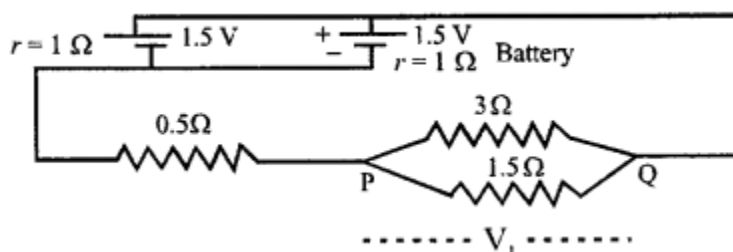
Question 1.

Two cells, each of e.m.f 1.5 V and internal resistance 1Ω are connected in parallel, to form a battery. The battery is connected to an external resistance of 0.5Ω and two resistances of 3Ω and 1.5Ω in parallel.

- (a) Draw the circuit diagram.
- (b) Calculate the current in main circuit.
- (c) Calculate the current in 1.5Ω resistor.
- (d) Calculate the drop in potential across the terminal of the battery.

Answer:

- (a) Circuit diagram



(b) Current in the main circuit

Total internal resistance of two parallel cells $1/R_1 = 1 + 1$

$$R = 1/2 = 0.5 \Omega$$

Effective resistance between PQ = $1/R_2 = 1/3 + 2/3$

$$R_2 = 1 \Omega$$

Total resistance of circuit $R = R_1 + R_2 + \text{external resistance}$

$$R = 0.5 + 1 + 0.5 = 2\Omega, V = 1.5 \text{ V}$$

current in main circuit

$$I = V/R = 1.5/2 = 0.75 \text{ A}$$

(c) Current in 1.5Ω resistor

p.d. between PQ = IR_2

$$V_1 = 0.75 \times 1$$

$$V_1 = 0.75 \text{ V}$$

$$V_1 = 0.75$$

$$I_1 = V_1/1.5 = 0.75/1.5 = 0.5 \text{ A}$$

(d) Drop in potential across the terminals of battery $E - V = Ir = 0.75 \times 0.5 = 0.375 \text{ V}$

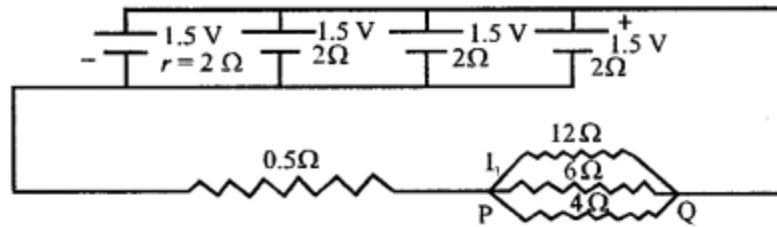
Question 2.

Four cells, each of e.m.f. 1.5 V and internal resistance 2Ω . each are connected in parallel to form a battery. The battery is connected to an external resistance of 0.5Ω . and three resistances of 12Ω , 6Ω and 4Ω . in parallel.

1. Draw the circuit diagram.
2. Calculate current in main circuit
3. Calculate current in 4Ω resistor.
4. Calculate drop in potential across the terminals of battery.

Answer:

1.circuit diagram is drawn



$$(ii) \quad \text{Resistance across PQ} = \frac{1}{R_1} = \frac{1}{12} + \frac{1}{6} + \frac{1}{4} = \frac{1+2+3}{12} = \frac{1}{2}$$

$$\therefore R_1 = 2\Omega$$

$$\text{Total internal resistance of 4 cells } \frac{1}{r} = \frac{1}{2} + \frac{1}{2} + \frac{1}{2} + \frac{1}{2}$$

$$r = \frac{1}{2}\Omega$$

$$\therefore \text{Total resistance of the circuit } R = R_1 + r + 0.5$$

$$R = 2 + 0.5 + 0.5 = 3\Omega$$

$$(iii) \quad \text{Current in the main circuit} = I = \frac{E}{R} = \frac{1.5V}{3\Omega}$$

$$\therefore I = 0.5 \text{ A}$$

$$(iii) \quad \text{Current in } 4\Omega \text{ resistor } V_1 = \frac{1}{2} \times 2 = 1V$$

4. Drop in potential across the terminals of battery

$$E - V = I_r \\ = 0.5 \times 0.5 = 0.25 \text{ V}$$

Practice Problems : 7

Question 1.

A cell of e.m.f 1.5 V, records a p.d. of 1.35 V, when connected to an external resistance R, such that current flowing through circuit is 0.75 A. Calculate the value of R and internal resistance of cell

Answer:

$$E = 1.5, V = 1.35 \text{ V}, I = 0.75 \text{ A}$$

$$R = \frac{V}{I} = \frac{1.35}{0.75} = 1.8\Omega$$

$$\text{Also } I = \frac{E}{R+r} \text{ or } 0.75 = \frac{1.5}{1.8+r}$$

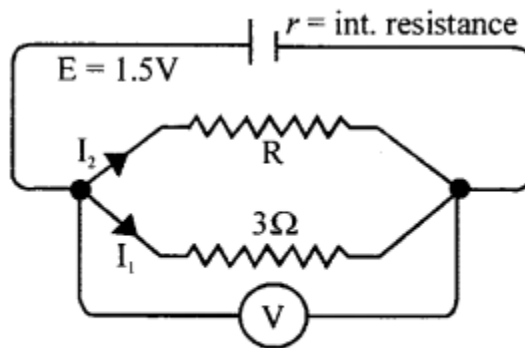
$$1.8 + r = \frac{1.5}{0.75} = 2$$

$$r = 2 - 1.8 = 0.2\Omega$$

$$r = 0.2\Omega$$

Question 2.

In figure a current of 1 A flows through the circuit, when p.d. recorded at the ends of parallel resistors is 1 volt. Calculate the value of R and r.



For parallel resistors

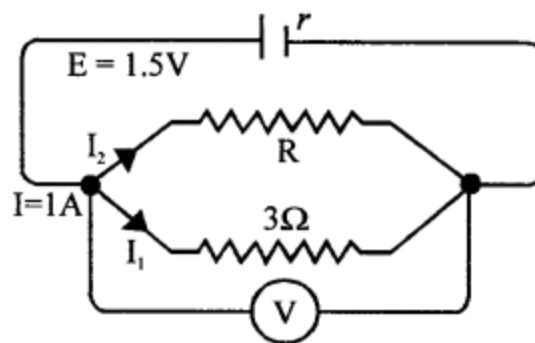
Answer: For parallel resistors

$$I = 1\text{A} \quad V = 1\text{V}$$

$$I_1 = \frac{V}{3} = \frac{1}{3} \text{ A}$$

$$\therefore I_2 = 1 - \frac{1}{3} = \frac{2}{3} \text{ A}$$

$$\therefore R = \frac{V}{I_2} = \frac{1}{\frac{2}{3}} = 1.5\Omega$$



Now Resultant resistance of parallel combination

$$\frac{1}{R_1} = \frac{1}{3} + \frac{2}{3} = \frac{1}{1}$$

$$\therefore R_1 = 1\Omega$$

$$\text{But } I = \frac{E}{R_1 + r}$$

$$\text{But } I = \frac{E}{R_1 + r}$$

$$1 = \frac{1.5}{1 + r}$$

$$\therefore 1 + r = 1.5$$

$$r = 1.5 - 1 = 0.5$$

Practice Problems : 8

Question 1.

A cell of e.m.f 1.8 V is connected to an external resistance of 2 Ω, when p.d. recorded at

the ends of resistance is 1.6 V. Calculate the internal resistance of the cell.

Answer:

$$I = V/R$$

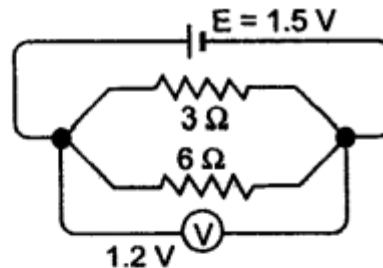
$$I = \frac{1.6}{2} = 0.8 \text{ A}$$

$$E - V = Ir$$

$$1.8 - 1.6 = 0.8 r \quad \therefore r = \frac{0.2}{0.8} = 0.25 \Omega$$

Question 2.

Study the circuit diagram in Fig. 8.44, and hence, calculate the internal resistance of



$\therefore 3 \Omega$ and 6Ω are in parallel

$$R = \frac{3 \times 6}{(3+6)} = 2 \Omega$$

$$I = \frac{V}{R} = \frac{1.2}{2} = 0.6 \text{ A}$$

$$E - V = Ir$$

$$1.5 - 1.2 = 0.6 r$$

$$r = \frac{0.3}{0.6} = 0.5 \Omega$$

cel

Practice Problems 9

Question 1.

A cell, when connected to an external resistance of 4.5Ω shows a p.d of 1.35 V. If 4.5Ω resistance is replaced by 2.5Ω resistance the p.d drops to 1.25 V. Calculate:

(a) em.f.,

(b) internal resistance of the cell

Answer:

Let 'E' be the e.m.f and 'r' the internal resistance

Case(I) $r = R [e-v]/v$

$$r = \frac{4.5[E-1.35]}{1.35} = \frac{10(E-1.35)}{3} \quad \dots(i)$$

$$\text{Case (2)} \quad r = \frac{2.5[E-1.25]}{1.25} = \frac{10}{5}(E-1.25) \quad \dots(ii)$$

Comparing (i) and (ii)

$$\frac{10[E-1.35]}{3} = \frac{10}{5}(E-1.25)$$

$$5[E - 1.35] = 3[E - 1.25]$$

$$5E - 6.75 = 3E - 3.75$$

$$5E - 3E = 6.75 - 3.75$$

$$(i) \quad 2E = 3$$

$$\text{e.m.f.} \quad E = \frac{3}{2} = 1.5 \text{ V}$$

Put in (i)

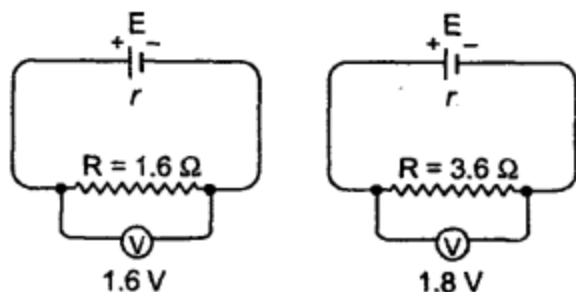
$$r = \frac{10}{3} [E - 1.35]$$

$$r = \frac{10}{3} [1.5 - 1.35]$$

$$= \frac{10}{3} \times \frac{15}{100} = 0.5 \, \Omega$$

Question 2.

Study the figures carefully and hence calculate the value of E and r.



Answer:

Let 'E' be the e.m.f. and 'r' in internal resistance from fig.

(b)

$$r = \frac{R(E - V)}{V}$$

$$r = 3.6 \frac{[E - 1.8]}{1.8} = 2[E - 1.8] \quad \dots(i)$$

In fig. (a)

$$r = \frac{1.6[E - 1.6]}{1.6} = [E - 1.6] \quad \dots(ii)$$

From (i) and (ii)

$$2[E - 1.8] = [E - 1.6]$$

$$2E - 3.6 = E - 1.6$$

$$2E - E = 3.6 - 1.6$$

$$E = 2V \text{ put in (ii)}$$

$$r = E - 1.6$$

$$r = 2 - 1.6 = 0.4 \, \Omega$$

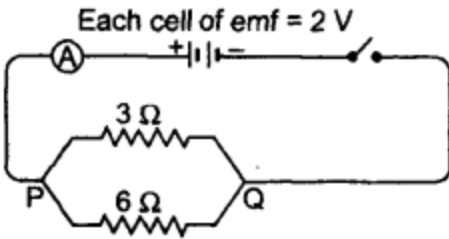
Questions from ICSE Examination Papers

2003

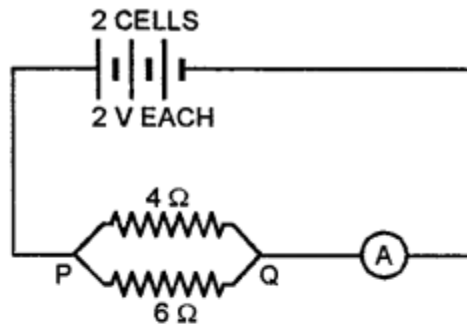
Question 1.

Study the diagram carefully and calculate :

(a) the equivalent resistance between P and Q.



- (b) the reading of the ammeter.
 (e) the electrical power between P and Q.



Ans. (a) Equivalent resistance between P and Q.

$$= \frac{1}{R} = \frac{1}{3} + \frac{1}{6} = \frac{2+1}{6} = \frac{3}{6} = \frac{1}{2}$$

$$\therefore \frac{1}{R} = \frac{1}{2}$$

$$\therefore R = 2 \, \Omega$$

Equivalent resistance between P and Q = 2 Ω **Ans.**

(b) Ammeter reading

$$V \text{ of two cells in series} = 2 + 2 = 4 \, \text{V}$$

$$I = \frac{V}{R} = \frac{4}{2} = 2 \, \text{A}$$

(c) Electric power = VI = P

$$P = 4 \times 2 = 8 \, \text{W}$$

2004

Question 2.

Mention two factors which determine the internal resistance of a cell.

Answer:

The internal resistance of a cell depends on

1. Surface area of electrodes and
2. distance between the electrodes.

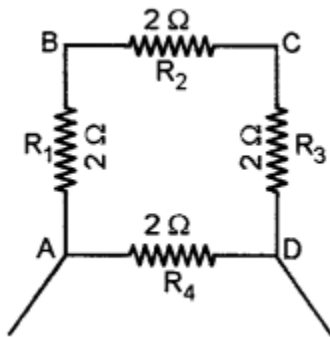
2005

Question 3.

Four resistances of 2.0Ω each are joined end to end to form a square A B C D. Calculate the equivalent resistance of the combination between any two adjacent corners.

Answer:

Resistors R_1 , R_2 and R_3 are in series, therefore their equivalent resistance is $R_s = R_1 + R_2 + R_3 = 2 + 2 + 2 = 6 \text{ ohm}$.



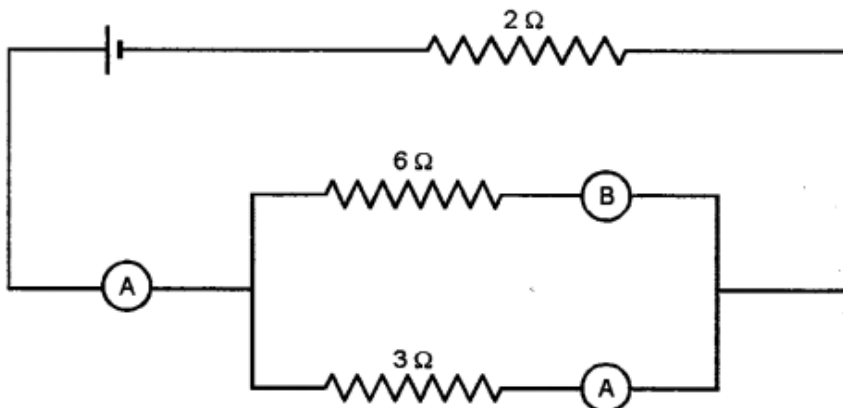
Now R_s and R_4 are in parallel, therefore equivalent resistance of the combination between two adjacent corners is

$$1/R_p = 1/R_s + 1/R_4 = 1/6 + 1/2 = 2/3$$

Therefore $R_p = 1.5 \text{ ohm}$.

Question 4.

The figure shows three ammeters A, B and C. The ammeter B reads 0.5 A . If all the ammeters have negligible resistance calculate: Calculate:



1. the readings in the ammeters A and C
2. the total resistance of the circuit

(i) Total resistance in B and C $\frac{1}{r} = \frac{1}{6} + \frac{1}{3} = \frac{1+2}{6} = \frac{3}{6}$ therefore,

$$r_p = 2 \Omega.$$

Resistance of B = 6Ω

Current in B = $0.5A$

Voltage = ?

$$V = IR. = 0.5 \times 6 = 3 V.$$

Current in C = ?

$$I = \frac{V}{R} = \frac{3}{3} = \boxed{1A} \text{ Ans.}$$

$$\text{Current in A} = 1 + 0.5 = \boxed{1.5A} \text{ Ans.}$$

$$(ii) \text{ Total resistance} = 2 + 2 = \boxed{4\Omega.} \text{ Ans.}$$

2006

Question 5.

