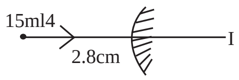
PHYSICS

61. A car is fitted with a convex side-view mirror of focal length 20 cm. A second car 2.8m behind the first car is overtaking the first car at a relative speed of 15m/s. The speed of the image of the second car as seen in the mirror of the first one is
1) 10 m/s   2) 15 m/s
3) 1/10 m/s   4) 1/15 m/s

Sol: convex f = 20cm



$$\frac{1}{u}+\frac{1}{v}=\frac{1}{f}\Rightarrow -\frac{1}{u^2}\cdot\frac{du}{dt}-\frac{1}{v^2}\left(\frac{dv}{dt}\right)=0$$

$$\frac{dv}{dt}=-\left(\frac{v^2}{u^2}\right)\frac{du}{dt}$$

$$=-\left(\frac{u}{f}-1\right)^{-2}\frac{du}{dt}\qquad =-\frac{1}{15^2}\times 15$$ **Ans : 4**

62. The half life of a radioactive substance is 20 minutes. The approximate time interval $(t_2 - t_1)$ between the time t_2 when 2/3 of it has decayed and time t_1 when 1/3 of it had decayed is
1) 20 min   2) 28 min
3) 7 min   4) 14 min

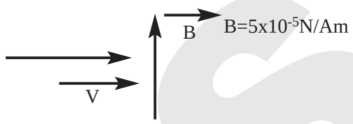
Sol: $T_{1/2}=20\,\text{min}\; N=\frac{N_0}{2^n}\Rightarrow\frac{N}{N_0}=\frac{1}{2^n}=\frac{2}{3}$

$\frac{N^1}{N}=\frac{1}{2^n}=\frac{1}{3}$ The substance has decayed by half $\Rightarrow \Delta t = T_{1/2} = 20$ min

Ans : 1

63. A boat is moving due east in a region where the earth's magnetic field is 5.0×10^{-5} NA^{-1} due north and horizo-ntal. The boat carries a vertical aerial 2m long. If the speed of the boat is 1.50 ms^{-1}, the magnitude of the induced emf in the wire of aerial is
1) 0.50 mV   2) 0.15 mV
3) 1 mV   4) 0.75 mV

Sol:



1 = 2m $\Rightarrow \varepsilon = Blv =$
$5\times10^{-5}\times 2\times 1.5$
$= 15\times10^{-5} = 0.15$ mV **Ans : 2**

64. The transverse displacement y(x, t) of a wave on a string is given by

$$y(x,t)=e^{-\left(ax^2+bt^2+2\sqrt{ab}xt\right)}.$$

This represents a:
1) Standing wave of frequency $\sqrt{b}$
2) Standing wave of frequency $1/\sqrt{b}$
3) Wave moving in + x direction with speed $\sqrt{\frac{a}{b}}$
4) Wave moving in –x direction with

Sol: $y=e^{-}\left(\sqrt{a}x+\sqrt{bt}\right)^2=f\,(x+vt)$

$v=\sqrt{b/a}$ and -ve x direction. **Ans:4**

65. A water fountain on the ground sprinkles water all around it. If the speed of water coming out of the fountain is υ, the total area around the fountain that gets wet is
1) $\frac{\pi}{2}\frac{\upsilon^4}{g^2}$ 2) $\pi\frac{\upsilon^2}{g^2}$
3) $\pi\frac{\upsilon^2}{g}$ 4) $\pi\frac{\upsilon^4}{g^2}$

Sol: $R_{max}=\frac{u^2}{g}\Rightarrow$ and $A=\pi R^2_{max}=\frac{\pi v^4}{g^2}$

Ans:4

66. Two particles are executing simple harmonic motion of the same amplitude A and frequency ω along the x-axis. Their mean position is separated by distance $x_0(x_0>A)$. If the maximum separation between them is (X_0+A), the phase difference between their motion is
1) π/4   2) π/6   3) π/2   4) π/3

Ans : 3

67. This question has Statement-1 and Statement-2. Of the four choices given after the statements, choose the one that best describes the two statements.

Statement-1

A metallic surface is irradiated by a monochromatic light of frequency $\nu > \nu_0$ (the threshold frequency). The maximum kinetic energy and the stopping potential are K_{max} and V_0 respectively. If the frequency incident on the surface is doubled, both the K_{max} and V_0 are also doubled.

