DAY THIRTY NINE

Mock Test 2

(Based on Complete Syllabus)

Instructions

1. This question paper contains of 30 Questions of Physics, divided into two Sections :
   Section A Objective Type Questions and **Section B** Numerical Type Questions.
2. Section A contains 20 Objective questions and all Questions are compulsory (**Marking Scheme** : Correct +4, Incorrect −1).
3. Section B contains 10 Numerical value questions out of which only 5 questions are to be attempted (**Marking Scheme** : Correct +4, Incorrect 0).

Section A : Objective Type Questions

1 A particle projected with velocity v_0 strikes at right angles a plane passing through the point of projection and having inclination β with the horizontal. Find the height (from horizontal plane) of the point, where the particle strikes the plane

(a) $y = \dfrac{2v_0^2}{g(4+\cot^2\beta)}$ (b) $y = \dfrac{v_0^2}{g(4+\cot^2\beta)}$

(c) $y = \dfrac{v_0^2}{(4+\cot^2\beta)}$ (d) $y = \dfrac{v_0^2}{2g(4+\cot^2\beta)}$

2 If the charge of $10\mu C$ and $-2\mu C$ are given to two plates of a capacitor, which are connected across a battery of 12 V, find the capacitance of the capacitor.

(a) 0.33 μF (b) 0.5 μF (c) 0.41 μF (d) 0.66 μF

3 A body when projected vertically up, covers a total distance s, during its time of flight. If we neglect gravity then how much distance the particle will travel during the same time. Will it fall back?

(a) s, Yes (b) s, No (c) $2s$, Yes (d) $2s$, No

4 The density of hydrogen nucleus with $Z=1$ is 2.29×10^{17} kgm^{-3}. The density of gold nucleus $Z=79$ would be

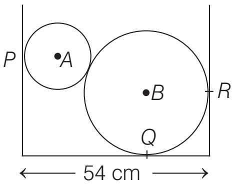
(a) $\dfrac{2.29}{79}\times10^{17}\text{kgm}^{-3}$ (b) $2.29\times79\times10^{17}\text{kgm}^{-3}$

(c) $2.29\times10^{17}\text{kgm}^{-3}$ (d) $\dfrac{2.29}{\sqrt{79}}\times10^{17}\text{kgm}^{-3}$

5 If mass of a proton is 1.007825 amu and mass of a neutron is 1.008665 amu, then mass of $_3Li^7$ nucleus approximately be

(a) 7.058075 amu (b) 7.000000 amu
(c) 7.023475 amu (d) 7.034600 amu

6 Two steel balls A and B are placed inside a right circular cylinder, of diameter 54 cm making contacts at points P, Q and R as shown in the figure. The radius $r_A = 12$ cm and $r_B = 18$ cm. The masses are $m_A = 15$ kg and $m_B = 60$ kg. The force exerted by the floor at the point Q and the wall at R are respectively (taking, $g = 10$ ms^{-2})



(a) 600 N, 150 N
(b) 750 N, 150 N
(c) 600 N, 200 N
(d) 750 N, 200 N

7 A particular piano string is supposed to vibrate at a frequency of 440 Hz. In order to check its frequency, a tuning fork known to vibrate at a frequency of 440 Hz is sounded at the same time the piano key is struck, and a beat frequency of 4 beats/s is heard. Find the possible frequencies at which the string could be vibrating.

(a) 444 Hz, 436 Hz (b) 440 Hz, 436 Hz
(c) 444 Hz, 440 Hz (d) 449 Hz, 440 Hz

8 A uniform rectangular marble slab is 3.4 m long and 2.0 m wide. It has a mass of 180 kg. If it is originally lying on the flat ground, how much work is needed to stand it on one end?

(a) 2.0 kJ (b) 3.0 J (c) 3.0 kJ (d) 3000 kJ

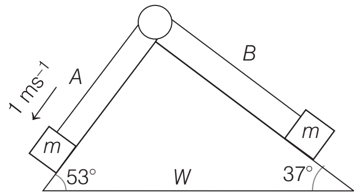
9 **Statement I** When the range of projectile is maximum, the time of flight is the largest.