A wire of uniform thickness with a resistance of 27Ω is cut into three equal pieces and they are joined in parallel. Find the resistance of the parallel combination.

Answer:

A wire is cut into 3 pieces

Also Resistance of wire is proportional to length

Resistance $\propto l$

Let length of wire $= 3l = 27\Omega$

Resistance of each piece, $l = 27/3 = 9 \Omega$

When connected in parallel Resultant resistance of combination

R is $1/R = 1/9 + 1/9 + 1/9 = 3/9 = 1/3$

$\therefore R = 3\Omega$

Question 6.

Mention two factors on which the resistance of a wire depends.

Answer:

Two factors are

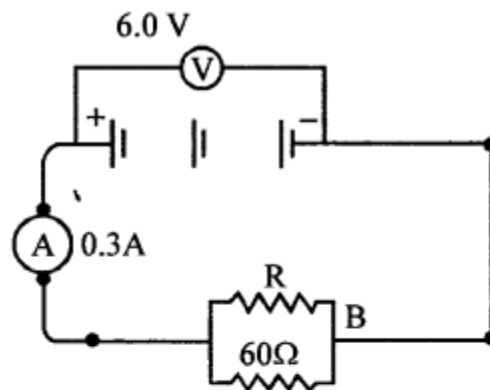
1. length of wire $R \propto l$
2. Area of cross-section of wire

$$R \propto 1/a$$

Question 7.

In the figure below, the ammeter A reads 0.3 A. Calculate :-

- (a) the total resistance of the circuit.
- (b) the value of R.
- (c) the current flowing through R.



Ans. $I = 0.3 \text{ A}$, $V = 6.0 \text{ V}$

$$(a) \therefore \text{Total Resistance of the circuit } R_1 = \frac{V}{I} = \frac{6}{\frac{3}{10}} = \frac{6}{3} \times 10 = 20 \Omega$$

$$(b) \text{ Value of } R, \frac{1}{R} = \frac{1}{20} - \frac{1}{60} = \frac{3-1}{60} = \frac{2}{60} = \frac{1}{30}$$

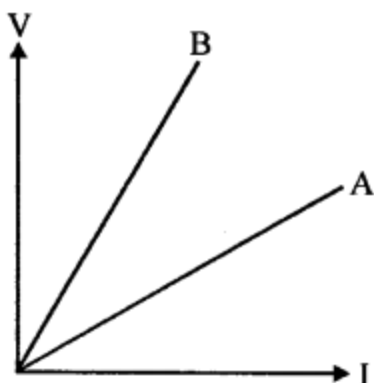
$$\therefore R = 30 \Omega$$

$$(c) \text{ Current through } R = I_1 = \frac{V}{R} = \frac{6}{30} = 0.2 \text{ A}$$

2007

Question 8.

The V-I graph for a series combination and for a parallel combination of two resistors is as shown in the figure below:



Which of the two, A or B, represents the parallel combination? Give a reason for your answer.

Answer:

Slope of V-I graph gives us the resistance of the resistor. Slope of A is less, therefore, combination A has less resistance as compared to B. Further, since the net resistance decreases in parallel combination, therefore, A represents the parallel combination.

Question 9.

Calculate the value of the resistance which must be connected to a $15\ \Omega$ resistance to provide an effective resistance of $6\ \Omega$.

Answer:

As the effective resistance is $6\ \Omega$ less than $15\ \Omega$

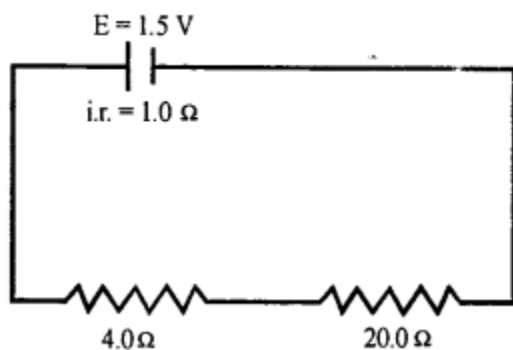
$\therefore$ Resistance R must be connected in parallel with $15\ \Omega$

$$\frac{1}{15} + \frac{1}{R} = \frac{1}{6} \Rightarrow \frac{1}{R} = \frac{1}{6} - \frac{1}{15} = \frac{5-2}{30} = \frac{1}{10}$$

$$\therefore R = 10\ \Omega$$

Question 10.

A cell of e.m.f. 1.5 V and internal resistance $1.0\ \Omega$ is connected to two resistors of $4.0\ \Omega$ and $20.0\ \Omega$ in series as shown in the figure:



1. current in the circuit.
2. potential difference across the $4.0\ \Omega$ resistor.

3. voltage drop when the current is flowing.
4. potential difference across the cell.

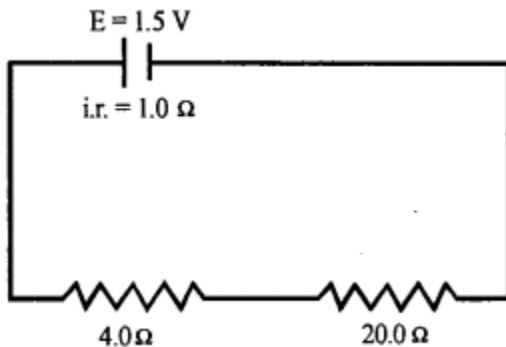
Answer:

Here e.m.f., $E = 1.5 \text{ V}$

Internal resistance 1.0Ω

All the resistances are connected in series

The total circuit resistance, $R = 1 + 4 + 20 = 25 \Omega$



The current, $i = E/R = 1.5/25 = 0.06 \text{ A}$

Potential difference across 4Ω resistance $= r \times i = 4 \times 0.06 = 0.24 \text{ V}$

Voltage drop across the cell $= 0.06 \times 1$
 $= 0.06 \text{ V}$

Potential difference across the cell $= 1.5 - 0.06$
 $= 1.44 \text{ V}$

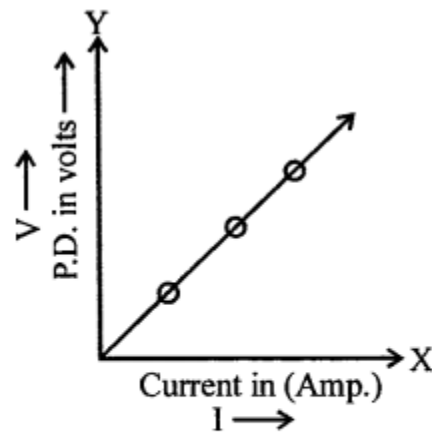
2008

Question 11.

1. Sketch a graph to show the change in potential difference across the ends of an ohmic resistor and the current flowing in it Label the axis of your graph.
2. What does the slope of the graph represent?

Answer:

(i)



(ii) Slope says $I \propto V$ and $V \propto I$

$$\text{or } \frac{V}{I} = \text{constant}, \frac{V}{I} = R \text{ (Resistance)}$$

Question 12.

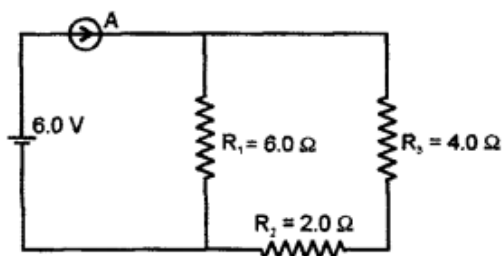
Three resistors of 6.0Ω , 2.0Ω and 4.0Ω respectively are joined together as shown in the figure. The resistors are connected to an ammeter and to a cell of e.m.f. 6.0 V .

Calculate:

(i) the effective resistance of the circuit

(ii) the current drawn from the cell

Answer:



As R_3 and R_2 are in series.

$$\therefore R_s = 4 + 2 = 6 \Omega$$

and R_1 is in parallel to its combination

$$\therefore \frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_s} = \frac{1}{6} + \frac{1}{6} = \frac{1}{3}$$

$$R_p = 3 \Omega$$

2009

Question 13.

The equivalent resistance of the following circuit diagram is 4Ω . Calculate the value of x .

Answer:

(i) Equivalent resistance = 4Ω , 5Ω , $x\Omega$ are in series

$$\therefore R_1 = (5 + x)\Omega$$

8Ω and 4Ω are in series

$$R_2 = 8 + 4 = 12\Omega$$

R_1 and R_2 are in parallel

$$\begin{aligned}\therefore R &= \frac{R_1 R_2}{R_1 + R_2} \\ &= \frac{(5+x)12}{(5+x)+12} = 4\end{aligned}$$

$$3(5+x) = 5+x+12$$

$$15 + 3x = x + 17$$

$$3x - x = 17 - 15 = 2$$

$$2x = 2$$

$$x = 2/2 = 1\Omega$$

Question 14.

1. State Ohm's Law.
2. Diagrammatically illustrate how you would connect a key, a battery, a voltmeter, an ammeter, an unknown resistance R and a rheostat so that it can be used to verify the above law?

Answer:

1. Ohm's law states that current flowing in a conductor is directly proportional to the potential difference across its ends provided the physical conditions remain constant.

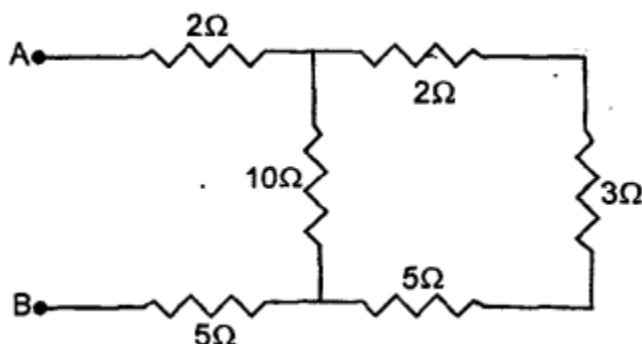
$$I \propto V \text{ or } V = IR$$

Verification of Ohm's Law: Use the circuit as shown taking care the +ve of voltmeter and +ve of Ammeter should be connected to the +ve of battery and voltmeter in parallel. Key is closed and Rheostat is set to get the minimum reading in Ammeter and voltmeter. The rheostat is then gradually moved and each time value of A and V are noted. The ratio of V/I is always found constant. This verifies Ohm's law.

2010

Question 15.

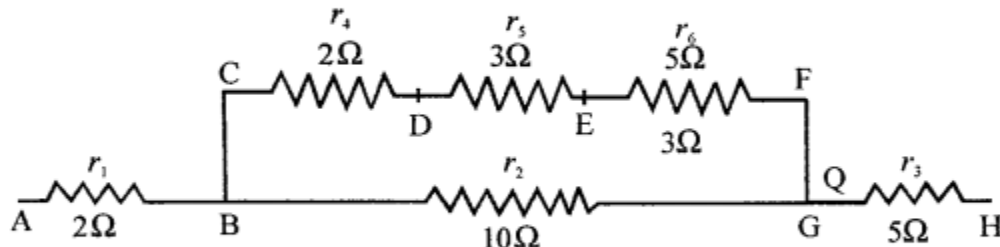
Six resistances are connected together as shown in the figure. Calculate the equivalent resistance between the points A and B.

**Answer:**

Clearly, the resistance of 2Ω , 3Ω and 5Ω are in series. Total resistance is $2\Omega + 3\Omega + 5\Omega = 10\Omega$ and the circuit reduces to as shown. Now, 10Ω and 10Ω are in parallel, there combined resistance R' is:

$$\frac{1}{R'} = \frac{1}{10} + \frac{1}{10} = \frac{2}{10} = \frac{1}{5}$$

$$\therefore R' = 5\Omega$$



Now, 2Ω , 5Ω , 5Ω are in series, therefore the net resistance is:

$$R = 2\Omega + 5\Omega + 5\Omega = 12\Omega$$

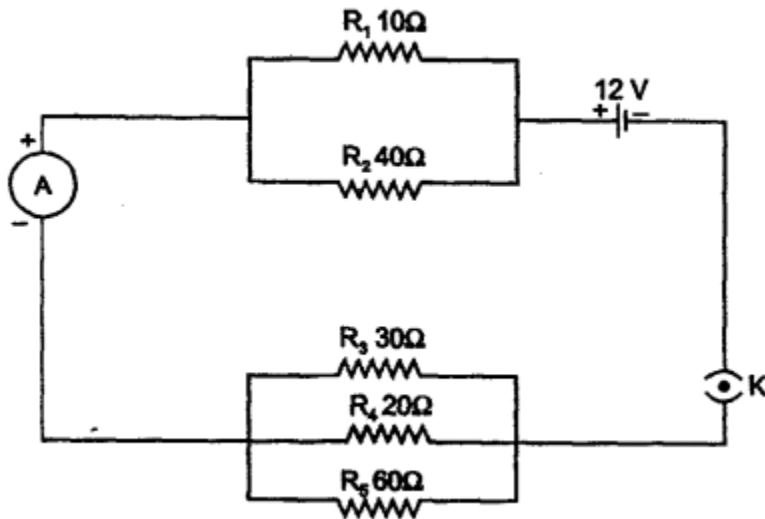
Question 16.

(a)

1. A substance has nearly zero resistance at a temperature of 1 K. What is such a substance called ?
2. State any two factors which affect the resistance of a metallic wire.

(b) Five resistors of different resistances are connected together as shown in the figure. A 12 V battery is connected to the arrangement. Calculate :

1. the total resistance in the circuit.
2. the total current flowing in the circuit.



Answer:

(a)

1. Superconductor
2. The resistance of a metallic wire is affected by
 - (a) Its area of cross-section. $R \propto 1/a$
 - (b) Length of conductor $R \propto l$

(b) To solve the above Question, we have to first find the total resistance of the circuit.

1. Here we find that R_1 and R_2 are in parallel and their combined resistance R' is given by $R' = \frac{10 \times 40}{10+40} = 8\Omega$
 Also, the resistances of 30Ω , 20Ω and 60Ω are in parallel and their combined resistance R'' is given by

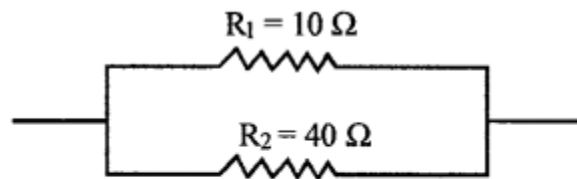
$$\frac{1}{R''} = \frac{1}{30} + \frac{1}{20} + \frac{1}{60}$$

$$= \frac{2}{60} + \frac{3}{60} + \frac{1}{60} = \frac{6}{60}$$

$$R'' = \frac{60}{6} = 10\Omega$$
 Now, R' and R'' are in series and their combined resistance R is given by .

$$R = R' + R'' = 8\Omega + 10\Omega = 18\Omega$$

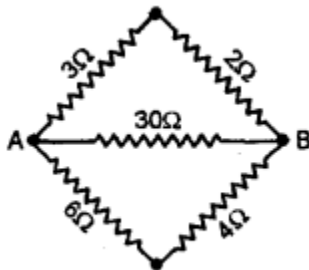
∴ Total resistance in the circuit = 18Ω



$$(ii) \text{ Now, } I = \frac{V}{R} = \frac{12V}{18\Omega} = \frac{2}{3} A = 0.67 A$$

Question 17.

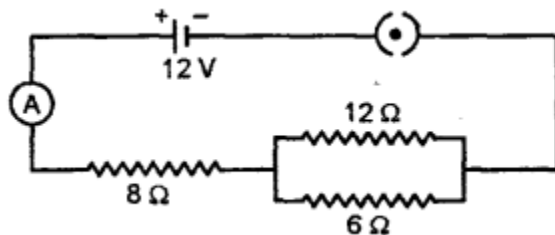
(a) Calculate the equivalent resistance between the points A and B from as shown in fig.