Statement-2

The maximum kinetic energy and the stopping potential of photoelectrons emitted from a surface are linearly dependent on the frequency of incident light
1) Statement-1 is true, Statement-2 is true, Statement-2 is not the cor-rect explanation of Statement-1.
2) Statement-1 is false, Statement-2 is true.
3) Statement-1 is true, Statement-2 is false
4) Statement-1 is true, Statement-2 is true, Statement-2 is the correct explanation of Statement-1.

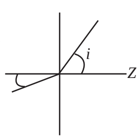
Sol: $\upsilon > \upsilon_0$
$h\upsilon = k_{max} + \phi$
$2h\upsilon = k^1_{max} + \phi \Rightarrow k^1_{max} > 2k_{max}$
$k_{max} = eV_0$
Statements 1 is incorrect
Statements 2 is correct

Ans : 2

68. Let the x-z plane be the boundary between two transparent media. Medium 1 in z≥0 has a refractive index of $\sqrt{2}$ and medium 2 with z<0 has a refractive index of $\sqrt{3}$. A ray of light in medium 1 given by the vector $\vec{A}=6\sqrt{3}\hat{i}+8\sqrt{3}\hat{j}-10\hat{k}$ is incident on the plane of separation. The angle o refraction in medium 2 is
1) 60°   2) 75°   3) 30°   4) 45°

Sol:

$\mu_1=\sqrt{3}$ $\mu_2=\sqrt{2}$



$\vec{A}=6\sqrt{3}\hat{i}+8\sqrt{3}\hat{j}-10\hat{k}$

angle made by the incident ray with z axis

$$\cos i=\frac{\vec{A}\cdot(-\hat{k})}{|\vec{A}|}=\frac{10}{\sqrt{36\times3+64\times3+100}}=\frac{10}{20}$$

$\therefore$ i = 60°
$\sqrt{2}$.sin 60 = $\sqrt{3}$.sin r

$$\sqrt{2}\cdot\frac{\sqrt{3}}{2}=\sqrt{3}.\sin r\Rightarrow r=45°$$

Ans: 4

69. A carnot engine operating between temperatures T_1 and T_2 has efficiency 1/6. When T_2 is lowered by 62K, its efficiency increases to 1/3. Then T_1 adn T_2 are, respectively:
1) 330 K and 268 K
2) 310 K and 248 K
3) 372 K and 310 K
4) 372 K and 330 K

Sol: $1-\frac{T_2}{T_1}=\frac{1}{6}\qquad \frac{T_2}{T_1}=\frac{5}{6}$

$$1-\left(\frac{T_2-62}{T_1}\right)=\frac{1}{3}$$

$$1-\frac{T_2}{T_1}+\frac{62}{T_1}=\frac{1}{3}\Rightarrow\frac{1}{6}+\frac{62}{T_1}=\frac{1}{3}$$

$$\Rightarrow\frac{62}{T_1}=\frac{1}{6}\Rightarrow T_1=62\times6=372k$$

$T_2 = 62\times5 = 310$K

Ans: 3

70. Energy required for the electron excitation in Li^{++} from the first to the third-Bohr orbit is
1) 108.8eV   2) 122.4 eV
3) 12.1 eV   4) 36.3 eV

Sol: $\Delta E=13.6\times3^2\left[1-\frac{1}{3^2}\right]$

= 13.6[9–1]=13.6×8
=108.8 eV

Ans : 1

71. A resistor 'R' and 2μF capacitor in series is connected through a switch to 200V direct supply. Across the capacitor is a neon bulb that lights up at 120 V. Calculate the value of R to make the bulb light up 5s after the switch has been closed. $(\log_{10}2.5 = 0.4)$
1) $2.7\times10^6\Omega$ 2) $3.3\times10^7\Omega$
3) $1.3\times10^4\Omega$ 4) $1.7\times10^5\Omega$