Statement II Range is maximum, when angle of projection is 45°.

In the light of above statements, choose the most appropriate answer from the options given below.

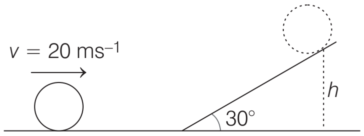
(a) Statement I is true but Statement II is false.
(b) Both Statement I and Statement II are true.
(c) Both Statement I and Statement II are false.
(d) Statement I is false but Statement II is true.

10 The two blocks as shown in the figure, have equal masses and $\mu_s = \mu_k = 0.3$ for both blocks. Wedge W is fixed and block A is given initial speed of 1 ms^{-1}, down the plane. How far will it move before coming to rest, if inclines and strings are quite long? (take, $g = 10\ ms^{-2}$)



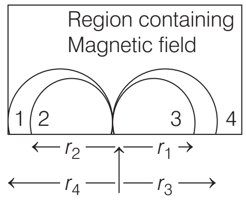
(a) 0.45 m (b) 0.9 m
(c) + 4.8 m (d) Question is irrelevant

11 As shown in figure, a uniform solid sphere rolls on a horizontal surface at 20 ms^{-1}. It then rolls up the incline shown. What will be the value of h, where the ball stops?



(a) 28.6 m (b) 8.6 m (c) 6 m (d) 18.6 m

12 A beam consisting of four types of ions a, b, c and d enters a region that contains a uniform magnetic field as shown in figure. The field is perpendicular to the plane of the paper, but its precise direction is not given. All ions in the beam travel with the same speed.



The table below gives the masses and charges of the ions

ION	MASS	CHARGE
A	$2m$	$+e$
B	$4m$	$-e$
C	$2m$	$-e$
D	m	$+e$

The ions fall at different positions 1,2,3 and 4 as shown. Correctly match the ions with respective falling positions

Column I	Column II
A	1
B	2
C	3
D	4

	A	B	C	D		A	B	C	D
(a)	4	3	2	1	(b)	1	2	3	4
(c)	4	1	2	3	(d)	3	4	1	2

13 A small conducting circular loop is placed inside a long solenoid carrying a current. The plane of the loop contains the axis of the solenoid. If the current in the solenoid is varied, the current induced in the loop is

(a) clockwise
(b) anti-clockwise
(c) zero
(d) clockwise or anti-clockwise depending on whether the current is increased or decreased

14 Two wires, each having a weight per unit length of $1.0 \times 10^{-4}\ Nm^{-1}$, are strung parallel to one another above earth's surface, one directly above the other. The wires are aligned in a North-South direction, so that earth's magnetic field will not affect them. When their distance of separation is 0.10 m, what must be the current in each in order for the lower wire to levitate the upper wire? Assume that the wires carry the same currents, travelling in opposite directions.

(a) 2.7 A (b) 0.1 A
(c) 3.5 A (d) 7.1 A

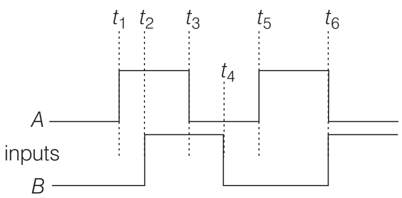
15 Calculate the minimum thickness of a soap-bubble film $(n = 1.33)$ that will result in constructive interference in the reflected light, if the film is illuminated by light with a wavelength in free space of 602 nm.

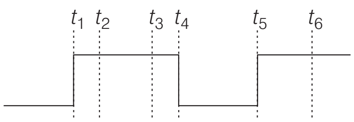
(a) 98 nm (b) 113 nm
(c) 125 nm (d) 25 nm

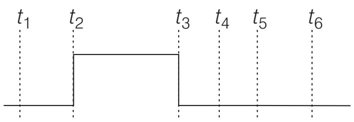
16 A ground receiver station is receiving a signal at 100 MHz, transmitted from a ground transmitter at a height of 300 m located at a distance of 100 km. Then, ($N_{max} = 10^{12}$ per m^3)