(b)

1. Draw a graph of Potential difference (V) versus Current (I) for an ohmic resistor.
2. How can you find the resistance of the resistor from this graph ?
3. What is a non-ohmic resistance ?

(c) Three resistors are connected to a 12 V battery as shown in the figure given below :



1. What is the current through the 8 Q resistor ?
2. What is the potential difference across parallel combination of 6 Q and 12 Q ?
3. What is the current through the 6 Q resistor ?

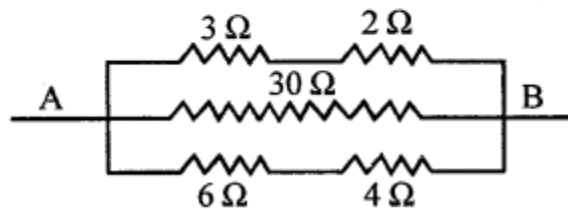
Answer:

(a)

1. $2 + 3 = 5\Omega$ are in series
 $6 + 4 = 10\Omega$ are in series
 $5, 30, 10\Omega$ are connected in parallel

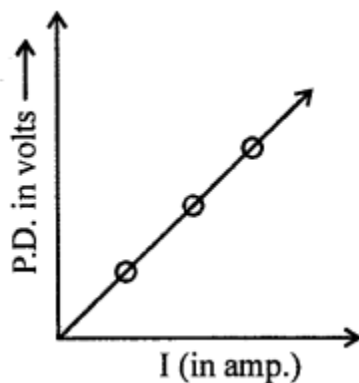
$$\therefore \frac{1}{R} = \frac{1}{5} + \frac{1}{30} + \frac{1}{10} = \frac{6+1+3}{30} = \frac{1}{3}$$

$$R = 3 \Omega$$



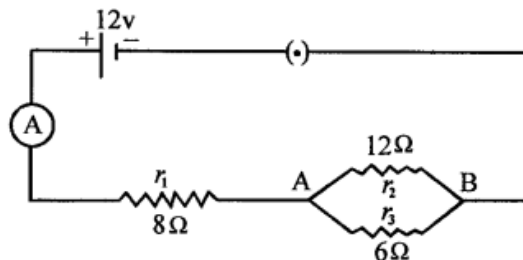
(b)

1. $V \propto I$ for ohmic resistor



2. Resistance can be found by finding the reading of V corresponding to I from graph.
 $R = V/I$
3. Non-Ohmic Resistance : "The resistors which do not obey the Ohm's Law are called non-ohmic resistors."

(c)



r_2, r_3 are in parallel

$$1/R_p = 1/12 + 1/6 = 3/12 = 1/4$$

$$R_p = 4$$

r_1 and R_p are in series

$$\therefore R = r_1 + r = 8 + 4 = 12\Omega$$

$$1. \quad I = v/R = 12/12 = 1 \text{ A}$$

2. P.D across parallel combination AB

$$V = I R_p$$

$$1 \times 4 = 4 \text{ V}$$

3. Current through 6Ω

$$I = v/r_3 = 4/6 = 0.666$$

$$I = 0.67 \text{ A}$$

2012

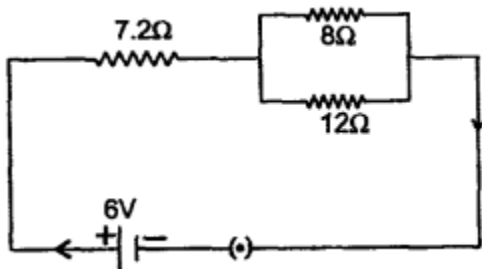
Question 18.

(a) Calculate the equivalent resistance between P and Q in the following diagram:



(b) A cell is sending current in an external circuit. How does the terminal voltage compare with the e.m.f of the cell?

(c) Three resistors are connected to a 6 V battery as shown in the figure in 8.59.

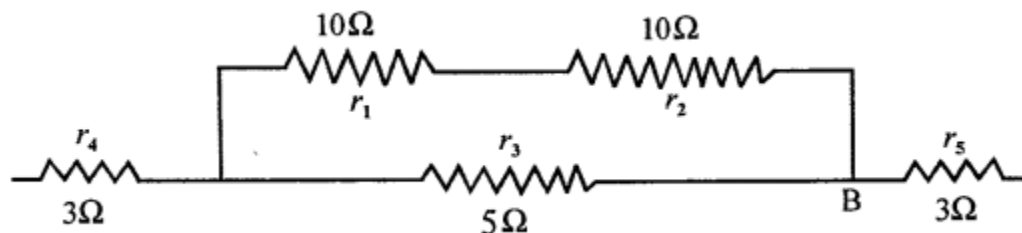


Calculate:

1. the equivalent resistance of the circuit.
2. total current in the circuit.
3. potential difference across the 7.2 c resistor.

Answer:

(a)



1. r_1, r_2 are in series

$$R_s = 10 + 10 = 20 \, \Omega$$

R_s and r_3 are in parallel

$$1/R_p \text{ between A and B} = 1/20 + 1/5 = 5/20 = 1/4$$

$$\therefore R_p = 4$$

Now r_4, R_p and r_5 are in series

$$\therefore R = 3 + 4 + 3 = 10 \, \Omega$$

(b) When cell is sending current in an external circuit i.e. current is drawn from the cell, its TERMINAL VOLTAGE 'V' is less than its e.m.f. (E) by an amount equal to the voltage drop inside the cell.

(c) (i) **Equivalent resistance of the circuit**

$$R = 7.2 + R_p$$

$$= 7.2 + \left(\frac{8 \times 12}{8 + 12} \right)$$

$$R = 7.2 + 4.8 = 12 \, \Omega$$

(ii) **Total current in the circuit**

$$I = \frac{V}{R} = \frac{6}{12} = 0.5 \, \text{A}$$

(iii) **P.D. across $7.2 \, \Omega$**

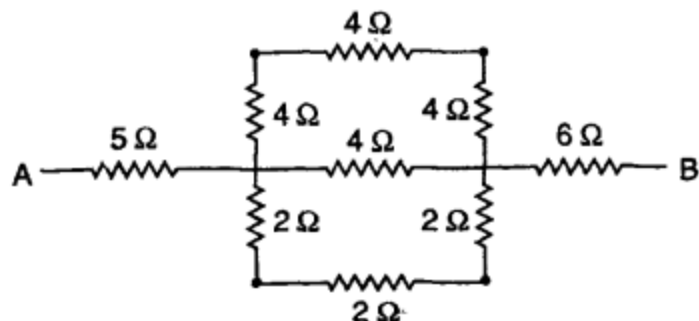
$$V = IR$$

$$= 0.5 \times 7.2 = 3.6 \, \text{V}$$

2013

Question 19.

(a) Calculate the equivalent resistance between the points A and B for the following combination of resistors :



(b)

1. State Ohm's law.
2. A metal wire of resistance 6Ω is stretched so that its length is increased to twice the original length. Calculate the new resistance.

(c) The figure shows a circuit when the circuit is switched on, the ammeter reads 0.5 A . 6.0 V

1. Calculate the value of the unknown resistor R .
2. Calculate the charge passing through the 3Ω resistor in 120 s .
3. Calculate the power dissipated in the 3Ω resistor.

Answer:

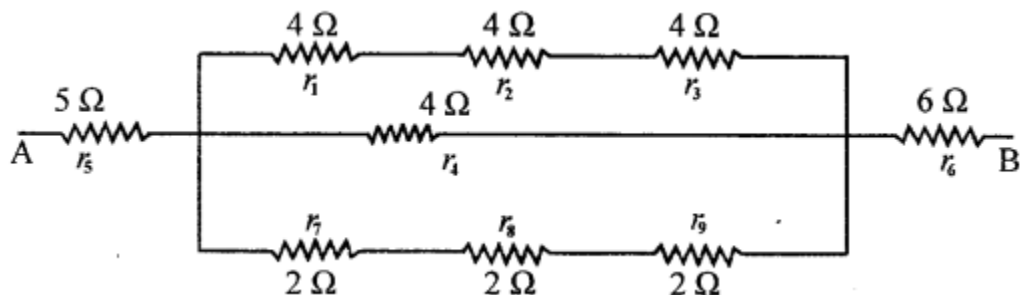
(a) Resistance of three 4Ω resistors in series $= 4 \times 3 = 12\Omega$ Resistance of three 2Ω resistors in series $= 2 \times 3 = 6\Omega$

$\therefore$ Equivalent resistance of 12Ω , 6Ω and 4Ω in parallel.

$$1/R_p = 1/12 + 1/6 + 1/4 = 1 + 2 + 3/12 = 1/2 \Rightarrow R_p = 2\Omega$$

Equivalent resistance of 5Ω , 2Ω and 6Ω in series.

$$R = (5 + 2 + 6)\Omega = 13\Omega$$



(b)

1. Ohm's Law : It states, all physical conditions of a conductor remaining same, the current flowing through it is directly proportional to the potential difference at its ends.

2. Let the original length be (l) and area of cross-section (a), such that its resistance is 6Ω

Applying, $R = K l/a \Rightarrow 6 = kl/a \dots(i)$

When the length $2l$, its area of cross-section becomes $a/2$. If

R is the new resistance of conductor then :

$$R = k 2l/a/2 = 4kl/a \dots(ii)$$

Dividing (ii) by (i) $R/6 = 4$ $R = 24\Omega$

(c)

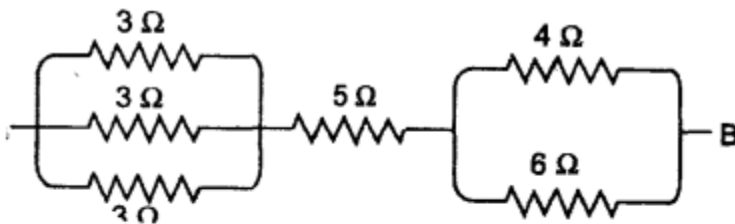
1. $I = V/R$ $0.5 = 6/R + 3$
 $0.5R + 1.5 = 6 \Rightarrow 0.5R = 4.5 \Rightarrow R = 9\Omega$
2. Charge $Q = I \times t = 0.5 \times 120 = 60$ Coulombs
3. Power dissipated, $P = I \times V = 0.5 \times 6 = 3$ Watt.

2014

Question 20.

Find the equivalent resistance between points A and B in the following figure.

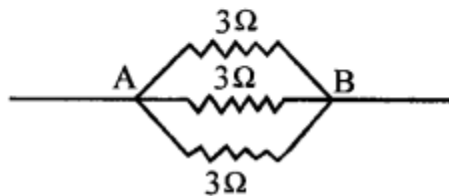
Answer:



Resistance between A and B in parallel R_1

$$\frac{1}{R_1} = \frac{1}{3} + \frac{1}{3} + \frac{1}{3} = \frac{3}{3} = 1$$

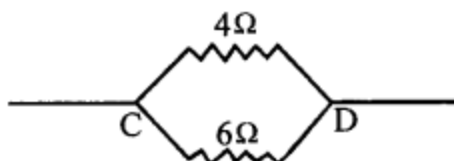
$$R_1 = 1\Omega$$



Resistance between CD in parallel R_2 .

$$\frac{1}{R_3} = \frac{1}{4} + \frac{1}{6} = \frac{3+2}{12} = \frac{5}{12}$$

$$R_3 = \frac{12}{5} = 2.4\Omega$$



$$\text{Total } R = R_1 + R_2 + R_3 = 1 + 5 + 2.4 = 8.4\Omega.$$

Question 21.

(a) Two resistors of 4Ω and 6Ω are connected in parallel to a cell to draw a current of 0.5 A from the cell.

1. Draw a labelled circuit diagram showing the above arrangement.
2. Calculate the current in each resistor.

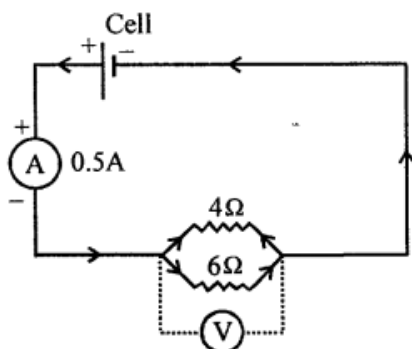
(b)

1. What is an Ohmic resistance ?
2. Two copper wires are of the same length, but one is thicker than the other.
 - (i) Which wire will have more resistance?
 - (ii) Which wire will have more specific resistance?

Answer:

(a)

1. $I = V/R$ $V = IR$



$$\frac{1}{R_p} = \frac{1}{12} + \frac{1}{6} + \frac{1}{4} = \frac{1+2+3}{12} = \frac{1}{2}$$

2. Let current through 4 Ω resistance is I then current through 6 Ω resistance is $(0.5 - I)$

$$\dots 1 \times 4 = (0.5 - I) \times 6$$

$$4I = 3 - 6I$$

$$4I + 6I = 3$$

$$10I = 3$$

$$I = 0.3 \text{ A}$$

$\therefore$ Current through 4 Ω resistance = 0.3 A

and current through 6 Ω resistance = $0.5 - 0.3 = 0.2 \text{ A}$

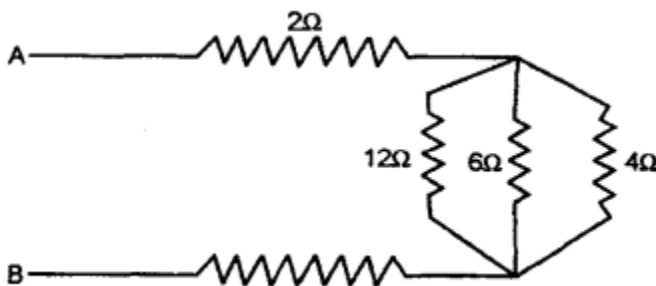
(b)

1. **Ohmic Resistors** : The resistors which obey Ohm's law are called the Ohmic resistors or linear resistances. For such resistors, a graph plotted for the potential difference V against current I is a straight line.
2. (i) Thin wire will have more resistance.
(ii) Specific resistance of both wire is same.

2015

Question 22.

- (a) What happens to the resistivity of semi-conductor with the increase in temperature?
(b) Fig. the equivalent resistance between point A and B.



Answer:

- (a) The resistivity of a semiconductor decreases with increase in temperature.
(b) Let R_p be the equivalent resistance of the resistors 12 Ω , 6 Ω and 4 Ω connected in parallel. Hence, we have

$$1/R_p = 1/12 + 1/6 + 1/4 = 1 + 2 + 3/12 = 1/2$$

$$R_p = 2 \Omega$$

Therefore, the equivalent resistance of the circuit is 2

$$2\ \Omega + R_p + 5\ \Omega = 2\ \Omega + 5\ \Omega = 9\ \Omega$$

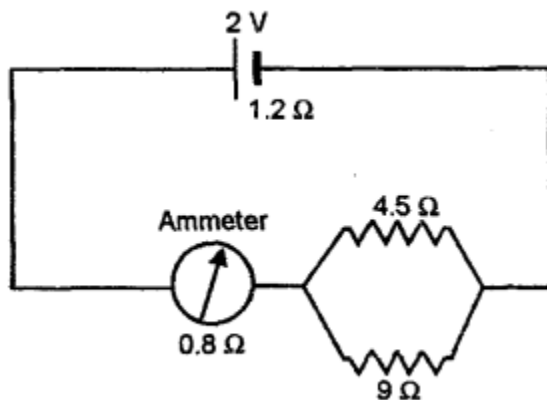
Thus, the equivalent resistance between points A and B is $9\ \Omega$

Question 23.

(a) The relationship between the potential difference and the current in a conductor is stated in the form of a law.

1. Name the law.
2. What does the slope of V-I graph for a conductor represent?
3. Name the material used for making the connecting wire.