Sol: q = 120 × 2 = 240μC
q_0 = 400μC, $q = q_0\,(1-e^{-t/\tau})$
$40 = 400\,(1-e^{-t/\tau})$

$$\frac{6}{10}=\frac{3}{5}=\left(1-e^{-t/\tau}\right)\qquad 1-\frac{3}{5}=e^{-t/\tau}$$

$$\frac{2}{5}=e^{-t/\tau}\Rightarrow l\mu\left(\frac{5}{2}\right)=\frac{t}{\tau}$$

t = τ × $l\mu$(2.5) =

$$RC^{RC}=\frac{5}{l\mu\,(2.5)}=\frac{5}{\log\,(2.5)}\times\log e$$

$$R=\frac{2.5\times\log e}{\log\,(2.5)}=\frac{5}{\log\,(2.5)}\times\log e$$

$$\frac{2.5\times0.43}{0.4}\times10^6\approx2.7\times10^6$$ **Ans :1**

72. A thermal insulated vessel contains an ideal gas of molecular mass M and ratio of specific

heats γ. It is moving with speed υ and is suddenly brought to rest. Assuming no heat is lost to the surroundings, its temperature increases by

1) $\frac{\gamma M\upsilon^2}{2R}K$ 2) $\frac{(\gamma-1)}{2R}M\upsilon^2$

3) $\frac{(\gamma-1)}{2(\gamma+1)R}M\upsilon^2K$ 4) $\frac{(\gamma-1)}{2\gamma R}M\upsilon^2K$

Sol: $\frac{C_p}{C_v}=v$

$\frac{1}{2}(n\times N_0M)\upsilon^2 = nC_v\Delta T$

$\Rightarrow \Delta T = \frac{N_0M\upsilon^2}{2C_v} - \frac{N_0M\upsilon^2}{2\left(\frac{R}{r-1}\right)}$ **Ans: 2**

73. Work done in increasing the size of a soap bubble from a radius of 3cm to 5cm is nearly (Surface tension of soap solution = $0.03Nm^{-1}$):

1)2π mJ 2)0.4π mJ 3)4πmJ 4)0.2πmJ

Sol: Surface energy : $8\pi r^2T$

$W=\Delta V_s=8\pi T(6^2-9^2)=8 \times \pi 0.03(25-9)\times 10^{-2} \approx 0.4\pi mJ$ **Ans : 2**

74. A fully charged capacitor C with initial q_0 is connected to a coil of self inductance L at t = 0. The time at which the energy is stored equally between the electric and the magnetic field is

1) $2\pi\sqrt{LC}$ 2) $\sqrt{LC}$

3) $\pi\sqrt{LC}$ 4) $\frac{\pi}{4}\sqrt{LC}$

Sol: $U_E=\frac{q^2}{2C},\ U_L=\frac{1}{2}LI^2,$

$U_E=U_L \Rightarrow \frac{q^2}{2C}=\frac{1}{2}\frac{q_0^2}{2C} \Rightarrow q=\frac{q_0}{\sqrt{2}}$

$\therefore \omega t\frac{\pi}{4} \Rightarrow t=\frac{\pi}{4\omega}=\frac{\pi}{4}\sqrt{LC}$ **Ans:4**

75. **Direction:** The question has a parag-raph followed by two statements, **statement-1** and **statement-2** of the given four alternatives after the statement, choose the one that describes the statements.

A thin air film is formed by putting the convex surface of a plate. With monochromatic light, this film gives an interference pattern due to light reflected from the top (convex) surface and the bottom (glass plate) surface of the film.

Statement-1: When light reflects from the air-glass plate interface, the reflected wave suffers a phase change of π.

Statement-2: The centre of the interference pattern is dark.

1) Statement-1 is true, statement-2 is true and statement-2 is not the co-rrect explanation of statement-1
2) statement-1 is false, statement-2 is false
3) statement-1 is true, statement-2 is false
4) statement-1 is true, statement-2 is true and statement-2 is the correct explanation of statement-1

Sol: statement: 1 is true

(∴ rarer to denser propatation)

statement : 2 is true

at the centre Δx = 0, ⇒ Δϕ = π

Ans: 4

76. A screw gauge gives following reading when used to measure the diameter of a wire. Main scale reading: 0mm.

Circular scale reading: 52 divisions

Given that 1 mm on main scale corresponds to 100 divisions of the circular scale

The diameter of wire from the above data is

1) 0.26 cm 2) 0.005 cm
3) 0.52 cm 4) 0.052 cm

Sol: Reading

$=0+52\times\frac{1}{100}mm=0.52mm=0.052cm$

Ans: 4

77. Three perfect gases at absolute temparatures T_1, T_2 and T_3 are mixed. The masses of molecules are m_1, m_2 and m_3 and the number of molecules are n_1, n_2 and n_3 respectively. Assuming no loss of energy, the final temparature of the mixture is