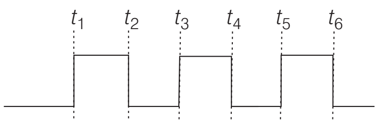
(a) signal is coming *via* space wave
(b) signal is coming *via* sky wave
(c) signal is coming *via* satellite transponder
(d) None of the above

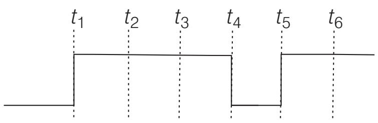
17 The output waveform (Y) of AND gate for the following inputs A and B given below is



(a)


(b)


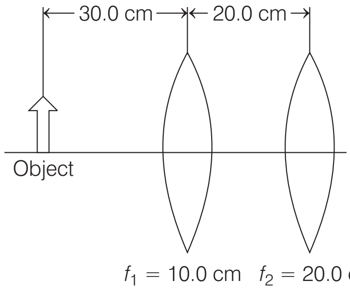
(c)


(d)


18 Satellite dishes do not have to change directions in order to stay focussed on a signal from a satellite. This means that the satellite always has to be found at the same location with respect to the surface of the earth. For this to occur, the satellite must be at a height such that its revolution period is the same as that of earth, 24 h. At what height must the satellite be so to achieve this?

(a) $\left(\frac{T^2}{4\pi^2} GM_e\right)^{1/3}$
(b) $\left(\frac{T^2}{4\pi^2} GM_e\right)$
(c) $\left(\frac{T^2}{4\pi^2} GM_e\right)^{1/2}$
(d) $\left(\frac{T}{4\pi^2} GM_e\right)^{1/3}$

19 Two converging lenses are placed 20.0 cm apart, as shown in the figure. If the first lens has a focal length of 10.0 cm and the second has a focal length of 20.0 cm, locate the final image formed of an object 30.0 cm in front of the first lens.



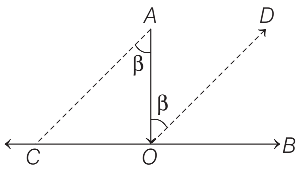
(a) 6.67 cm left
(b) 6.67 cm right
(c) 15.0 cm left
(d) 15.0 cm right

20 **Assertion** In Young's double slit experiment, the fringe width for dark fringes is same as that for white fringes.
Reason In Young's double slit experiment, when the fringes are performed with a source of white light, then only dark and bright fringes are observed.
In the light of the above statements, choose the most appropriate answer from the options given below.

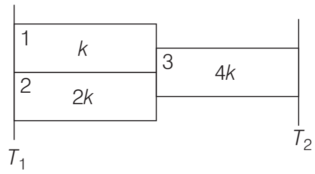
(a) Both A and R are correct and R is the correct explanation of A.
(b) Both A and R are correct but R is not the correct explanation of A.
(c) A is correct but R is not correct
(d) A is not correct but R is correct

Section B : Numerical Type Questions

21 A man can swim with a speed of 4 Kmh^{-1} in still water. How long does he take to cross a river 1 km wide, if the river flows steadily 3 Kmh^{-1} and he makes his strokes normal to the river current. How far (in m) down the river does he go when he reaches the other bank?



22 The equivalent thermal resistance of the combination of rods shown below is $\frac{xl}{12kA}$, then find the value of x, if rod has the same length l and cross-sectional area A. Thermal conductivities are mentioned in figure. Assume that there is no heat loss due to radiation or convection.



23 In J J Thomson's experiment, a potential difference of 320 V is accelerating the electron. The electron beam is entering a region having uniform magnetic field 6×10^{-5} T, acting perpendicular to it. Find the value of electric field (in Vm^{-1}) in this region, so that the electron does not experience any deflection.
(Take, $m_e = 9.1\times10^{-31}$ kg)

24 A wire of length 100 cm is connected to a cell of emf 2V and negligible internal resistance. The resistance of the wire is $3\,\Omega$. The additional resistance required to produce a potential difference of 1 mV/cm is $x\,\Omega$, then find the value of x.