(b) A cell of Emf 2 V and internal resistance $1.2\ \Omega$ is connected with an ammeter of resistance $0.8\ \Omega$ and two resistors of $4.5\ \Omega$ and $9\ \Omega$ as shown in the diagram below:



1. What would be the reading on the Ammeter?
2. What is the potential difference across the terminals of the cell?

Answer:

(a)

1. The relationship between the potential difference and the current in a conductor is given by Ohm's law.
2. The slope of the V-I graph gives the resistance of the conductor.
Slope $R = \frac{V}{I} = R$
The material used for making connecting wires is copper.

(b) Given that $\mathcal{E} = 2\text{ V}$, $r = 1.2\ \Omega$, $R_A = 0.8\ \Omega$, $R_1 = 4.5\ \Omega$, $R_2 = 9\ \Omega$

1. We know that for the circuit
 $\mathcal{E} = IR_{\text{total}}$
Now, the total resistance of the circuit is

$$R_{\text{total}} = r + R_A + R_p$$

$$1/R_p = 1/4.5 + 1/9 = 3/9$$

$$R_p = 3 \Omega$$

$$R_{\text{total}} = 1.2 + 0.8 + 3 = 5 \Omega$$

Hence, the current through the ammeter is

$$I = \frac{V}{R_{\text{total}}} = \frac{2}{5} = 0.4 \text{ A}$$

$$(ii) I = \frac{E - V}{r}$$

$$\Rightarrow 0.4 = \frac{2 - V}{1.2}$$

$$I = v/R_{\text{total}} = 2/5 = 0.4 \text{ AB}$$

$$\Rightarrow 0.48 = 2 - V - I$$

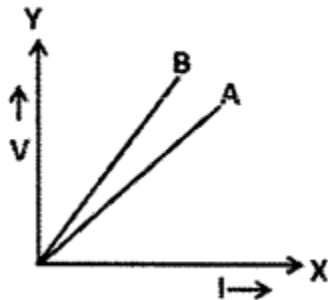
$$V = 2 - 4.8 - 1.52 \text{ V}$$

$\therefore$ Potential difference $V_{\text{cell}} 1.52 \text{ V}$

2016

Question 24.

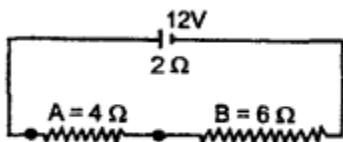
(a) The V-I graph for a series combination and for a parallel combination of two resistors is shown in the figure below. Which of the two A or B. represents the parallel combination? Give reasons for your answer.



(b) A music system draws a current of 400 m A when connected to a 12 V battery.

1. What is the resistance of the music system?
2. The music system f left playing for several hours and finally the battery voltage drops and the music system stops playing when current drops to 320 m A. At what voltage the music system stops playing?

(c) A battery of emf 12 V and internal resistance 2Ω is connected with two resistors A and B of resistance 4Ω and 6Ω respectively joined in series.



Find:

1. Current in circuit
2. The terminal voltage of the cell
3. P.D. across 6Ω resistor.
4. Electrical energy spent per minute in 4Ω resistor.

Answer:

(a) A represents Parallel Combination

Reason : More current flows in parallel combination as compared to series combination.

(b)

1. (i) Given : $I = 400 \text{ m A} = 400 \times 10^{-3} \text{ A}$
 $V = 12 \text{ V}$
 $V = IR$
 $R = V/I = 12 \text{ V} / 400 \times 10^{-3} \text{ A}$
 $R = 400 \times 10^{-3} \text{ A}$
 $R = 30\Omega$
2. Current drops to $I = 320 \text{ m A} = 320 \times 10^{-3} \text{ A}$
 The music stops playing at
 $V = IR$
 $V = 320 \times 10^{-3} \times 30$
 $V = 9.6 \text{ V}$

(C) Given, Emf (E) = 12 V; $r_1 = 2\Omega$; $R_A = 4\Omega$; $R_B = 6\Omega$

1. The current in the circuit is
 $I = E/R_{\text{total}} = E/R_1 + R_A + R_B$
 $I = 12/2 + 4 + 6 = 1 \text{ A}$
2. The terminal voltage of the cell is
 Terminal Voltage = Emf- Ir ,
 Terminal Voltage = $12 - (1 \times 2) = 12 - 2 = 10 \text{ V}$
3. The potential difference across the 6Ω resistor is
 $V_B = IR_B$
 $\therefore V_B = 1 \times 6 = 6 \text{ V}$

4. The electrical energy spent per minute (= 60 s) is

$$E = I^2 R t$$

$$E = 1^2 \times 4 \times 60 = 240 \text{ J}$$

Electric Energy, Power & Household Circuits

Exercise – 1

Question 1.

(a) What do you understand by the term electric work ?

Answer:

Electric work : “Electric work is said to be done when an electric charge flows through a conductor, at some potential difference.”

$$\therefore v = \frac{W}{Q}$$

$$\therefore W = vQ$$

(b) State and define SI unit of electric work.

Answer:

S.I. unit of electric work → Joule (J)

1J = 1 volt × 1 coulomb

1 Joule : “Is the amount of work done when a charge of one coulomb flows through a conductor at a pot. diff. of 1 volt.”

(c) Name two bigger units of electric work. How are they related to SI unit ?

Answer:

Two bigger units of electric work :

1. Kilo – Joule (kJ) = 10^3 J
2. Mega-joule (MJ) = 10^6 J

Question 2.

Derive an expression for electric work connecting :

- (a) Current, resistance and time
- (b) Current, potential difference and time.
- (c) Potential difference, resistance and time.

Answer:

Derivation of electric work

We know that $v = \frac{W}{Q}$

$$\therefore W = vQ \text{ but } Q = It$$

$$W = VIt \quad \dots(i)$$

(a) Ohm's Law $V = IR$ part in (i)

$$\therefore W = IRI t$$

$$W = I^2 R t \quad \dots(ii) \text{ current, resistance and time.}$$

(b) but $I = \frac{V}{R}$

$$\therefore R = \frac{V}{I} \text{ put in (ii)}$$

$$W = \frac{V}{I} I^2 t = VIt$$

(c) $I = \frac{V}{R}$ Ohm's Law

put in (i)

$$W = V \cdot \frac{V}{R} t = \frac{V^2 t}{R}$$

Question 3.

State three factors which determine the quantity of heat produced in a conductor.

Answer:

Three factors which determine heat produced in a conductor :

Heat produced = Energy Work done

$$W = H = I^2 R t$$

$\therefore$ Three factors are I – current

R – Resistance of conductor

t – time for which current flows.

Question 4.

- (a) What do you understand by the term electric power ?
- (b) State SI unit of electric power and define it
- (c) Name two bigger units of electric power and their relation with SI unit.

Answer:

(a) Electric power : “The rate at which electrical energy is supplied by a source.”

Or

“The rate at which electrical energy is consumed by an appliance.”

$$P = \frac{w}{t}$$

but $w = VIt$

$$P = \frac{VIt}{t} = VI$$

- (b) S.I. unit of power $\longrightarrow$ Watt = Js^{-1}

One watt : “is the electric power consumed when a current of 1 ampere flows through a circuit having a potential difference of 1 volt.”

- (c) Two bigger units of power and relation with S.I. unit.

1 kilowatt (1 kw) = 1000 w

1 Mega watt (1 mw) = 10^6 w

Question 5.

Derive an expression for electric power connecting :

- (a) Current and resistance.
- (b) Current and potential difference.
- (c) Potential difference and resistance.

Answer:

Derivation of electric power

$$\text{Power } P = \frac{\text{work done } (w)}{\text{time taken } (t)}$$

(a) $w = I^2 R t$

$$\therefore P = \frac{I^2 R t}{t} = I^2 R \quad \dots(i)$$

(b) but $w = V I t$

$$P = \frac{w}{t} = \frac{V I t}{t} = V \times I \quad \dots(ii)$$

(c) $\therefore P = VI$ but $I = \frac{V}{R}$

$$\therefore P = V \frac{V}{R} = \frac{V^2}{R}$$

Pot. diff and resistance.

Question 6.

- (a) What do you understand by term electric energy ?
- (b) Name and define the smallest commercial unit of electric energy.
- (c) Name and define the standard commercial unit of electric energy.

Answer:

(a) **Electric energy** : $E = P \times t = V I t$

"Electric energy is the product of power and time." i.e. electric energy consumed by an electrical appliance is produced of 'power rating' and 'time' for which it is used.

(b) Unit of electric energy $\rightarrow$ Joule (J)

S.I. unit of electric work $\rightarrow$ Joule (J)

$1 \text{ J} = 1 \text{ volt} \times 1 \text{ coulomb}$

1 Joule : "Is the amount of work done when a charge of one coulomb flows through a conductor at a pot. diff. of 1 volt."

(c) **Standard Commercial unit of Electric Energy** : Kilo-watt-Hour 1 kWh : "Is the amount of electrical energy consumed when an electrical appliance having a power rating of 1 kilowatt is used for 1 hour."

Question 7.

With respect to electricity, define :

1. watt hour
2. watt
3. kilowatt
4. kilowatt hour. Amongst the above units, which are the units of : (i) electric energy
(ii) electric power.

Answer:

(i) **Watt Hour** : “Is the amount of electrical energy consumed when an electrical appliance of 1 watt power is used for 1 hour.”

(ii) **Watt** : “Power of 1 watt is a rate of working of 1 joule per second.”

$$1 \text{ watt} = \frac{1 \text{ Joule}}{1 \text{ Second}}$$

(iii) **Kilowatt** : “Power of 1 k-w is the rate of working 1000 J per second.” $1 \text{ k-w} = 1000 \text{ J s}^{-1}$

(iv) **Kilowatt hour** : Standard Commercial unit of Electric Energy : Kilo-watt-Hour 1 kWh : “Is the amount of electrical energy consumed when an electrical appliance having a power rating of 1 kilowatt is used for 1 hour.”

(a) watt hour and kWh are units of electric energy.

(b) Watt and Kwatt are units of power.

Question 8.

How many joules of energy is equal to one kilowatt hour?

Answer:

1 kilowatt hour

1000 watt hour

$$1000 \frac{\text{J}}{\text{s}} \times (60 \times 60 \text{ s}) = 3600000 \text{ J}$$

$$1 \text{ kWh} = 3.6 \times 10^6 \text{ J}$$

Question 9.

Distinguish between kilo-watt and kilowatt hour.

Answer:

Kilo-watt is a unit of power.

$$\text{Kilowatt} = 1000 \text{ w} = 1000 \text{ Js}^{-1}$$

Kilo-Watt-Hour — is a unit of energy consumed in 1 hour.

$$1 \text{ Kwh} = 1000 \text{ w} \times 1 \text{ hour}$$

$$1 \text{ Kwh} = 3.6 \times 10^6 \text{ J}$$

Question 10.

How many kilowatt is equal to one hour power ?

Answer:

$$\text{One hour power} = 746 \Rightarrow 750 \text{ w}$$

$$= \frac{746}{1000} = 0.746 \text{ kwatt}$$

$$\Rightarrow 0.750 \text{ kwatt.}$$

Multiple Choice Questions

Tick (✓) the most appropriate option.

1. A bulb has a resistance of 20Ω and the p.d across its terminals is V . If the bulb is used for t seconds then energy consumed by the bulb is :

(a) $\frac{V}{20} \times t$

(b) $\frac{V^2}{20} \times t$

(c) $V \times t = 20$

(d) $\frac{V \times t^2}{20}$

Answer:

(b) $\frac{V^2}{20} \times t$

2. A current I flows through a resistance R for the time ' t ', the electric energy consumed by the resistance is :

(a) $I \times R \times t$

(b) $I \times R^2 \times t$

(c) $I^2 \times R \times t$

(d) $\frac{I^2 \times R}{t}$

Answer:

(c) $I^2 \times R \times t$

3. The unit for electric work in SI system :

- (a) Joule
- (b) watt
- (c) watt second
- (d) watt hour

Answer:

- (a) Joule

4. An electric appliance has a rating of 1000 W – 200 V. The resistance of the element of electric appliance is :

- (a) 200 Ω
- (b) 400 Ω
- (c) 40 Ω
- (d) 4000 Ω

Answer:

- (c) 40 Ω

5. Kilowatt hour is commercial unit of :

- (a) power
- (b) electric energy
- (c) heat energy
- (d) mechanical energy

Answer:

- (b) electric energy

6. Kilowatt hour and kilowatt are :

- (a) SI units of power and electric energy
- (b) commercial units of power and electric energy
- (c) SI units of electric energy and power
- (d) commercial units of electric energy and power

Answer:

- (d) commercial units of electric energy and power

Numerical Problems on Electric Energy

Practice Problems 1

Question 1.

Calculate the energy released by a heater, which draws a current of 5A at 220 V for 1 min.

Answer:

$$w = \text{Energy released} = VI t$$

$$w = 220 \times 5 \times 60 = 66000 \text{ J}$$

Question 2.

An electric device consumes 8640 J of energy in 30 min. while operating at 24 V. Calculate the current drawn by the device.

Answer:

$$VI t = w$$

$$24 \times I \times (30 \times 60) = 8640$$

$$I = \frac{8640}{24 \times 30 \times 60} = 0.2 \text{ A}$$

Practice Problems 2

Question 1.

An electric kettle draws a current of 4A for 2.5 min. if the resistance of its element is 100Ω , calculate the electric energy drawn by kettle in kilojoules.

Answer:

$$\text{Current } I = 4 \text{ A,}$$

$$t = (2.5 \times 60) \text{ sec.,}$$

$$R = 100 \Omega$$

$$\text{Electric energy drawn } W = I^2 R t$$

$$W = 4 \times 4 \times 100 \times \left(\frac{25}{10} \times 60 \right) = 240000 \text{ J}$$

$$W = \frac{240000}{1000} = 240 \text{ kJ}$$

Question 2.

A soldering iron draws an energy of 43200 J in 4 min, when the current flowing through its element is 6 A, calculate the resistance of its heating element.

Answer:

$$\text{Energy drawn } E = 43200 \text{ J,}$$

$$t = 4 \text{ min.} = (4 \times 60) \text{ s.}$$

$$I = 6\text{A}$$

$$R = \frac{E}{I^2 t} = \frac{43200}{6 \times 6 \times (4 \times 60)} = 5\Omega$$

Practice Problems 3**Question 1.**

Calculate the heat energy given out by the filament of an electric bulb in 20 s, when its resistance is 4 Ω and p.d. across its ends is 12 V.

Answer:

$$t = 20 \text{ s, } R = 4\Omega, \text{ p.d. } V = 12 \text{ V}$$

$$\text{Heat energy given out by filament } E = \frac{V^2 t}{R}$$

$$E = \frac{12 \times 12 \times 20}{4} = 720 \text{ J}$$

Question 2.

An electric device gives out 5760 J of heat energy in 1 min, when current flows through it at a p.d. of 24 V. Find the resistance of the device.

Answer:

$$\text{Heat Energy given out } E = 5760 \text{ J}$$

$$t = 1 \text{ min.} = 60 \text{ s. p.d } V = 24\text{V}$$

$$\text{Resistance } R = \frac{V^2 t}{E} = \frac{24 \times 24 \times 60}{5760} = 6 \Omega$$

$$R = 6\Omega$$

Practice Problems 4

Question 1.

An electric heater draws a current of 3.5 A at a p.d. of 250 V. Calculate the power of 4 such heaters.

Answer:

$$\begin{aligned} \text{Power } P &= VI & I &= 3.5 \text{ A} \\ & & V &= 250 \text{ V} \end{aligned}$$

$$\therefore \text{Power of 4 heaters } P = 4 VI$$

$$P = 4 \times 250 \times \frac{35}{10} = 3500 \text{ W}$$

Question 2.

An electric bulb is rated 500 W – 200 V. Calculate the magnitude of current.

Answer:

$$P = 500 \text{ W}, V = 200 \text{ V}$$

$$\text{Current } I = \frac{P}{V} = \frac{500}{200} = 2.5$$

$$\therefore I = 2.5 \text{ A}$$

Question 3.

An electric heater of power 1000 W, draws a current of 5.0 A. Calculate the line voltage.

