ICSE Board

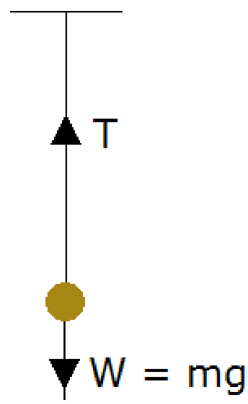
Class X Physics

Board Paper – 2017 (Solution)

SECTION - I

1.

(a) Forces acting on the brass ball and thread:



Tension acts on the thread in the upward direction, while weight mg of the ball acts downwards.

(b) Force of gravity:

$$F = \frac{Gm_1m_2}{r^2}$$

It is given that $r_2 = 2r_1$

$$\therefore \frac{F_2}{F_1} = \frac{r_1^2}{r_2^2} = \frac{r_1^2}{4r_1^2} = \frac{1}{4}$$

$$\therefore F_2 = \frac{1}{4}F_1$$

Therefore, the force of gravity is reduced four times.

(c) A jack screw is provided with a long arm in order to have the effort less than the load. According to the principle of moments, load $\times$ load arm = effort $\times$ effort arm. So, if the load arm is more, then the effort will be more than the load.

(d) Power is the product of force and velocity.

$$P = Fv$$

$$\therefore v = \frac{P}{F} = \frac{100 \times 10^3}{50000} = 2 \text{ ms}^{-1}$$

(e) A Class II lever will always have MA > 1. This is because the load is between the fulcrum and the effort. So, the effort arm is always greater than the load arm. Hence, MA = E/L > 1.

2.

(a) Heat capacity of a body is the amount of heat energy required to raise its temperature by 1°C. Its SI unit is JK^{-1}.

(b) By making the base of a cooking pan thick, its thermal capacity becomes large and it imparts sufficient heat energy at a low temperature to the food for proper cooking. Further, it keeps the food warm for a long time after cooking.

(c) Mass of the solid, m_s = 50 g
Initial temperature of the solid, t_s = 150°C
Mass of water, m_w = 100 g
Temperature of water, t_w = 11°C
Final temperature of the mixture, t = 20°C
According to the principle of calorimetry,
Heat gained by water = Heat lost by the solid

$$\therefore m_w c_w (t - t_w) = m_s c_s (t_s - t)$$

$$\therefore 100 \times 4.2 \times (20 - 11) = 50 \times c_s \times (150 - 20)$$

$$3780 = 6500 c_s$$

$$\therefore c_s = \frac{3780}{6500} = 0.581 \text{ J/g °C}$$

(d)

(i) Ratio of real depth to apparent depth is equal to the refractive index.

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

(ii) Refractive index is the ratio of the velocity of light in vacuum to the velocity of light in a medium.

$$\mu = \frac{c}{v}$$

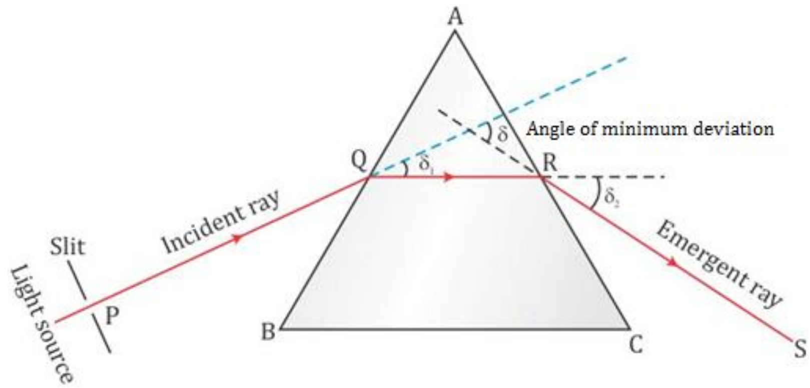
(e) Conditions necessary for total internal reflection to take place are

(i) Light must travel from a denser medium to a rarer medium.

(ii) Angle of incidence must be greater than the critical angle for the pair of media.