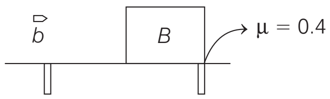
25 A 1.6 kg block on a horizontal surface is attached to a spring with a spring constant of 1.0×10^3 Nm^{-1}. The spring is compressed to a distance of 2.0 cm, and the block is released from rest. Calculate the speed (in ms^{-1}) of the block as it passes through the equilibrium position, $x = 0$, if the surface is frictionless.

26 An inductor coil joined to a 6 V battery draws a steady current of 12 A. This coil is connected to a capacitor and an AC source of rms voltage 6 V in series. If the current in the circuit is in phase with the emf, then find the rms current (in A).

27 A sledge and its rider together weight 800 N. They move down on a frictionless hill through a vertical distance of 10.0 m. Use conservation of mechanical energy to find the speed (in ms^{-1}) of the sledge at the bottom of the hill, assuming the rider pushes off with an initial speed of 5.00 ms^{-1}. Neglect air resistance,

28 Water with a mass of 2.0 kg is held at constant volume in a container while 10.0 kJ of energy is slowly added by a flame. The container is not well insulated, and as a result 2.0 kJ of energy leaks out to the surroundings. What is the temperature (in °C) increase of water?

29 A 20 g bullet is fired horizontally with a speed of 600 ms^{-1} into a 7 kg block on a table top. The bullet b lodges in the block B. If the coefficient of kinetic friction between the block and the table top is 0.4, what is the distance (in cm) the block will slide?



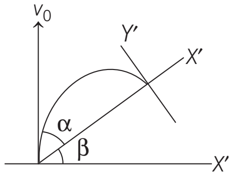
30 A uniform rope, of mass m per unit length, hangs vertically from a support, so that the lower end just touches the table top. If it is released, then at the time a length y of the rope has fallen, the force on the table is equivalent to the weight of the length $k\,y$ of the rope. Find the value of k.

ANSWERS

1. (a)	**2.** (b)	**3.** (d)	**4.** (c)	**5.** (a)	**6.** (d)	**7.** (a)	**8.** (c)	**9.** (d)	**10.** (a)
11. (a)	**12.** (c)	**13.** (c)	**14.** (d)	**15.** (b)	**16.** (c)	**17.** (b)	**18.** (a)	**19.** (a)	**20.** (c)
21. (750)	**22.** (7)	**23.** (637)	**24.** (57)	**25.** (0.5)	**26.** (12)	**27.** (14.9)	**28.** (0.96)	**29.** (37)	**30.** (3)

Hints and Explanations

1 Let α be the angle between the velocity of projection and the inclined plane



$$v_{0x'} = v_0 \cos\alpha,\ v_{0y'} = v_0 \sin\alpha$$

$$a_{x'} = -g\sin\beta,\ a_{y'} = -g\cos\beta$$

$$\Rightarrow \quad v_{x't} = v_0\cos\alpha - g\sin\beta\, t$$

At the point of impact $v_{x'} = 0$

$$\Rightarrow \quad t = \frac{v_0\cos\alpha}{g\sin\beta} \quad \ldots(i)$$

Also, y at this point is zero

$$\Rightarrow \quad v_0 \sin\alpha\, t - 1/2 g\cos\beta\, t^2 = 0$$

$$t^2 = \frac{2v_0\sin\alpha}{g\cos\beta} \quad \ldots(ii)$$

From Eqs. (i) and (ii), we get

$$\tan\alpha = \frac{\cot\beta}{2}$$

$$x = v_0\cos(\alpha+\beta)t$$

$$= \frac{v_0^2}{g}\left[\left(\frac{2}{\sqrt{4+\cot^2\beta}}\right)^2 \cot\beta - \frac{\cot\beta}{\sqrt{4+\cot^2\beta}}\cdot\frac{2}{\sqrt{4+\cot^2\beta}}\right]$$

$$= \frac{v_0^2}{g}\,\frac{2\cot\beta}{(4+\cot^2\beta)}$$

$$\therefore\ y = y\tan\beta = \frac{v_0^2}{g}\,\frac{2\cot\beta}{4+\cot^2\beta}\cdot\tan\beta$$

$$= \frac{2v_0^2}{g(4+\cot^2\beta)}$$

2 Charge of capacitor is the charge on facing surfaces of the plates of capacitor

$$Q = \left(\frac{q_1 - q_2}{2}\right) = \frac{[10 - (-2)]}{2} = 6\ \mu C$$

Potential difference across the capacitor $= 12$ V

$$\text{So,}\ C = \frac{Q}{V} = \left[\frac{(6\times10^{-6})}{12}\right] F = 0.5\ \mu F$$