Answer:

$$\text{Power of heater } P = 1000 \text{ W}, I = 5.0 \text{ A}$$

$$\text{Voltage } V = \frac{P}{I} = \frac{1000}{5} = 200$$

$$\therefore V = 200 \text{ V}$$

Practice Problems 5**Question 1.**

An electric heater has a resistance of 40 Ω and draws a current of 4 A. Calculate :

1. its power
2. p.d. at its ends

Answer:

(i) Power $P = I^2 R$ $R = 40\Omega$

$I = 4A$

$P = 4 \times 4 \times 40 = 640 \text{ W}$

(ii) P.d. at its ends $V = \frac{P}{I} = \frac{640}{4} = 160 \text{ V}$

Question 2.

An electric heater of power 900 W, has a resistance of 36Ω Calculate the magnitude of current and the p.d. at its ends.

Answer:

(i) Current $I = ?$ $P = 900 \text{ W}$

$R = 36 \Omega$

$P = I^2 R$ $\therefore I^2 = \frac{P}{R} = \frac{900}{36} = 25 = 5^2$

$\therefore I = 5A$

(ii) P.d. across ends $V = \frac{P}{I} = \frac{900}{5} = 180 \text{ V}$

Practice Problems 6

Question 1.

An electric motor of power 1000 W, operates at 250 V. Calculate the inductive resistance of motor and current flowing through it.

Answer:

Power $P = 1000 \text{ W}$, $V = 250 \text{ V}$

$R = ?$

(i) $P = \frac{V^2}{R}$ $\therefore R = \frac{V^2}{P} = \frac{250 \times 250}{1000} = 62.5\Omega$

(ii) Current $I = \frac{V}{R} = \frac{250}{62.5} = 4A$

Question 2.

An electric device operates at 24 V and has a resistance of 8Ω Calculate the power of

the device and current flowing through it

Answer:

$$V = 24 \text{ V}, \quad R = 8\Omega$$

$$(i) P = \frac{V^2}{R} = \frac{24 \times 24}{8} = 72 \text{ W}$$

$$(ii) \text{ Current flowing } P = VI$$

$$72 = 24 I$$

$$I = \frac{72}{24} = 3A$$

Practice Problems 7

Question 1.

An electric bulb is rated 200 W – 200 V. It is immersed in 200 g of oil (SHC $0.8 \text{ Jg}^{-10} \text{ C}^{-1}$) at 10°C . The bulb is switched on for 2 minutes. If all the electric energy is absorbed in the form of heat energy by the oil, calculate :

- (a) Resistance of the filament of the bulb.
- (b) Current flowing through the bulb.
- (c) Final temperature of the oil.

Answer:

$$P = 200 \text{ w} \quad \text{p.d. } v = 200 \text{ v}$$

$$VI = P$$

$$200 \times I = 200$$

$$I = \frac{200}{200} = 1A$$

$$(a) \quad P = \frac{V^2}{R} \quad R = \frac{V^2}{P} = \frac{200 \times 200}{200} = 200 \Omega$$

$$(b) \quad I = 1A$$

$$(c) \quad \text{Final temp. of oil}$$

$$Q = \text{heat supplied} = mc (T - t) \text{ in 2 min.}$$

$$P \times t = 200 \times 0.8 \times (T - 10)$$

$$200 \times (2 \times 60) = 20 \times 8 (T - 10)$$

$$(T - 10) = \frac{200 \times 120}{160} = 150$$

$$T = 150 + 10 = 160^\circ\text{C}$$

Question 2.

An electric kettle is rated 1000 W – 250 V. It is used to bring water at 20°C to its boiling point. If the kettle is used for 11 minutes and 12 seconds, **calculate** :

- (a) Resistance of the element of the kettle.
- (b) Current flowing through the element.
- (c) Mass of water in the kettle [SHC of water = $4.2 \text{ Jg}^{-10} \text{ C}^{-1}$]

Answer:

Kettle rated 1000 w – 250 v

$$P = 1000 \text{ w} \quad \text{p.d. } v = 250 \text{ v}$$

$$t = 20^\circ \text{ T} = 100^\circ \text{C}$$

- (a) Resistance of element R = ?

$$P = \frac{V^2}{R} \quad \therefore R = \frac{V^2}{P} = \frac{250 \times 250}{1000}$$

$$R = 62.5 \Omega$$

- (b) Current flowing through the element

$$I = \frac{P}{V} = \frac{1000}{250} = 4 \text{ A}$$

- (c) Mass of water in kettle = m

Heat energy consumed in 11 min 12s.

$$Q = P \times t = 1000 \times (11 \times 60 + 12) \\ = (1000 \times 672) \text{ J}$$

$$Q = mc (T - t)$$

$$(1000 \times 672) = m \times 4.2 (100 - 20)$$

$$m = \frac{672 \times 1000}{4.2 \times 80} = 2000 \text{ g} = \frac{2000}{1000} = 2 \text{ kg}$$

Practice Problems 8

Question 1.

Calculate the resistance of nichrome wire, which will bring 200 g of water at 20° C to its boiling points in 7 minutes, when current flowing through wire is 4A.

Answer:

$$I = 4\text{A}, R = ? \quad t = 7 \text{ min} = 420 \text{ s}$$

$$\text{Energy required to heat water } E = Q = mc (T - t)$$

$$\text{or } E = mc (T - t) = I^2 R t$$

$$200 \times 4.2 \times (100 - 20) = 4 \times 4 \times R \times 420$$

$$\therefore R = 200 \times \frac{42}{10} \times 80 \times \frac{1}{420 \times 16} = 10\Omega$$

Question 2.

Calculate p.d. at the ends of a power source which, supplies current to a 4 ohm resistance wire for 20 minutes and raises temperature of 400 g of water through 20°C .

Answer:

$$\text{P.d. } V = ? \quad R = 4\Omega, \quad \text{time} = (20 \times 60) \text{ s}$$

$$\text{Heat required to raise the temperature of water through } 20^\circ\text{C}$$

$$Q = E = mc T$$

$$m = 400 \text{ g}, c = 4.2 \text{ J/g } ^\circ\text{C}^{-1}, T = 20^\circ$$

$$\text{Also } t = 20 \text{ min}$$

$$t = 2 \times 60 \text{ sec.}$$

$$\therefore \frac{V^2 t}{R} = mc T$$

$$\frac{V^2 \times (20 \times 60)}{4} = 400 \times \frac{42}{10} \times 20$$

$$V^2 = \frac{400 \times 42 \times 20 \times 4}{10 \times 20 \times 60} = 112$$

$$\therefore V = \sqrt{112} \quad V = \sqrt{16 \times 7} \quad V = 4\sqrt{7} \text{ V}$$

$$V = 10.5 \text{ V}$$

Question 3.

Calculate the current flowing through an electric drill, connected to 200 V supply, if it

drills a hole in a metal plate of mass 500 g, such that its temperature rises from 10°C to 60°C in 5 minutes, assuming all the work done is converted into heat energy. [S.H.C. of metal $0.6 \text{ Jg}^{-1}^{\circ}\text{C}^{-1}$]

Answer:

$$I = ?, \quad V = 200 \text{ V}, \quad t = (5 \times 60) \text{ s}$$

$$\text{Heat energy } Q = W = mc \Delta T$$

$$m = 500 \text{ g}, \quad C = 0.6 \text{ Jg}^{-1}^{\circ}\text{C}^{-1}$$

$$\therefore VIt = mc \Delta T$$

$$\text{Rise in temp.} = \Delta T = (60 - 10) = 50^{\circ}\text{C}$$

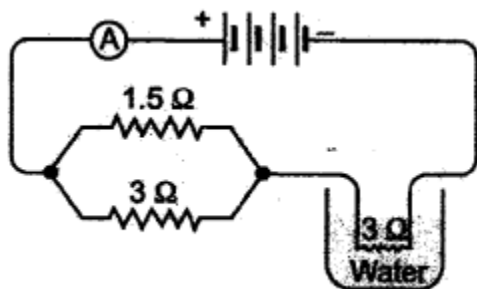
$$200 \times I \times 300 = 500 \times \frac{6}{10} \times 50$$

$$I = \frac{500 \times 30}{300 \times 200} = \frac{1}{4} = 0.25 \text{ A}$$

Practice Problems 9

Question 1.

Circuit diagram shows four dry cells of e.m.f. 1.5 V and internal resistance 0.25Ω connected to an external circuit. A 3Ω wire is immersed in 20 g of water at 20°C . The current switched on for 6 minutes and 36 seconds. Calculate :



- Reading shown by the ammeter
- Current in 1.5Ω wire
- Final temperature of water

Answer:

Potential difference of 4 cells $E = 4 \times 1.5 = 6\text{v}$

$$R_p = \frac{1}{1.5} + \frac{1}{3} = 1\Omega$$

External resistance $R = R_p + 3\Omega$

$$1 + 3 = 4\Omega$$

(a) Reading in ammeter $= I = \frac{E}{R}$

$$I = \frac{6}{4} = 1.5 \text{ A}$$

(b) v across parallel resistances $v = IR_p$
 $V = 1.5 \times 1 = 1.5 \text{ v}$

$\therefore$ Current through 1.5Ω wire $I_1 = \frac{v}{1.5} = \frac{1.5}{1.5} = 1\text{A}$

(c) Final temperature of water.

$$Q = I^2 R t = mc_w (T - 20)$$

{ $\because$ By the principle of calorimetry}

$$\Rightarrow 1.5 \times 1.5 \times 3 \times (6 \times 60 + 36) = 20 \times 4.2 (T - 20)$$

$$\Rightarrow \frac{27}{4} \times 396 = 84 (T - 20^\circ\text{C})$$

$$\Rightarrow \frac{27 \times 99}{84} = T - 20^\circ\text{C}$$

$$\Rightarrow T = 31.8 + 20^\circ\text{C} = 51.8^\circ\text{C}$$

Question 2.

A battery of 12 V and negligible internal resistance is connected to an external circuit consisting of three resistors of 6Ω , 3Ω and 2Ω in parallel, which further connected to a resistance of 3Ω in series to the battery. The 3Ω resistance is immersed in 50 g oil of sp. heat capacity $0.8 \text{ Jg}^{-1} 10^\circ\text{C}^{-1}$, when the temperature of the oil rises by 54°C .

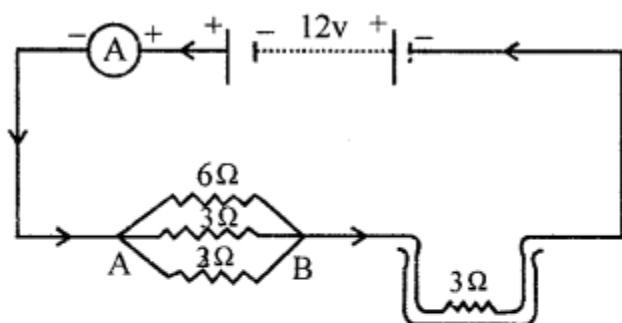
(a) Draw the labelled circuit diagram.

(b) Calculate the value of current in the train circuit.

- (c) Calculate the current following in $2\ \Omega$ resistance in parallel.
 (d) Calculate the time for which current is switched on.

Answer:

(a)



(b) R_p across AB

$$\frac{1}{R_p} = \frac{1}{6} + \frac{1}{3} + \frac{1}{2} = \frac{1}{1} \quad \therefore R_p = 1\ \Omega$$

$$R = R_p + 3\ \Omega = 1 + 3 = 4\ \Omega$$

$$\text{Current in circuit } I = \frac{V}{R}$$

$$I = \frac{12}{4} = 3\text{A}$$

$$(c) \text{ V across AB} = IR_p = 3 \times 1 = 3\text{v}$$

Current through $2\ \Omega$

$$I_1 = \frac{V}{2} = \frac{3}{2} = 1.5\text{ A}$$

$$(d) \quad E = Q = m \times \text{Coil} \times \text{Rise in temperature}$$

Energy flowing through wire in oil

$$I^2 R t = m \times \text{Coil} \times \text{Rise in temperature}$$

$$3 \times 3 \times 3 \times t = 50 \times 0.8 \times 54$$

$$t = 50 \times \frac{8}{10} \times \frac{54}{27} = 80\text{s}$$

$$t = 1\text{ min } 20\text{ sec.}$$

Practice Problems 10

Question 1.

An electric kettle rated 250 V can bring a certain amount of water to its boiling point in 8 min. If it is connected to 200 V mains, calculate the time in which water comes to its boiling point.

Answer:

Energy consumed by water in 8 min at 250 V

$$E = \frac{V^2 t}{R} = \frac{250 \times 250 \times 8 \text{ min}}{R} \quad \dots(i)$$

Energy consumed by water at 200 V

$$E = \frac{V^2 t}{R} = \frac{200 \times 200 \times t}{R} \quad \dots(ii)$$

By law of conservation of energy (i) = (ii)

$$\frac{200 \times 200 \times t}{R} = \frac{250 \times 250 \times 8}{R}$$

$$t = \frac{250 \times 250 \times 8}{200 \times 200} = 12.5 \text{ min.}$$

Question 2.

An immersion heating rod is rated 220 V and can bring certain amount of water to its boiling point in 15 min. When this immersion rod is actually connected to an electric circuit, it brings the water to boil in 18.15 min. Calculate the line voltage.

Answer:

Energy consumed by water in 15 min at 220 V

$$E = \frac{V^2 t}{R} = \frac{220 \times 220 \times 15 \text{ min}}{R} \quad \dots(i)$$

Energy consumed by water at 18.15 min at Volt

$$E = \frac{V^2 t}{R} = \frac{V^2 \times 18.15 \text{ min}}{R} \quad \dots(ii)$$

By law of conservation of energy (i) = (ii)

$$\frac{V^2 \times 18.15 \text{ min}}{R} = \frac{220 \times 220 \times 15}{R}$$

$$V^2 = (220)^2 \times \frac{1500}{1815} = 40000$$

$$V^2 = (200)^2$$

$$V = 200 \text{ Volt.}$$

Practice Problems 11

Question 1.

An electric oven is marked 1000 W – 200 V. Calculate :

- (a) Resistance of its element
- (b) Energy consumed by the oven in 1/2 hour in joules.
- (c) Time, in which it will consume 15 kWh of energy.

Answer:

An electric oven marked 1000 W – 200 V means

Power of oven $P = 1000 \text{ W}$

Voltage $V = 200 \text{ V}$

$$(a) \quad \text{Resistance of its element } R = \frac{V^2}{P} = \frac{200 \times 200}{1000}$$

$$R = 40 \text{ OHM}$$

$$(b) \quad \text{Energy consumed by oven in } \frac{1}{2} \text{ hr i.e. in } 1800 \text{ s}$$

$$E = P \times t = 1000 \times 1800 = 18 \times 10^5 \text{ J}$$

$$18 \times 10^5 \text{ J of energy is consumed in } \frac{1}{2} \text{ hour}$$

$$\text{As } 1 \text{ kWh} = 36 \times 10^5 \text{ J}$$

$$\therefore 15 \text{ kWh} = 15 \times (36 \times 10^5 \text{ J})$$

$$\therefore 15 \text{ kWh} = 15 \times (36 \times 10^5 \text{ J}) \text{ is consumed in } = \frac{1}{2} \times \frac{15 \times 36 \times 10^5}{18 \times 10^5}$$

$$= 15 \text{ hr}$$

Question 2.

An electric motor is rated 2 HP – 250 V. Calculate :

- (a) Current flowing through it
- (b) Energy consumed by it in one second
- (c) Time in which it will consume 90 kWh of energy. [1 HP = 750 W]

Answer:

Electric motor is rated 2HP – 250 V means

Power of motor $P = 2\text{HP} = 2 \times 750 = 1500 \text{ W}$

Voltage of motor $= V = 250 \text{ V}$

(a) Current flowing $I = \frac{P}{V} = \frac{1500}{250} = 6A$

(b) Energy consumed in 1 sec. $= E = VIt$
 $E = 250 \times 6 \times 1 = 1500 \text{ J}$

(c) time $t = ?$

1500 J is consumed in 1 sec

1 J is consumed in $= \frac{1}{1500}$

90 kWh $= 90 \times (36 \times 10^5 \text{ J})$ is consumed in

$= \frac{1}{1500} \times 90 \times 36 \times 10^5 \text{ sec}$

$= 6000 \times 36 \text{ sec.}$

$= \frac{6000 \times 36}{60 \times 60} = 60 \text{ hours}$

Practice Problems 12

Question 1.