3.

(a) Refraction of a monochromatic ray through a prism when it goes through minimum deviation:



(b) Audible range of hearing for a normal human ear is 20 Hz to 20,000 Hz.

Speed of sound in air, v = 330 ms^{-1}

Speed, wavelength and frequency are related as

$v = n\lambda$

$\therefore \lambda = \frac{v}{n}$

$n_{lower} = 20$ Hz

$n_{upper} = 20,000$ Hz

$\therefore \lambda_{lower} = \frac{v}{n_{lower}}$

$\therefore \lambda_{lower} = \frac{330}{20} = 16.5$ m

Similarly, $\lambda_{upper} = \frac{v}{n_{upper}}$

$\therefore \lambda_{upper} = \frac{330}{20,000} = 0.0165$ m $= 16.5$ mm

(c) Distance between the plane and the radar, d = 300 km = 300,000 m

Velocity of radio waves, c = 3×10^8 ms^{-1}

Waves from the radar will travel to the plane and then reflect and travel back to the receiver of the radar. Hence, the total distance travelled by the waves is 2d.

$\therefore 2d = c \times t$

$\therefore t = \frac{2d}{c}$

$\therefore t = \frac{2 \times 300000}{3 \times 10^8}$

$\therefore t = 2 \times 10^{-3}$ s $= 2$ ms

(d)

(i) Frequency of a stretched string is inversely proportional to its length.

$$f \propto \frac{1}{l}$$

(ii) Frequency of a stretched string is directly proportional to the square root of the tension in the string.

$$f \propto \sqrt{T}$$

(e) Specific resistance or resistivity of a material is the resistance of a wire of that material of unit length and unit area of cross-section. Its SI unit is ohm metre (Ω m).

4.

(a) Current drawn by the bulb, I = 0.4 A
Resistance of the bulb, R = 300 Ω
Power of the bulb is

$$P = I^2R$$

$$\therefore P = (0.4)^2 \times 300 = 48 \text{ W}$$

Potential difference at the ends of the bulb is

$$V = IR$$

$$\therefore V = 0.4 \times 300 = 120 \text{ V}$$

(b) Causes of energy loss in a transformer:
(i) Eddy currents developed in the core.
(ii) Hysteresis loss because of repeated magnetisation and demagnetisation of the iron core.

(c) Characteristics of a good thermion emitter:
(i) The work function of the substance should be low so that electrons may be emitted from it even when it is not heated to a high temperature.
(ii) The melting point of the substance should be high so that it may not melt when it is heated to the temperature required for thermionic emission.

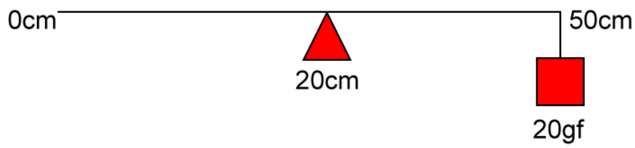
(d) Factors on which the rate of emission of thermions depend:
(i) Nature of the metal surface: Lower the work function of the metal, greater is the rate of emission of electrons.
(ii) Temperature of the surface: Higher the temperature of the surface, greater is the rate of emission of electrons.

(e) A nucleus tends to be radioactive when the number of neutrons inside it is more than the number of protons.

Section II

5.

(i) Diagram of the arrangement mentioned in the corresponding question:



(ii)

The centre of gravity of a uniform half meter rule is 25 cm.
The rule balances horizontally on a knife edge at 29 cm mark when a weight of 20 kgf is suspended from one end.
The difference in the centre of gravity and the point of balance = 29 - 25 = 4 cm (Y).
The weight is suspended at one of the extremes, let us assume at the 50 cm end.
Therefore, the distance from the point of knife edge to the weight = 50 - 29 = 21 cm (X).

$$\text{Weight of meter rule} = \frac{X}{Y} \times \text{Suspended weight}$$

$$\therefore \text{Weight of meter rule} = \frac{21}{4} \times 20 = 105 \text{ gf}$$

Weight of the half metre rule is 105 gf.