3 Let particle is projected with speed **u**, so total time of flight,

$$T = \left(\frac{2u}{g}\right)$$

and $s = 2\ \times$ maximum height

$$= 2\times\frac{u^2}{2g} = \frac{u^2}{g}$$

If there is no gravity, then $s' = u \times T$

$$= \frac{2u^2}{g} = 2s$$

If gravity is not there, it will never fall back.

4 Density of every nucleus is same $= 2.29\times10^{17}$ kgm^{-3}

5 In $_3Li^7$, $Z = 3$; $N = A - Z = 7 - 3 = 4$

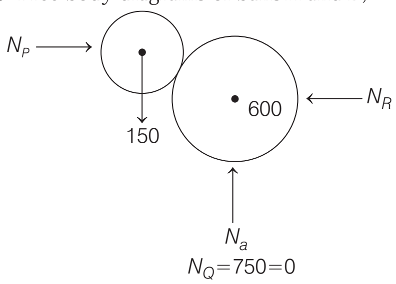
$\therefore$ Mass of nucleus $= Zm_p + (A - Z)m_n$

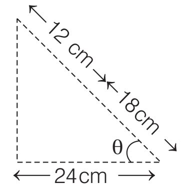
$= 3\times1.007825 + 4\times1.008665$

$= 7.058075$ amu

The actual mass of nucleus is slightly less than this calculated value.

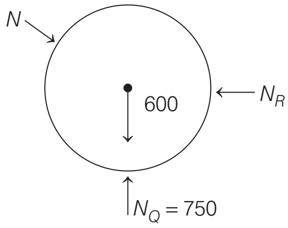
6 Free body diagrams of balls *A* and *B*,





$\cos\theta = 24/30 = 4/5$

Free body diagram of ball *B*,



$$N\sin\theta + 600 - 750 = 0$$

$$\frac{3N}{5} = 150$$

$$\Rightarrow \quad N = \frac{150\times5}{3} = 250$$

$$N\cos\theta - N_R = 0$$

$$N_R = 200\ N$$

7 The number of beats per second is equal to the difference in frequency between the two sound sources. In this case, because one of the source frequencies is 440 Hz, 4 **beats** s^{-1} would be heard, if the frequency of the string (the second source) were either 444 Hz or 436 Hz.

8 The work done by gravity is the work done, as if all the mass were concentrated at the centre of mass. The work necessary to lift the object can be thought of as the work done against gravity and is just **W = mgh**, where **h** is the height through which the centre of mass is raised.

$$W = 180\,(9.8)\,(1.7) = 3.0\ kJ$$

9 The horizontal range, $R = \dfrac{u^2\sin 2\theta}{g}$

Time of flight, $T = \dfrac{2u\sin\theta}{g}$

Range is maximum, when $\theta = 45°$

So that, $\sin 2\theta = \sin 90° = 1$

$$R_{max} = \frac{u^2}{g}$$

Time of flight is maximum when $\theta = 90°$

So that, $\sin\theta = \sin 90° = 1$

$$T_{max} = \frac{2u}{g}$$

10 Find acceleration,

$$2ma = mg\sin 53° - \mu\, mg\cos 53° - mg\sin 37° - \mu\, mg\cos 37°$$

Then, use $v^2 = u^2 + 2as$, $v = 0$,

$u = 1\ ms^{-1}$

On solving, we get $s = 0.45$ m

11 The rotational and translational kinetic energy of the ball at the bottom will be changed to gravitational potential energy, when the sphere stops. We therefore write

$$\left(\frac{Mv^2}{2} + \frac{I\omega^2}{2}\right)_{start} = (Mgh)_{end}$$

For a solid sphere, $I = \dfrac{2Mr^2}{5}$

Also, $\omega = \dfrac{v}{r}$. Then, above equation becomes

$$\frac{1}{2}Mv^2 + \frac{1}{2}\left(\frac{2}{5}Mr^2\right)\left(\frac{v}{r}\right)^2 = Mgh$$