A geyser is rated 2000 W and operates 2 hours a day on 200 V mains. Calculate the monthly bill for running the geyser when energy costs ₹ 1.90 per kWh.

Answer:

$$\text{Power of geyser } P = 2000 \text{ W} = \frac{2000}{1000} = 2 \text{ kW}$$

$$t = 2 \text{ hrs per day}$$

$$\text{Energy consumed per day } E = P \times t = 2 \times 2 = 4 \text{ kWh}$$

$$\text{Energy consumed in 30 days} = 4 \times 30 = 120 \text{ kWh}$$

$$\text{Cost of 120 kWh} = 120 \times 1.90 = ₹228$$

$$\therefore \text{Monthly bill} = ₹228$$

Question 2.

An electric oven of resistance 20Ω draws a current of 10 A . It works 3 hours daily. Calculate the weekly bill when energy costs ₹ 1.50 per kWh.

Answer:

$$R = 20\Omega, I = 10 \text{ A}, t = 3\text{hrs daily}$$

$$P = VI$$

$$\text{Also } V = IR$$

$$\therefore P = (IR) I$$

$$P = I^2 R$$

$$P = 10 \times 10 \times 20 = \frac{2000 \text{ W}}{1000} = 2\text{kW}$$

$$\therefore \text{Total consumption of electric oven per day} = 2 \times 3 = 6 \text{ kWh}$$

Electric oven works 3 hours daily

$$\therefore \text{Energy consumed per day} = 6 \text{ kWh}$$

$$\text{Cost per kWh} = \text{Rs. } 1.50$$

$$\therefore \text{Energy consumed in one week} = 6 \times 7 = 42 \text{ kWh}$$

$$\text{Weekly bill} = 42 \times 1.5 = ₹63$$

Question 3.

An electric bulb draws a current of 0.8 A and works on 250 V on an average 8 hrs a day. If energy costs ₹ 1.50 per board of trade unit, calculate the monthly bill

Answer:

$$I = 0.8 \text{ A} \quad V = 250 \text{ V}$$

$$\text{Power} = VI = 250 \times \frac{8}{10} = 200 \text{ W}$$

$$\text{Energy consumed per day} = 200 \times 8 = 1600 \text{ Wh}$$

$$= \frac{1600}{1000} = 1.6 \text{ kWh}$$

$$\text{Energy consumed in 30 days} = 1.6 \times 30 = 48 \text{ kWh}$$

$$\text{Cost per kWh} = ₹1.5$$

$$\therefore \text{Monthly bill} = 48 \times 1.5 = ₹72$$

Practice Problems 13

Question 1.

4 tube lights of 40 W each and 2 fans of 100 W each are connected to 200 V mains and operate on an average 8 hours a day. If energy costs ₹ 1.50 kWh, calculate

(a) monthly bill

(b) minimum fuse rating.

Answer:

$$\text{Power of 4 tube lights} = 40 \times 4 = 160 \text{ W}$$

$$\text{Power of 2 fans} = 2 \times 100 = 200 \text{ W}$$

$$\begin{aligned} \text{Energy consumed per day} &= [200 + 160] \times 8 = (360 \times 8) \text{ Wh} \\ &= \frac{(360 \times 8)}{1000} \text{ kWh} \end{aligned}$$

$$(a) \text{ Energy consumed in 1 month} = \frac{360 \times 8 \times 30}{1000} \text{ kWh}$$

$$\text{Bill per month} = \frac{36 \times 24}{10} \times 1.5 = ₹129.60$$

$$(b) \text{ Minimum fuse rating} = \text{current drawn} = \frac{P}{V}$$

$$= \frac{360}{200} = 1.8 \text{ A}$$

Question 2.

An electric motor of 2 H.P. and two coolers of 500 W each operate on 250 V mains for 4 hours a day. If the energy costs ₹ 1.80 per kWh, calculate

- (a) weekly bill
- (b) minimum fuse rating. [Take 1 HP = 750 W]

Answer:

$$\text{Power of motor} = 2\text{H.P} = 2 \times 750 = 1500 \text{ W}$$

$$\text{Power of 2 coolers} = 2 \times 500 = 1000 \text{ W}$$

$$\text{Energy consumed per day} = P \times \text{hr}$$

$$= [1500 + 1000] \times 4 = 10000 \text{ Wh}$$

$$= \frac{10000}{1000} = 10 \text{ kWh}$$

$$\text{Energy consumed per week} = 10 \times 7 = 70 \text{ kWh}$$

(a) Cost per kWh = ₹1.8

∴ Weekly bill = $10 \times 7 \times 1.8 = ₹126$

(b) Minimum fuse rating = current drawn = $\frac{P}{V} = \frac{2500}{250} = 10 \text{ A}$

Practice Problems 14

Question 1.

A boys hostel has following appliances when energy is supplied at 200 V and costs ₹ 5.25 per kWh.

- (a) 40 bulbs of 100 W each, working 8 hours a day.
- (b) 20 fans each drawing a current 9.8 A and working 15 hours a day.
- (c) Two T.V. sets, each offering a resistance of 200Ω and working 4 hours a day.
- (d) Two electric motors of 1.5 H.P. each and working 4 hours a day

1. Calculate the monthly bill
2. Amongst the fuse of 48 A and 50 A which one you will use and why ?

Answer:

Energy consumed by bulbs

(a) $40 \times 100 \times 8 = 32000 \text{ WH}$

(b) Energy consumed by 20 fans = $20 \times (V \times I) \times 15 \text{ hours}$

$$= 20 \times 200 \times \frac{8}{10} \times 15 = 48000 \text{ wH}$$

(c) Energy consumed by 2 T.V.S.

$$= 2 \times \left(\frac{V^2}{R} \right) \times 4 \text{ hrs}$$

$$= 2 \times \frac{200 \times 200 \times 4}{200} = 1600 \text{ WH}$$

(d) Energy consumed by electric motor

$$2 \times (1.5 \times 750) \times 4 = 9000 \text{ WH}$$

(i) Total energy consume in 30 days

$$= \frac{30(32000+48000+1600+9000)}{1000}$$

$$= 30 \times \frac{90600}{1000} \text{ kWh}$$

$$= 2718 \text{ kWh}$$

$$\text{Total Monthly bill} = 2718 \times 5.25 = ₹14269.50$$

(ii) Total P = $4000\text{W} + 3200\text{W} + 400\text{W} + 2250 \text{ W} = 9850 \text{ W}$

$$\therefore \text{Minimum fuse rating} = \frac{P}{V} = \frac{9850 \text{ W}}{200 \text{ V}} = 49.75 \text{ A}$$

$$\Rightarrow 50\text{A}$$

Question 2.

An establishment receives electric energy at a rate of ₹ 4.50 per kWh at a p.d. of 240 V. It uses following appliances.

(a) 20 tube lights of 40 W each working 10 h a day.

(b) Two stereo systems, each drawing a current of 2A and working 4h a day.

(c) Four ovens, each of resistance 24 Q working 6 h a day.

(d) Two cooling machines of 4 H.P. each working 15 hours a day.

1. calculate monthly bill
2. minimum fuse rating of circuit

Answer:

Energy consumed per day by

- (a) 20 tube lights = $(20 \times 40) \times 10 = 8000 \text{ WH}$
- (b) 2 series = $2 (240 \times 2) \times 4 = 3840 \text{ WH}$
- (c) 4 ovens = $4 \times \left(\frac{240 \times 240}{24} \right) \times 6 = 57600 \text{ WH}$
- (d) Two cooling machines = $2[4 \times 750] \times 15 = 90000 \text{ WH}$

$$\text{Total energy consumed per day} = \frac{15940}{1000} \text{ kWh}$$

$$= 159.44 \text{ kWh}$$

- (i) Energy consumed in 1 month = $159.44 \times 30 \text{ kWh}$
 $= 4783.20 \text{ kWh}$

$$\text{Cost} = 4783.20 \times 4.50$$

$$= ₹21524.40$$

- (ii) Total power = $800 \text{ W} + 960 \text{ W} + 9600 \text{ W} + 6000 \text{ W}$

$$\therefore \text{Minimum fuse rating} = \frac{16360 \text{ W}}{240 \text{ V}} = 68.1$$

$$\Rightarrow 69\text{A}$$

Exercise – 2

Question 1.

- (a) What do you understand by the term electric fuse ?

Answer:

Electric fuse : "Is a safety device which is used to limit the current in an electric circuit. The use of a fuse safe guards the circuit and the appliances connected in that circuit from being damaged."

- (b) Name a material from which an electric fuse is made.

Answer:

Material used for fuse is 'Alloy of lead and Tin' having low melting point and high resistance."

(c) State two properties of a material which makes it suitable for an electric fuse.

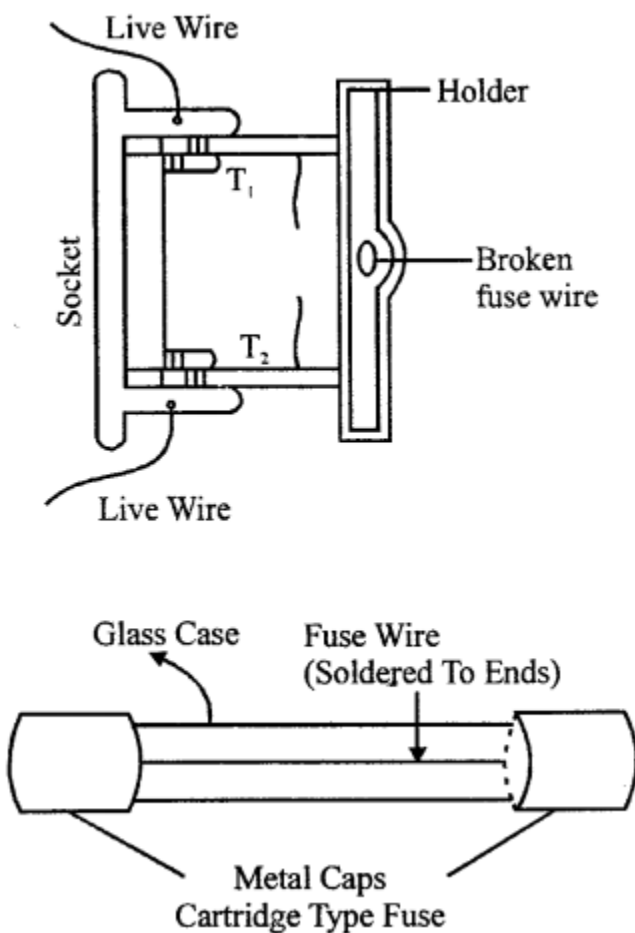
Answer:

Two properties of material are :

1. Low melting point
2. High resistance.

(d) Draw a diagram of a fuse wire, connected in a fuse socket.

Answer:



Question 2.

(a) Why is a fuse wire always placed in a live wire ?

Answer:

So that 'The fuse may melt first, before current reaches the appliance'.

(b) How does fuse wire protect an electric circuit ?

Answer:

When current in the circuit exceeds the specified value (due to any reason such as high voltage, short circuiting etc.) the fuse wire gets heated up to the extent that it melts. As a result a gap is produced and the circuit breaks. The current does not flow through the live wire and appliance is saved.

(c) Two fuse wires of the same length are rated 15A and 5A. Which of the two is thicker and why ?

Answer:

5A wire is thicker as resistance is $\propto 1/a$ Thicker the wire less is resistance and electrons can run freely with less collisions.

(d) Why is it dangerous to replace a fuse wire with a copper wire?

Answer:

"Copper has low resistivity and high melting point and does not serve the purpose of fuse."

Question 3.

(a) What do you understand by the term earthing ?

Answer:

Earthing : or Grounding : "Bringing the appliance to zero potential".

"Earthing means to connect the metal case of electrical appliance to the earth (at zero potential) by means of a metal wire is called "Earth wire".

(b) How does earthing protect a user from receiving an electric shock?

Answer:

When we connect the earth wire to the metal case of the electrical appliance by using three pinplug.

The metal casing of the appliance will now always remain at zero potential of the earth, this will avoid the risk of shock if we touch the metal body as the current passes directly to earth through the earth wire.

(c) How is a household circuit earthed ?

Answer:

The neutral and earth wires on supply end (power station) are connected potential together, so that both of them are at zero potential and inside the house live and neutral wires are connected to the input terminals of kWh meter, where as earth wire is connected to the body of kWh meter. The live wire coming out from the output terminals of the kWh meter has another fuse in it, which is commonly called main fuse. The neutral wire and earthwire is common to all circuits.

(d) Explain how the fuse melts when a short circuit appliance gets earthed.

Answer:

When an earthed appliance gets short circuited, then current from its metal body flows into the earth. Since earth does not offer any resistance, therefore magnitude of the current in the circuit of a short-circuited appliance suddenly rises to a very high value. This rise in magnitude of current in turn overloads the circuit, and hence. The fuse in that circuit melts.

Question 4.

(a) What is the function of a switch in an electric circuit?

Answer:

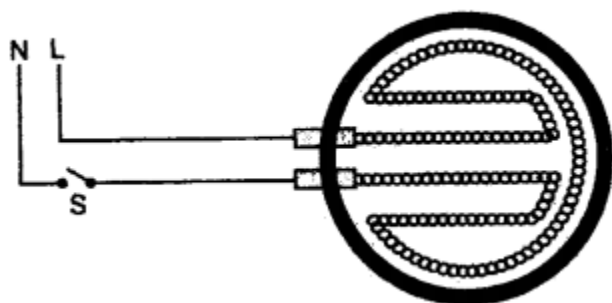
Function of a switch :

Function of a switch is to connect or disconnect an electric appliance in the electric circuit.

(b) Why is switched placed in a live wire ?

Answer:

Let the appliance (heater) when connected in a neutral wire, when the switch is in the off position and even if no current is flowing through the heater and it is not operating, how ever the heater is in contact with live wire and heating element is at the same potential as the live wire. Thus if we touch the heating coil of the heater, current will flow through our body giving us a severe shock and may prove fatal, this proves that switch should always be placed in the live wire.



(c) what consequences will follow, if a switch is placed in the neutral wire ?

Answer:

Even if switch is in off position the appliance will be at the potential of live wire and current will flow through the appliance.

Question 5.

(a) Why is household wiring done in parallel ? Give at least two reasons ?

Answer:

Two advantages of parallel wiring :

1. Electrical appliances get same voltage (220 V) as that of the power supply line.
2. If one electrical appliance stops working due to some defect, then all other appliances keep working normally.

(b) What are the disadvantages of wiring in series in a house?

Answer:

Disadvantages in series circuit :

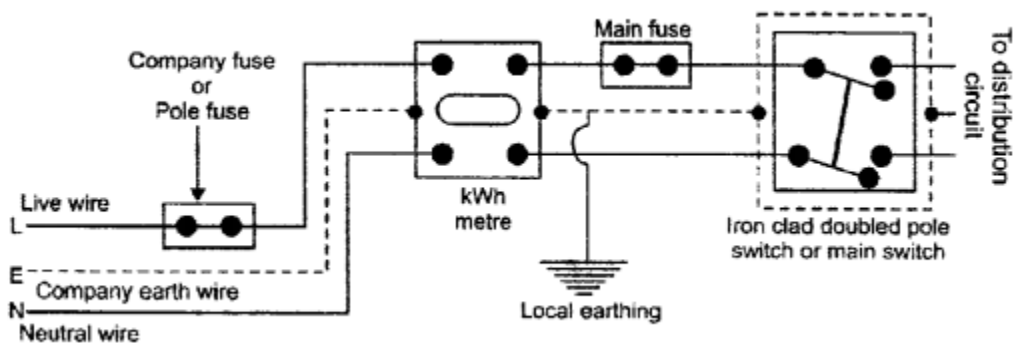
1. Over all resistance increases and current from the power supply is low.
2. If one electrical appliance stops working, due to some defect, then all other appliances also stop working.