(a)

(i)

The ratio of load to effort is called mechanical advantage.

$$\text{Mechanical advantage (MA)} = \frac{\text{Load } (\ell)}{\text{Effort (E)}}$$

The above equation indicates that 'MA' and 'Effort' are inversely proportional.
The mechanical advantage of single fixed pulley is 1.
For, single movable pulley, MA = 2
Load on both the pulleys = 50 kgf

$$\therefore \text{Effort } (E_{\text{single fixed pulley}}) = \frac{\text{Load}}{MA_{\text{single fixed pulley}}}$$

$$= \frac{50}{1} = 50 \text{ kgf}$$

$$\text{Effort } (E_{\text{single movable pulley}}) = \frac{\text{Load}}{MA_{\text{single movable pulley}}}$$

$$= \frac{50}{2} = 25 \text{ kgf}$$

Therefore, the boy using a single movable pulley requires lesser effort to lift an equal load of 50 kgf when compared with the effort required by the boy using a single fixed pulley.

(ii) When a force acts on a body at rest which is free to move, the body starts moving at a constant speed in a straight path in the direction of force. This type of motion is called uniform linear or uniform translational motion.
Whereas when a body or a particle moves with a constant speed in a circular path, its motion is said to be uniform circular motion.

(iii) Nuclear fission is the process used for producing electricity using nuclear energy.

(b)

(i) Displacement due to the effort is

$VR = 4$

Load (L)= 175 kgf

Effort (E)= 50 kgf

Load displacement (d_L)=15 m

$$VR = \frac{d_E}{d_L}$$

Effort displacement $(d_E) = 4 \times d_L = 4 \times 15 = 60$ m

Distance moved by the effort is 60 m.

(ii) Work done by the effort is calculated using the following formula.

Work done by effort (W_E)= $Force_{Effort} \times d_E$

$$W_E = 50 \times 60 = 30000 \text{ J}$$

(iii) Mechanical advantage of the pulley system is calculated as

$$\text{MA of the pulley system} = \frac{\text{Load (L)}}{\text{Effort (E)}} = \frac{175}{50} = 3.5\,.$$

(iv) Efficiency of the pulley is the ratio of work output to the work input required by the system.

$$\text{Efficiency of the pulley system } (\eta) = \frac{\text{Work output (Work Done by Load)}}{\text{Work input (Work Done by Effort)}}$$

Work done by load = $Force_{Load} \times d_L = 175 \times 15 = 2625$ kgf

$$\therefore \eta = \frac{2625}{3000} = 0.875 \times 100 = 87.5\%$$

6.

(a)

(i) The outer and inner vessels of a calorimeter are highly polished to prevent the transference of heat energy by radiation.

(ii) Metal B with specific heat capacity 380 $Jkg^{-10}C^{-1}$ should be selected to make a calorimeter. By selecting this metal, the heat capacity of the calorimeter will be reduced and the amount of heat energy consumed by it from its contents to acquire their final temperature will also be negligible.

(b)

Heat enegy imparted by water

$= \text{Mass}_{\text{water}} \times \text{Specific Heat Capacity}_{\text{water}} \times (t_1 - t_2)$

$=150 \times 4.2(32-5) = 17010$ J

If 'm' gm is the amount of ice used,

then heat energy taken by ice to melt = m $\times$ Latent heat capacity of ice

$=330 \times m = 330$ m

And heat energy taken by the

melted ice to raise its temperature from 0° to $5^{\circ}C$

$= m \times 4.2 \times (5-0) = 21m$

By law of conservation of energy,

Heat energy imparted by water=heat energy taken by ice and melted ice

$17010 = 330\ m + 21m$

$17010 = 351m$

$\therefore m = 48.46$ g

Amount of ice required for this process is 48.46 gm.

(c)

(i) Infrared radiations of long wavelengths are absorbed by greenhouse gases in the Earth's atmosphere.