or $$\frac{1}{2}v^2 + \frac{1}{5}v^2 = (9.8)\,h$$

Using $v = 20$ ms^{-1}, gives $h = 28.6$ m

12 A $\rightarrow$ 4, B $\rightarrow$ 1, C $\rightarrow$ 2, D $\rightarrow$ 3

$$R = mv/qB$$

$$R_B > R_A$$

and $R_A = R_C$ (in opposite sense)

and R_D is smallest.

13 The angle between magnetic field and area vector is 90°, so the flux associated with coil is zero. Although magnetic field is changing but flux is remaining constant equal to zero, so emf induced and hence, current in the loop is equal to zero.

14 If the upper wire is to float, it must be in equilibrium under the action of two forces : the force of gravity and magnetic repulsion. The weight per unit length here $1.0 \times 10^{-4}\ \mathrm{Nm^{-1}}$ must be equal and opposite the magnetic force per unit length. Because the currents are the same, we have

$$\frac{F_1}{I} = \frac{mg}{I} = \frac{\mu_0 I^2}{2\pi d}$$

$$\Rightarrow 1.0 \times 10^{-4} = \frac{(4\pi \times 10^{-7})(I^2)}{(2\pi)(0.10)}$$

We solve for the current to find

$$I = 7.1\ \mathrm{A}$$

15 Because $2nt = \frac{\lambda}{2}$, we have

$$t = \frac{\lambda}{4n} = \frac{602}{(4)(1.33)} = 113\ \mathrm{nm}$$

16 Maximum distance covered by space wave communication

$$= \sqrt{2Rh}$$

$$= \sqrt{2 \times 6.4 \times 10^6 \times 300} = 62\ \mathrm{km}$$

Since, receiver-transmitter distance is 100 km, this is ruled out for signal frequency.

Further f_c for ionospheric propagation is

$f_c = 9\,(N_{max})^{1/2} = 9 \times (10^{12})^{1/2}$

$= 9\ \mathrm{MHz}$

So, the signal of 100 MHz $(7f_c)$ comes *via* the satellite mode.

17 For $t \le t_1$; $A = 0, B = 0$; Hence $Y = 0$

For t_1 to t_2; $A = 1, B = 0$; Hence $Y = 0$

For t_2 to t_3; $A = 1, B = 1$; Hence $Y = 1$

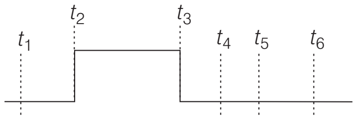
For t_3 to t_4; $A = 0, B = 1$; Hence $Y = 0$

For t_4 to t_5; $A = 0, B = 0$; Hence $Y = 0$

For t_5 to t_6; $A = 1, B = 0$; Hence $Y = 0$

For $t > t_6$; $A = 0, B = 1$; Hence $Y = 0$

Based on the above, the output waveform for AND gate can be drawn as given below.



18 The force that produces the centripetal acceleration of the satellite is the gravitational force, so

$$\therefore \quad G\frac{M_e m}{r^2} = \frac{m v^2}{r} \quad \ldots(i)$$

where, M_e is earth's mass and r is the satellite's distance from the centre of the earth.

Also, we find the speed of the satellite to be

$$v = \frac{d}{T} = \frac{2\pi r}{T} \quad \ldots(ii)$$

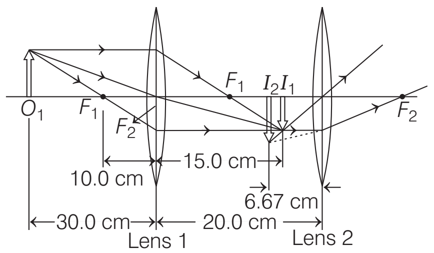
where, T is the orbital period of the satellite.