Question 6.

Draw a circuit diagram for distribution of power from pole to the main switch and label it

Answer:

Circuit Diagram For Distribution Of Power From Pole To Main Switch :



Question 7.

Name two systems of distribution of power in a house. Give the advantages and disadvantages of each system.

Answer:

Two systems of power distribution.

(i) Tree system Advantages

1. All appliances are connected parallel and can be independently switched on and switched off.
2. The neutral wire and earth wire is common to all circuits.
3. From the main distribution board, circuits are taken out for different rooms.

Disadvantages :

1. It is expensive and takes a long time to install.

2. It requires plugs and sockets of different current value for different appliances depending upon their power rating.
3. When a fuse in one particular line melts. It disconnects all appliances in that circuit.

(ii) Ring system :

Advantages :

1. Every appliance has its own fuse and can be handled without disturbing other appliances.
2. Length of wire used is very small.
3. It is easier to install and maintain.

Question 8.

(a) State the colour of (i) live wire, (ii) neutral wire, (iii) earth wire according to international convention

(b) State the position of (i) earth pin, (ii) live pin and (iii) neutral pin in an electric plug.

(c) Why is the earth terminal of a plug made (i) thicker, (ii) longer

Answer:

(a) The colour of

1. Live wire -- Brown
2. Neutral wire -- Light Blue .
3. Earth wire -- green or Yellow

(b) Position of

1. Earth pin -- is Long and Thicker so that it should not enter live or neutral cylinder of socket.
2. Live pin -- L is on the right when earth pin goes into E, live pin goes into L.
3. Neutral-pin -- N is on the left. When earth pin goes into E, live wire in L automatically neutral goes into N.

(c) Earth-pin is made thicker, so that it should not enter other cylinder of socket and helps in putting right pin in right place.

Longer -- So that earth connection is done first. This ensure the user will not get a shock.

Multiple Choice Questions

Tick (✓) the most appropriate option.

1. A fuse wire is connected in before the switch.

- (a) neutral wire
- (b) earth wire
- (c) live wire
- (d) either (a) or (c)

Answer:

- (c) live wire

2. A switch in a circuit is always connected in the :

- (a) live wire
- (b) earth wire
- (c) neutral wire
- (d) either (a) or (b)

Answer:

- (a) live wire

3. According to old convention, the colour of neutral wire is :

- (a) red
- (b) green
- (c) black
- (d) none of these

Answer:

- (c) black

4. According to new convention, the colour of live wire is :

- (a) light blue
- (b) yellow
- (c) green
- (d) brown

Answer:

- (d) brown

5. Which is not the characteristic of a fuse wire ?

- (a) It has high resistance
- (b) It has low melting point
- (c) It has low resistance
- (d) It is an alloy of lead and tin

Answer:

- (c) It has low resistance

6. In a three pin plug the live pin in :

- (a) thinner and is toward left
- (b) thicker and is towards left

- (c) thinner and is towards right
- (d) thicker and is towards right

Answer:

- (c) thinner and is towards right

7. In a household electric circuit all appliances are connected in :

- (a) parallel circuit
- (b) series circuit
- (c) mixed circuit
- (d) any of these

Answer:

- (a) parallel circuit

8. An average lighting circuit of a cpoor family has a fuse rating of

- (a) 10 A
- (b) 15 A
- (c) 5 A
- (d) 2 A

Answer:

- (c) 5 A

Questions From ICSE Examination Papers

2001

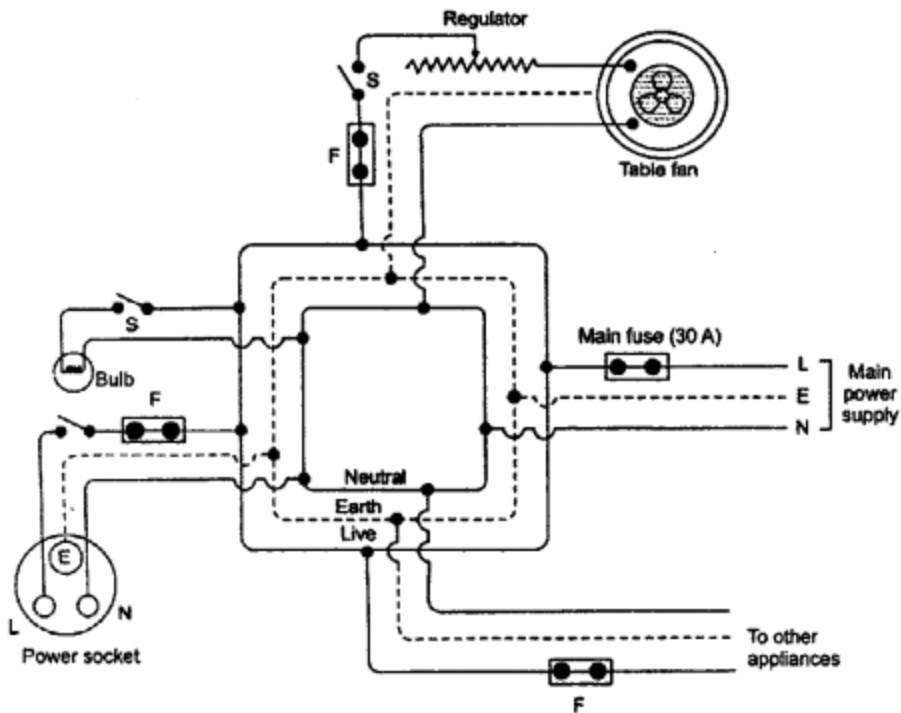
Question 1.

- (a) Draw a diagram of ring main circuit for domestic distribution of electric power.
- (b) Name the physical quantity which is measured in

- 1. Kilowatt hour
- 2. Kilowatt

Answer:

- (a)



- (b) (1) kilowatt hour -- energy consumed.
 (2) kilowatt -- power.

Question 2.

A bulb is marked 100 W – 220 V and an electric heater is marked 1000 W – 220 V
 Answer the following questions :

- (a) What is the ratio of resistance of the filament of the bulb to the element of the heater ?
 (b) How does power-voltage rating of an electric appliance help us to decide the type of connecting wires (leads) to be used for it ?
 (c) In the above mentioned devices in 2(a) which of the two devices needs a thicker wire.

Answer:

Bulb marked 100 W – 220 V

Heater marked 1000 W – 220 V

$$\frac{\text{bulb}}{\text{heater}} = \frac{100 \text{ W} = \frac{V^2}{R_1}}{1000 \text{ W} = \frac{V^2}{R_2}}$$

$$(a) \quad \therefore \quad \frac{R_1 = \frac{V^2}{100}}{R_2 = \frac{V^2}{1000}} \quad \frac{R_1}{R_2} = \frac{V^2}{100} \times \frac{1000}{V^2}$$

$$R_1 : R_2 = 10 : 1$$

- (b) The rate of heat produced in a conductor is given by the expression $I^2 R$. Copper wires have low resistance and the heat produced in them is so small that it gets radiated out without damaging the insulation. If current increases the heat produced burns the insulation and bare-copper wires come in contact with each other and will cause electric fire. Hence power-voltage rating helps to decide the type of connecting wires (leads) to be used for it so that it can tolerate the current flowing through it.
- (c) In case of heater the lead should be thicker to offer less resistance.

Question 3.

(a) Calculate the daily household electric bill for a family which uses the following appliances for 8 hours a day, when electrical energy costs Rs. 2 per unit

1. one 100 W bulb
2. one 100 W fan
3. one 1000 W heater.

Answer:

Energy used in kWh daily for 8 hours in Electric bulb

$$= \frac{100 \times 8}{1000} = 0.8 \text{ kWh}$$

$$\text{Fan} = \frac{100 \times 8}{1000} = 0.8 \text{ kWh}$$

$$\text{Heater} = \frac{1000 \times 8}{1000} = 8 \text{ kWh}$$

Total energy consumed in 1 day = $0.8 + 0.8 + 8$

$$= 9.60 \text{ kWh} = 9.6 \text{ units}$$

cost @ Rs. 2 per unit

$$= 9.6 \times 2 = \text{Rs. } 19.20$$

(b) How does earthing protect a user from electric shocks ?

Answer:

When we connect the earth wire to the metal case of the electrical appliance by using three pinplug. The metal casing of the appliance will now always remain at zero

potential of the earth, this will avoid the risk of shock if we happen to touch the metal body directly to earth through the earth wire.

2002

Question 4.

A geyser has a label 2 kW, 240 V. What is the cost of using it for 30 minutes, if the cost of electricity is Rs. 3.00 per commercial unit ?

Answer:

(i) Geyser marked 2 kW – 240 V means

Power = 2kW

Voltage = 240 V

$$\therefore \text{Energy consumed in 30 min } \left(\frac{1}{2} h \right) 2 \times \frac{1}{2} = 1 \text{ kWh}$$

Cost per unit = Rs. 3

Energy consumed = V I t

$$\begin{aligned} \text{Energy consumed} &= \text{Power} \times \text{time} = 2 \times \frac{1}{2} \\ &= 1 \text{ kW h} = 1 \text{ unit} \end{aligned}$$

$$\text{Total cost} = 3 \times 1 = \boxed{\text{Rs. 3}} \text{ Ans.}$$

Question 5.

Explain briefly the function of the following in the household wiring :

- (a) a three-pin plug
- (b) main switch.

Answer:

(a) **Three-pin plug** is a fixture provided with three cylindrical pins made of brass. The live pin is on the right, neutral pin on the left and earth pin is on the top. When inserted in the socket, its function is to provide a tight fitting between electrical circuit and the movable electric appliance.

(b) **Main switch** : It is the on-off device for current in a circuit or in a appliance. The switch should always be connected to live wire.

Question 6.

Make a table with the names of 3 electrical appliances used in home in one column, their power, voltage rating and approximate time for which each one is used in one day in the other columns.

Answer:

Appliance	Power	Voltage Rating	Time
Geyser	2000 W	220 V	1 hr
Fan	60 W	220 V	10 hr
Tubelight	40 W	220 V	8 hr

2003

Question 7.

An electric kettle is rated 2.5 kW, 250 V. Find the cost of running the kettle for two hours at 60 paise per unit.

Answer:

Electric kettle is rated (2.5 kW – 250 V) means

$$P = 2.5 \text{ kW}$$

$$T = 2 \text{ hours}$$

$$\text{Energy drawn in 2 hours} = E = 2.5 \times 2 = 5 \text{ kWh}$$

$$\text{Cost of running the kettle} = \frac{5 \times 60}{100} = \boxed{\text{Rs. 3}}.$$

Question 8.

Two fuse wires of the same length are rated 5 A and 20 A. Which of the fuse wires is thicker and why ?

Answer:

$$R \propto \frac{1}{\pi r^2} \quad R \propto \frac{1}{I}$$

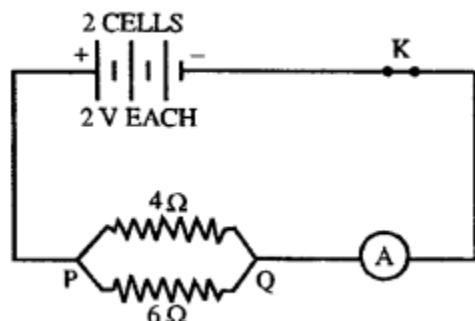
$$\therefore I \propto \pi r^2 \text{ i.e. more radius, more current.}$$

So 20 A wire will be thicker, as it carries large current.

Question 9.

With reference to the given diagram, calculate

- (a) Equivalent resistance between P and Q.
 (b) The reading of the ammeter.
 (c) The electrical power between P and Q.



Answer:

(a) Equivalent resistance between P and Q

$$\frac{1}{R_p} = \frac{1}{4} + \frac{1}{6} = \frac{3+2}{12} = \frac{5}{12}$$

$$\therefore \frac{1}{R_p} = \frac{5}{12}$$

$$\therefore R_p = \frac{12}{5} = 2.4 \, \Omega$$

Equivalent resistance between P and Q = $\boxed{2.4 \, \Omega}$ **Ans.**

(b) Ammeter reading

Key open = zero

P.D. of 2 cells = $2 \times 2 = 4V$

$$\text{Key closed} = I = \frac{V}{R} = \frac{4}{2.4} = \frac{40}{24} = \frac{5}{3} \text{ A} = 1.67 \text{ A} \text{ **Ans.**}$$

(c) Power between P and Q

$$P = VI$$

$$= I^2 R$$

$$= \left(\frac{5}{3}\right)^2 \times \left(\frac{12}{5}\right) = \frac{25}{9} \times \frac{12}{5} = \frac{20}{3} = 6.67 \text{ W}$$

Question 10.

Electrical power P is given by the expression : $P = (Q \times V)$, time.

- (a) What do the symbols Q and V represent ?
 (b) Express 'Power' in terms of current and resistance explaining the symbols used there in.

Answer:

(a) Q – Charge

V – Potential difference

$$(b) P = \frac{QV}{t} \quad \text{But } Q = It \therefore P = \frac{VI t}{t} = VI$$

But $V = IR$

$$\therefore P = IRI = \boxed{I^2 R}$$

P = Power (electrical)

I – Current flowing

R – Resistance

t – Time

2004

Question 11.

State the purpose of a fuse in an electric circuit. Name the material required for making a fuse wire.

Answer:

Purpose of Fuse :

1. The fuse limits the current in electric circuit and acts as a safety device.
 2. It saves us and protects us and our expensive appliances when circuit gets overloaded or higher current flows as the fuse blows off and current supply stops.
- Material used for making fuse wire is Lead and Tin alloy.

Question 12.

An electric bulb is rated 240V – 60 W and is working at 100% efficiency.

- (a) Calculate the resistance of the bulb.
 (b) If an identical bulb is connected in series with this bulb then:

1. Draw the circuit diagram.

2. What is the rate of conversion of energy in each bulb ?
3. Total power used by the bulbs.

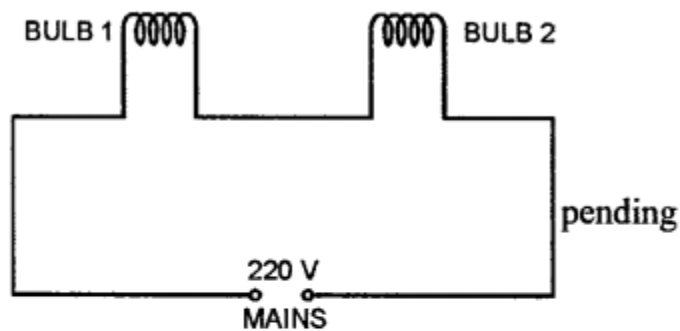
Answer:

(a) $P = 60 \text{ w}$ $V = 240 \text{ v}$

$$P = \frac{V^2}{R} \quad \therefore R = \frac{V^2}{P} = \frac{240 \times 240}{60}$$

$$R = 960 \Omega$$

(b) (i)



(ii) Rate of conversion of energy in each bulb

$$E = W = \frac{P}{t} = \frac{60 \text{ w}}{1 \text{ sec}} = 60 \text{ Js}^{-1}$$

(iii) Power used by bulbs

$$\text{Total resistance of two bulbs in series} = R_1 + R_2 = 960 + 960 = 1920 \Omega$$

$$\text{Total power used} = P = \frac{V^2}{R} = \frac{240 \times 240}{1920} = 30 \text{ W}$$

2005

Question 13.

(a) In a three-pin plug, why is the earth pin made longer and thicker than the other two pins ?

Answer:

The earth pin is made longer and thicker, (i) So that earth connection is made first. This ensures the safety of the user because, (ii) It is made thick so that its resistance is low and any leakage of current flows easily into the earth

(b) An electrical appliance is rated 1500 W – 250 V. This appliance is connected to 250 V mains.

Calculate :

1. the current drawn,
2. the electrical energy consumed in 60 hours,
3. the cost of electrical energy consumed at Rs. 2.50 per KWH.