(ii) Radiation X is infrared radiation.

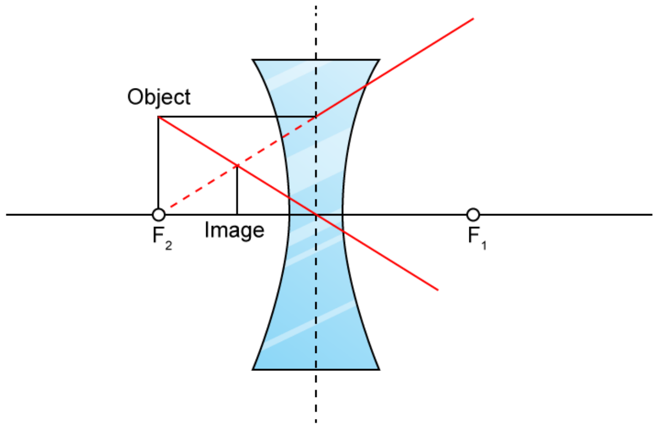
(iii) Heat liberated by a body depends on the mass of the body, the specific heat capacity of that body and the change in temperature experienced by the body.

7.

(a)

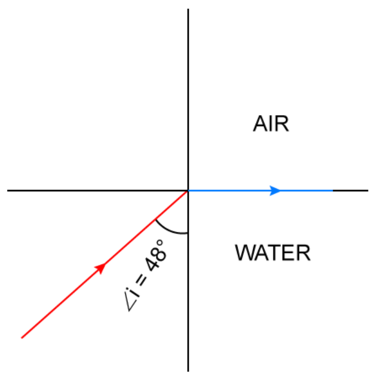
(i) The given lens is a concave lens.

(ii) Ray diagram showing image formation:



(b)

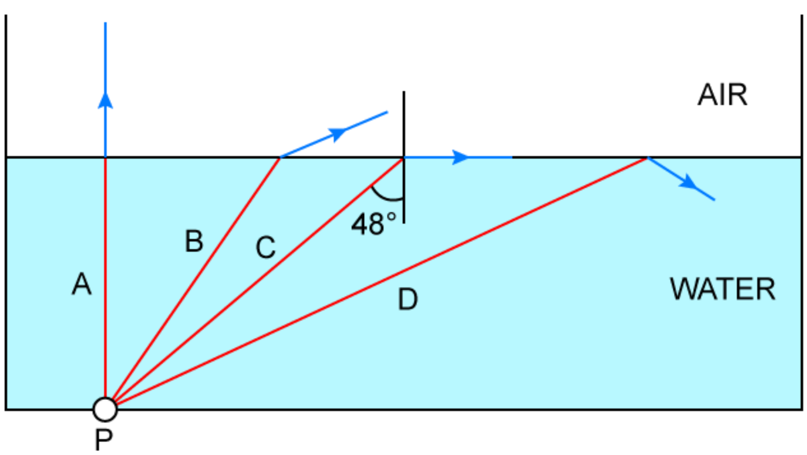
(i) The image formed by the lens is virtual and between the object and the lens. Hence, the lens used is a concave lens.



(ii) The condition for the occurrence of internal reflection in the above diagram is that the angle of incidence should be greater than the given critical angle for water, i.e. $i > 48°$.

(c)

(i) Path of the rays after striking the water surface is shown below:



(ii) Ray 'B' and ray 'D' exhibit the phenomenon of reflection and total internal reflection (TIR), respectively.

8.

(a)

(i) Amplitude
(ii) Waveform
(iii) Frequency

(b)

(i) Periodic vibrations of a body of decreasing amplitude in the presence of a resistive force are called damped vibrations.
(ii) When a slim branch of a tree is pulled and then released, it makes damped vibrations.
(iii) When the stem of a vibrating fork is pressed against the table top, the tuning fork forces the table top to vibrate with its own frequency. These forced vibrations send forth a greater energy and produce large sound. Now, if the natural frequency of the table is equal to that of the vibrating fork, resonance occurs and a louder sound is heard.