Solving Eqs. (i) and (ii) simultaneously for r yields,

$$r = \left(\frac{T^2}{4\pi^2} G M_e\right)^{1/3}$$

19 First we make ray diagrams roughly to scale to see where the image from the first lens falls and how it acts as the object for the second lens. The location of the image formed by the first lens is found *via* the thin lens equation

$$\frac{1}{30.0} + \frac{1}{v_1} = \frac{1}{10.0},\ v_1 = +\ 15.0\ \mathrm{cm}$$



The image formed by this lens becomes the object for the second lens. Thus, the object distance for the second lens is **20.0 cm − 15.0 cm = 5.00 cm**. We again apply the thin lens equation to find the location of the final image.

$$\frac{1}{5.00} + \frac{1}{v_2} = \frac{1}{20.0},\ v_2 = -6.67\ \mathrm{cm}$$

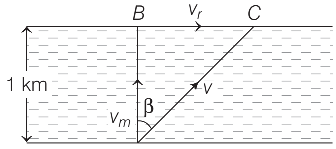
Thus, the final image is 6.67 cm to the left of the second lens.

20 In Young's double slit experiment fringe width for dark and white fringes are same while in the same experiment, when a white light as source is used, the central fringe is white around while few coloured fringes are observed on either side.

21 Given, speed of man $(v_m) = 4\ \mathrm{kmh^{-1}}$

Speed of river $(v_r) = 3\ \mathrm{kmh^{-1}}$

Width of the river $(d) = 1$ km



Time taken by the man to cross the river

$$t = \frac{\text{Width of the river}}{\text{Speed of the man}} = \frac{1\ \mathrm{km}}{4\ \mathrm{Kmh^{-1}}}$$

$$= \frac{1}{4}\ \mathrm{h} = \frac{1}{4} \times 60 = 15\ \mathrm{min}$$

Distance travelled along the river $= v_r \times t$

$$= 3 \times \frac{1}{4} = \frac{3}{4}\ \mathrm{km}$$

$$= \frac{3000}{4} = 750\ \mathrm{m}$$

22 $R_1 = \frac{l}{KA},\ R_2 = \frac{l}{2KA},\quad R_3 = \frac{l}{4KA}$

$$R_{eq} = \left(\frac{R_1 R_2}{R_1 + R_2} + R_3\right)$$

$$R_{eq} = \left[\frac{\frac{l}{KA}\cdot\frac{l}{2KA}}{\frac{l}{KA} + \frac{l}{2KA}} + \frac{l}{4KA}\right]$$

$$= \left[\frac{\frac{l^2}{2K^2A^2}}{\frac{2l + l}{2KA}} + \frac{l}{4KA}\right]$$

$$= \frac{l}{3KA} + \frac{l}{4KA} = \frac{4l + 3l}{12KA} = \frac{7l}{12KA}$$

$$= \frac{xl}{12KA} \quad \text{(given)}$$

$\therefore \quad x = 7$

(as rods 1 and 2 are in parallel and equivalent is in series with 3).

23 $E = \sqrt{\frac{2qv}{M}} \times B$

$$= \sqrt{\frac{2 \times 1.60218 \times 10^{-19} \times 320}{9.1 \times 10^{-31}}} \times 6 \times 10^{-5}$$

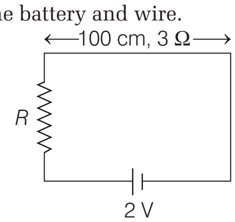
$$= \sqrt{112.680 \times 10^{12}} \times 6 \times 10^{-5}$$

$$= 10.61512 \times 10^{6} \times 6 \times 10^{-5}$$

$$= 63.69072 \times 10^{1}$$

$$= 636.9072\ \mathrm{Vm^{-1}} \approx 637\ \mathrm{Vm^{-1}}$$

24 Let a resistance R is connected in series with the battery and wire.



Voltage drop across wire

$= 1 \times 10^{-3} \times 100 = 0.1\ \mathrm{V}$

Let current in circuit is I.