Answer:

(i) Power = 1500 W

Voltage = 250 V

(i) $I = ?$

$$P = VI$$

$$I = \frac{P}{V} = \frac{1500}{250} = \boxed{6 \text{ A}} \text{ Ans.}$$

(ii) Electrical energy consumed in hours $E = p \times t = 1500 \times 60$

$$= 90,000 \text{ wh} = \boxed{90 \text{ kwh.}} \text{ Ans.}$$

(iii) Cost of electrical energy consumed per kWh = Rs. 2.50

$$\text{Cost} = 90 \times 2.50 = 90 \times \frac{25}{10} = \boxed{\text{Rs. 225}} \text{ Ans.}$$

2006

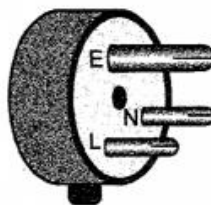
Question 14.

Draw a labelled diagram of a three-pin socket.

Answer:



Power socket



Question 15.

Find the cost of operating an electric toaster for 2 hours, if it draws a current of 8A on a 110 V circuit. The cost of electrical energy is Rs. 2.50 per kWh.

Answer:

$$P = VI \quad V = 110 \text{ volt}$$

$$= 110 \times 8 = 880 \text{ W} \quad I = 8\text{A}, \quad T = 2 \text{ hour}$$

$$= \frac{880}{1000} \text{ kW}$$

$$\therefore \text{Energy consumed in 2 hrs.} = \frac{880 \times 2}{100} = 1.76 \text{ kWh}$$

$$\text{Cost} = 1.76 \times 2.50 = 4.40$$

2007

Question 16.

Of the three connecting wires in a household circuit :

- (a) Which two of the three wires are at the same potential ?
- (b) In which of the three wires should the switch be connected ?

Answer:

- (a) Of the three wires, the Earth wire and the Neutral wire are at the same potential of zero.
- (b) The switch should be connected in the Live wire.

Question 17.

What is meant by earthing of an electrical appliance ? Why is it essential ?

Answer:

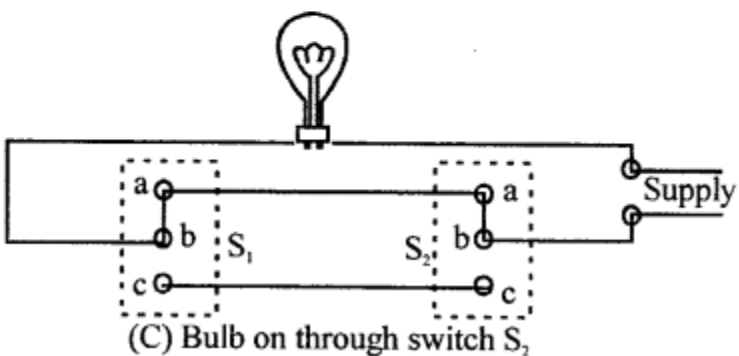
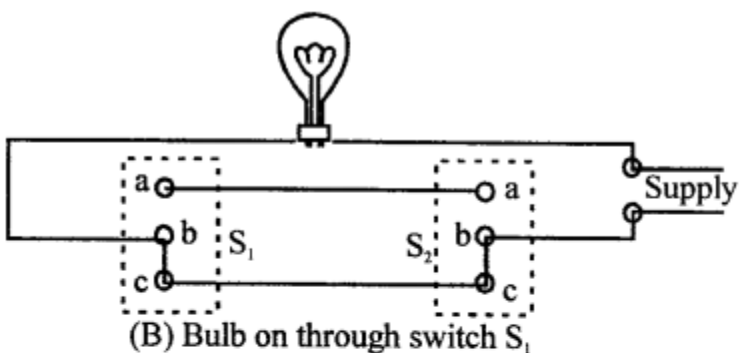
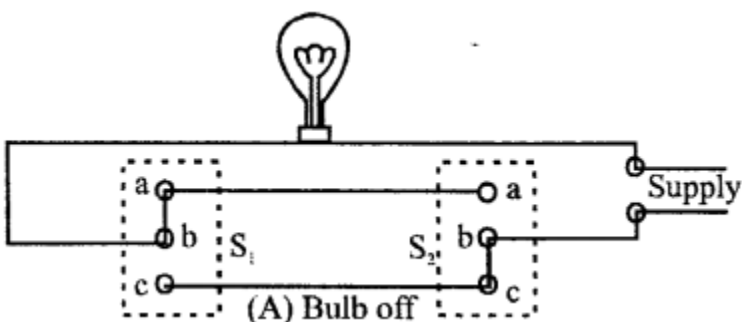
By earthing we mean that the metallic body of an electrical appliance is connected to thick wire of copper which is buried deep in the earth and at its end is a copper plate surrounded by a mixture of charcoal and common salt. It is essential to avoid any shock when the metal casing of the appliance happens to touch the live wire. The current due to short circuiting flows to the earth instead of through the human body.

2008

Question 18.

(a) Draw a labelled diagram of the staircase wiring for a dual control switch showing a bulb in the circuit.

Answer:



(b) The electrical gadgets used in a house such as bulbs, fans, heater, etc., are always connected in parallel, NOT in series. Give two reasons for connecting them in parallel.

Answer:

All electrical gadgets are connected in parallel because

1. All appliances will get same potential difference in parallel so flow of any one appliance is not affected on switching on or off, of other appliance.

2. In parallel arrangement if one appliance is switched off or fuses, other can effectively work.

(c) An electrical heater is rated 4 kW, 220 V. Find the cost of using this heater for 12 hours if one kWh of electrical energy costs Rs. 3.25.

Answer:

Power = 4 kW

Time = 12 hrs.

Cost per unit = Rs. 3.25

Total cost = Power (kW) $\times$ time (hrs.) $\times$ cost per unit
 $= 4 \times 12 \times 3.25 = 48 \times 3.25 = \text{Rs. } 156$

Question 19.

How does the heat produced in a wire or a conductor depend upon the :

- (a) current passing through the conductor.
(b) resistance of the conductor ?

Answer:

Heat produced in a conductor is directly proportional to

(a) the square of current and (b) the resistance of conductor.

$$H = I^2 R t$$

$H \propto I^2$ i.e. square of current following

$H \propto R$ i.e. directly proportional to the resistance of conductor

2009

Question 20.

(a) An electric heater is rated 1000 W – 200 V. Calculate :

1. the resistance of the heating element.
2. the current flowing through it.

Answer:

Power of heater = 1000 W

P.D. = 200 V

R = ?

I = ?

$$P = \frac{V^2}{R} \text{ or } R = \frac{V^2}{P} = \frac{200 \times 200}{1000}$$

$$= 40 \Omega$$

$$V = IR$$

$$200 = I \times 40$$

$$I = 5A$$

(b) (i) Give two characteristic properties of copper wire which make it unsuitable for use as fuse wire.

(ii) Name the material which is used as a fuse wire ?

Answer:

(i) **Copper cannot be used as fuse wire because :**

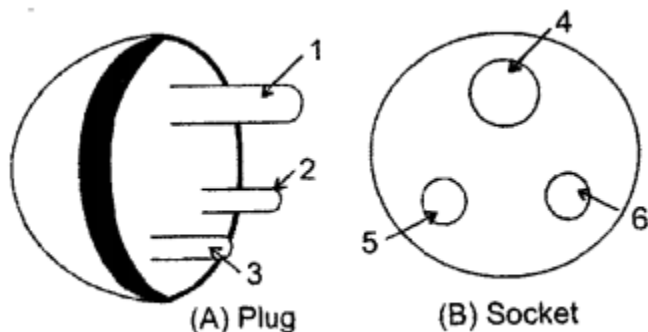
(a) it has high melting point

(b) low resistivity

(ii) **Alloy of lead and tin.**

Question 21.

(a) The diagrams (i) and (ii) given alongside are of a plug and a socket with arrows marked a as 1, 2, 3 and 4, 5, 6 respectively on them. Identify and write Live (L), Neutral (N) and Earth (E) against the correct number.



(b) Calculate the electrical energy consumed when a bulb of 40 W is used for 12.5 hours

everyday for 30 days.

Answer:

$$(a) \quad P = 1000 \text{ W}$$

$$V = 200 \text{ V}$$

$$(i) \quad P = \frac{V^2}{R} \quad \therefore R = \frac{V^2}{P} = \frac{200 \times 200}{1000}$$

$$R = 40 \, \Omega$$

$$(ii) \quad I = \frac{V}{R} = \frac{200}{40} = 5 \text{ A}$$

(b) (i) (1) Copper has high melting point.

(2) Copper has low resistance.

(ii) Material used for fuse wire is lead-tin alloy.

(b) (i) E (4) E

(2) N (5) N

(3) L (6) L

(ii) Power = 40W

Time = 12.5 hrs $\times$ 30 days

Electrical Energy = $P \times t$

$$= \frac{40}{1000} \times \frac{125}{10} \times 30 = 15 \text{ kWh}$$

2010

Question 22.

(a) Which part of an electrical appliance is earthed ?

(b) State a relation between electrical power, resistance and potential difference in an electrical circuit.

Answer:

(a) The metallic part of an electrical appliance is earthed.

(b) The required relation is $P = V^2 / R$ where P is power, V the potential difference and R is the resistance.

Question 23.

- (a) In what unit does the domestic electric meter measure the electrical energy consumed? State the value of this unit in S.I. Unit.
- (b) Why should switches always be connected to the live wire?
- (c) Give one precaution that should be taken while handling switches.

Answer:

1. The domestic electric meter measure, the electric energy in kWh.
 $1 \text{ kWh} = 3.6 \times 10^6 \text{ J}$
2. The switch should always be connected to the live wire, so that current is cut off to that appliance to which it is connected.
3. The switches should not be touched with wet hand otherwise we may receive a shock.

Question 24.

Calculate the quantity of heat that will be produced in a coil of resistance 75Ω if a current of 2 A is passed through it for 2 minutes.

Answer:

Here, $R = 75 \Omega$, $i = 2 \text{ A}$, $t = 2 \text{ minutes} = 2 \times 60 = 120 \text{ s}$

Now, Heat produced

$$H = i^2 R t$$

$$= 2 \times 2 \times 75 \times 120 \text{ J} = 36000 \text{ J}$$

2011

Question 25.

- (a) Two bulbs are marked $100 \text{ W}, 220 \text{ V}$ and $60 \text{ W}, 110 \text{ V}$. Calculate the ratio of their resistances.
- (b) (i) What is the colour code for insulation of earth wire?
- (ii) Write an expression for calculating electric power in terms of current and resistance.
- (c) (i) Name two safety devices which are connected to the live wire of a household electrical circuit.
- (ii) Give one important function of each of these devices.
- (d) (i) An electric bulb is marked $100 \text{ W}, 250 \text{ V}$. What information does this convey ?
- (ii) How much current will the bulb draw if connected to 250 V supply ?

Answer:

(a) We know that $R = \frac{V^2}{P}$

The resistance R_1 of the first bulb, $R_1 = \frac{220 \times 220}{100} = 484\Omega$

and $R_2 = \frac{110 \times 110}{60} = \frac{1210}{6} = 201.67\Omega$

$\therefore \frac{R_1}{R_2} = \frac{484}{1210} \times 6 = \frac{2.4}{1} = 2.4 : 1$

(b) (i) Yellow (ii) $P = I^2R$

(c) (i) Connected devices are fuses (ii) Earthing (Earth wire)

(ii) **Fuse** : It is a safety device which is used to limit current in an electric circuit.

Earth wire : To save a person touching the defective appliance so that he does not get a shock and also to save the appliance from being damaged.

(d) (i) $P = 100 \text{ W}$

$V = 250 \text{ V}$

It tells us that it will consume 100 watt at 250 V.

(ii) $R = \frac{V^2}{P}$

$= \frac{250 \times 250}{100} = 625\Omega$

$\therefore I = \frac{V}{R}$

$= \frac{250}{625} = 0.4 \text{ A}$

Question 26.

(a) An electrical appliance is rated at 1000 kVA, 220V. If the appliance is operated for 2 hours, calculate the energy consumed by the appliance in :

(i) kWh (ii) joule

(b) (i) What is the purpose of using a fuse in an electrical circuit?

(ii) What are the characteristic properties of a fuse wire ?

(c) (i) Write an expression for the electrical energy spent in the flow of current through an electrical appliance in terms of I, R and t.

(ii) At what voltage is the alternating current supplied to our houses ?

(iii) How should the electric lamps in a building be connected?

Answer:

(a) (i) Energy consumed in kWh = $1000 \text{ kVA} \times 2\text{h} = 2000 \text{ kWh}$.

(ii) Energy consumed in Joules = $1000 \times 1000 \text{ VA} \times 2 \times 3600 \text{ s}$
 $= 7,200,000,000 \text{ J} = 7.2 \times 10^9 \text{ J}$

(b) (i) The fuse wire melts and stops the flow of electric current in a given circuit, in case the circuit is overloaded or short circuited.

(ii) 1. Fuse wire should have low melting point around 200°C .

2. Fuse wire should have high electrical resistance.

(c) (i) Electrical energy (E) = $I^2.R.t$.

(ii) Alternating current is supplied at 220V for domestic consumption.

(iii) All lamps should be connected in parallel.

2013

Question 27.

(a) (i) Name the device used to protect the electric circuits from overloading and short circuits.

(ii) On what effect of electricity does the above device work?

Answer:

1. Electric fuse.

2. It works on the heating effect of electric current.

(b)(i) An electrical gadget can give an electric shock to its user under certain circumstances. Mention any two of these circumstances.

(ii) What preventive measure provided in a gadget can protect a person from an electric shock ?

Answer:

(a) (i) The electrical gadget may be short circuited i.e., its live or neutral wire is touching its metallic body directly.

(ii) The hands of the user may be wet, such that water dripping from his hands makes contact with the live wire.

(b) The body of the electric gadget is connected to the earth terminal by means of earth

wire. In case of short circuit a huge surge of current flows through the earth terminal. This in turn melts fuse in the live wire and hence the flow or current stops in the gadget.

2014

Question 28.

(i) Two sets A and B, of the three bulbs each, are glowing in two separate rooms. When one of the bulbs in set A is fused, the other two bulbs, cease to glow. But in set B, when one bulb fuses, the other two bulbs continue to glow. Explain why this phenomenon occurs.

(ii) Why do we prefer arrangement of Set B for house hold circuiting?

Answer:

1. The bulbs of set A are connected in series. Therefore when one bulb fuse the current stop flowing. Whereas the bulbs of set B are connected in parallel. When one bulb fuse then current flows through the other bulb.
2. Set B prefer parallel combination because in it potential difference remains same.

2015

Question 29.

(a) Fill in the blanks space.

For a fuse, higher the current rating _____ is the fuse wire.

Answer:

For a fuse, higher the current rating, **thicker** is the fuse wire.

(b) (i) Name the device used to increase the voltage at a generating station.

(ii) At what frequency is AC supplied to residential houses?

(iii) Name the wire in a household electrical circuit to which the switch is connected.

Answer:

1. The device used to increase voltage at the generating station is the step-up transformer.
2. The residential houses are supplied with AC of frequency 50 Hz.
3. The switch is connected to the live (or phase) wire in a house-hold electric circuit.

2016

Question 30.

(a) Calculate the quantity of heat produced in a $20\ \Omega$ resistor carrying 2.5 A current in 5 minutes.

Answer:

Given : $R = 20 \, \Omega$, $I = 2.5 \, \text{A}$

$t = 5 \text{ minutes} = 5 \times 60 = 300 \, \text{s}$

Quantity of heat produced is given as

$$H = I^2 \times R \times t$$

$$= (2.5)^2 \times 20 \times 300$$

$$\therefore H = 37500 \, \text{J}$$

(b) State the characteristics required in a material to be used as an effective fuse wire.

Answer:

The material should have high resistivity and low melting point.

(c) (i) Which particles are responsible for current in conductors?

(ii) To which wire of a cable in power circuit should the metal case of a geyser be connected ?

(iii) To which wire should the fuse be connected ?

Answer:

1. Moving Electrons are responsible for current in conductors.
2. The metal case of a geyser should be connected to the Earth wire.
3. The fuse should always be connected to the live wire.