(c)

(i) Wavelength λ= 80 cm = 0.8 m
Frequency f_1 = 256 Hz
Frequency f_2 = 1024 Hz
By the relation,
Speed = Wavelength $\times$ Frequency
$\rightarrow v_1 = f_1 \times \lambda_1$
$\rightarrow v_1 = 0.8 \times 256$
Also, $v_2 = f_2 \times \lambda_2$
$\rightarrow v_2 = 1024 \times \lambda_2$
Since $v_1 = v_2$
$\rightarrow 0.8 \times 256 = 1024 \times \lambda_2$
$\lambda_2 = 0.2$ m = 20 cm

(ii)

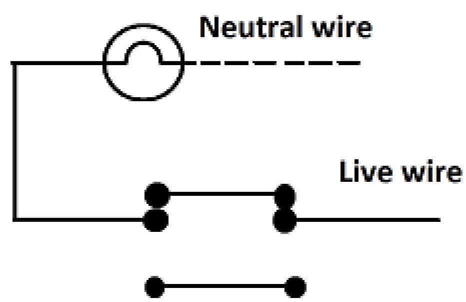
1. For first sound, f = 256 Hz and λ = 1.3 m
We know that
Speed $v = f \times \lambda = 256 \times 1.3$
$\rightarrow v = 332.8 \text{ m s}^{-1}$
Thus, the sound travels with a speed of 332.8 m s^{-1}.
2. For the second case, λ = 2.6 m and v = 332.8 m s^{-1}
$$\text{Frequency, } f = \frac{v}{\lambda} = \frac{332.8}{2.6}$$
$\rightarrow f = 128$ Hz
Frequency of the first sound is more that of the second sound.
$\therefore$The first sound will be shriller than the second sound.

9.

(a)

(i) According to the old convention of colour coding, the green wire is connected to the metallic body of an appliance. However, according to the new convention, the wire connected to the metallic body of an appliance may be either green or yellow.

(ii)



(b)

(i) Free electrons are responsible for current in conductors.

(ii) The metal case of a geyser should be connected to the Earth wire (green wire) of a cable in a power circuit.

(iii) The fuse is connected to the live wire.

(c)

(i) The prescribed limit for the maximum amount of current to be passed through the given fuse connected in live wire is 5 A, i.e. its current-carrying capacity is 5 A. Thus, if a current of more than 5 A passes through, the fuse will blow off.

(ii) For electric power, the current becomes low at a high voltage. So, according to the relation I^2RT, the loss of energy due to heating in the line wire becomes less. Thus, the alternating voltage generated is first stepped up from 11 kV to 132 kV at the generation station.

10.

(a)

(i) Electrons are charged particles.

(ii) The filament is heated by a filament connected to a low-tension battery of about 6 V.

(iii) When an electric field is produced between the two plates, the electron beam on entering the space between the plates gets deflected towards the positive plate. Because the electric field is normal to the direction of motion of electrons, electrons of the beam follow a parabolic path.

(b) Rate of emission of electrons from a metal surface depends on

(i) Nature of the metal surface: Lower the work function of the metal, greater is the rate of emission of electrons from its surface.

(ii) Temperature of the surface: Higher the temperature of the surface, greater is the rate of emission of electrons from the surface.

(iii) Surface area of the metal: Larger the surface area of the metal emitting electrons, greater is the rate of emission of electrons.

(c)

(i) Electrons revolving in the outermost orbit of an atom which are weakly held by the nucleus are called free electrons.

(ii) Free electrons cannot leave the metal surface on their own because they do not have sufficient kinetic energy.

(iii) Electron emission from the metal surface can be *(any two)*:

a. Thermionic emission – when energy is supplied as heat.
b. Photoelectric emission – when energy is supplied as energy.
c. Field emission – when energy is supplied by applying an electric field to accelerate the electrons.
d. Secondary emission – when energy is supplied from the kinetic energy of other electrons on collisions with them.