$\therefore \; 0.1 = I \times 3 = 3 \times \frac{2}{R + 3} \Rightarrow R = 57\ \Omega$

25 The initial elastic potential energy of the compressed spring is

$$PE_s = \frac{1}{2} k x_i^2$$

Because the block is always at the same height above earth's surface, the gravitational potential energy of the system remains constant. Hence, the initial potential energy stored in the spring is converted to kinetic energy at $x = 0$. i.e.

$$\frac{1}{2} k x_i^2 = \frac{1}{2} m v_f^2$$

Solving for v_f gives, $v_f = \sqrt{\frac{k}{m}}\, x_i$

$$= \sqrt{\frac{1.0 \times 10^3}{1.6}} (2.0 \times 10^{-2})$$

$= 0.50\ ms^{-1}$

26 Resistance of coil $= \frac{V_{DC}}{I_{DC}} = \frac{6}{12}$

In an AC circuit, the current is in phase with emf. This means that the net reactance of the circuit is zero. The impedance is equal to the resistance, i.e. $Z = 0.5\ \Omega$

Rms current $= \frac{\text{rms voltage}}{Z}$

$$= \frac{6}{0.5} = 12\ A$$

27 The initial energy of the sledge-rider-earth system includes kinetic energy because of the initial speed

$$\frac{1}{2} m v_i^2 + m g y_i = \frac{1}{2} m v_f^2 + m g y_f$$

or $\frac{1}{2} v_i^2 + g y_i = \frac{1}{2} v_f^2 + g y_f$

If we set the origin of our coordinates at the bottom of the incline, the initial and final y-coordinates of the sledge are $y_i = 10.0$ m and $y_f = 0$.

Thus, we get

$$\frac{1}{2} v_i^2 + g y_i = \frac{1}{2} v_f^2 + 0$$

$$v_f^2 = v_i^2 + 2g y_i$$

$$= (5.00)^2 + 2\,(9.80)(10.0)$$

$$v_f = 14.9\ ms^{-1}$$

28 Recall that an isovolumetric process is one that takes place at constant volume. In such a process the work done is equal to zero because there is no change in volume. Thus, the first law of thermodynamics gives

$$\Delta U = Q$$

This indicates that the net energy Q added to the water goes into increasing the internal energy of the water. The net energy added to the water is

$$Q = 10.0 - 2.0 = 8.0\ kJ$$

Because $Q = m c\, \Delta T$, the temperature increase of the water is

$$\Delta T = \frac{Q}{m c} = \frac{8.0 \times 10^3}{(2.0)(4.186 \times 10^3)}$$

$= 0.96°C$

29 By conservation of momentum, the momentum of the block bullet system just after the interaction is $p = mv$.

where, m is the mass of bullet and v is its velocity before striking the block.

Hence, the kinetic energy of the system just after the lodging of bullet into the block is

$$K = \frac{p^2}{2(M + m)} = \frac{(mv)^2}{2(M + m)} \quad ...(i)$$

The friction force does work

$$W_f = -f_s = -\mu_k (m + M) g s \quad ...(ii)$$

in stopping the block where s is the distance traversed by block-bullet system on the table top.

From work-energy theorem,

$$\Delta K = W_f$$

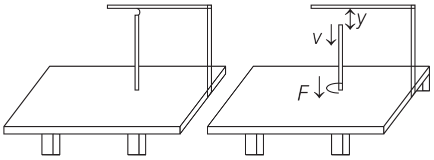
$$0 - K = -\mu_k (m + M) g s$$

Substituting values in Eqs.(i) and (ii), we get

$\therefore \quad s = 0.37$ m $= 37$ cm

Also the rest mass of photon is zero.

30 The descending part of the rope is in free fall. It has speed $v = \sqrt{2gy}$ at the instant all its points have descended a distance y. The length of the rope which lands on the table during an interval dt following this instant is $v dt$. The increment of momentum imparted to the table by this length in coming to rest is $m(v\,dt)v$. Thus, the rate at which momentum is transferred to the table is



$$\frac{dp}{dt} = m v^2 = (2\,m y)\,g$$

and this is the force arising from stopping the downward fall of the rope. Since, a length of rope y of the weight $(my)g$, already lies on the tabletop, the total force on the tabletop is $(2\,m y)g + (m y)g = (3\,m y)\,g$, or the weight of a length $3y$ of rope.

So, $\quad k = 3$