1) $\frac{n_1T_1^2+n_2T_2^2+n_3T_3^2}{n_1T_1+n_2T_2+n_3T_3}$

2) $\frac{n_1^2T_1^2+n_2^2T_2^2+n_3^2T_3^2}{n_1T_1+n_2T_2+n_3T_3}$

3) $\frac{(T_1+T_2+T_3)}{3}$ 4) $\frac{n_1T_1+n_2T_2+n_3T_3}{n_1+n_2+n_3}$

Sol: $n_1C_{v_1}T_1+n_2C_{v_2}T_2+n_3C_{v_3}T_3 = (n_1+n_2+n_3)C_{v_{mix}}.T$ **Ans:** 4

78. The electrostatic potential inside a charged spherical ball is given by $\phi = ar^2 + b$ where r is the distance from the centre; a, b are constants. Then the charge density inside the ball is

1) $-24\pi a\varepsilon_0$ 2) $-6a\varepsilon_0$
3) $-24\pi a\varepsilon_0 r$ 4) $-6a\varepsilon_0 r$

Sol: $\phi = ar^2 + b$

$E=\frac{-\partial\phi}{dr}=-2ar$ $\oint \vec{E}.\vec{ds}=\frac{q_{in}}{\epsilon_0}$

$-2ar\times 4\pi r^2=\int\frac{f\,4\pi r^2dr}{\epsilon_0}$

$=-2ar^3\in_0=\int fr^2dr$

$=-6ar^3\in_0=sr^2 \Rightarrow f=-6a\epsilon_0$ **Ans:** 2

79. The question has **Statement-1** and **Statement-2** of the four choices giv-en after the Statements, choose the one that best describes the statements.

Statement-1: Sky wave signals are used for long distance radio commu-nication. These signals are in general, less stable than ground wave signals.

Statement-2: The state of ionosphere varies from hour to hour, day to day and season to season.

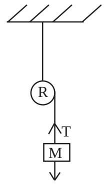
1) Statement-1 is true,Statement-2 is true and Statement-2 is **not** the co-rrect explanation of Statement-1
2) Statement-1 is false, Statement-2 is true.
3) Statement-1 is true, Statement-2 is false
4) Statement-1 is true, Statement-2 is true and Statement-2 is the co-rrect explanation of Statement-1.

Ans:4

80. A mass m hangs with the help of a string wrapped around a pulley on frictionless bearing. The pulley has mass m and radius R. Assuming pul-ley to be a perfect uniform circular disc. the acceleration of the mass m, if the string not slip on the pulley, is

1) 2/3g 2) g/3 3) 3/2 g 4) g

Sol:



$F_{Net}=ma,\ Mg-T=Ma$ ....(1)

$T_{net}=I\propto \quad TR=\frac{MR^2}{2}\frac{a}{R}$

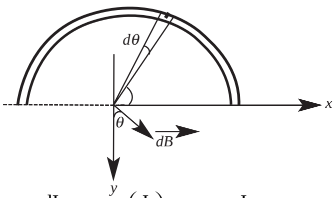
$\Rightarrow T=\frac{Ma}{2}$............(2)

Solving 1 and 2 ⇒ a = 2g/3 **Ans: 1**

81. A current I flows in a infinitely long wire with cross section in the form of a semicircular ring of radius R.The magnitude of the magnetic induction along its axis is

1) $\frac{\mu_0I}{2\pi R}$ 2) $\frac{\mu_0I}{4\pi R}$
3) $\frac{\mu_0I}{\pi^2R}$ 4) $\frac{\mu_0I}{2\pi^2R}$

Sol: $dI=\frac{I}{\pi R}.R\,d\theta=\frac{I}{\pi}d\theta$



$dB=\frac{\mu_0dI}{2\pi R}=\frac{\mu_0}{2\pi R}\cdot\left(\frac{I}{\pi}\right)d\theta=\frac{\mu_0I}{2\pi^2R}.d\theta$

$dB_y=dB\,Cos=\frac{\mu_0I}{2\pi^2R}.Cos\theta.d\theta,$

$dB_x=\frac{\mu_0I}{2\pi^2R}\sin\theta.d\theta$

$B_y=2\int_{\theta}^{\pi}\left(\frac{\mu_0I}{2\pi^2R}\right)Cos\theta.d\theta=zero$

$B_x=\int dB_x=2\frac{\mu_0I}{2\pi^2R}\int_0^{\pi/2}\sin\theta.d\theta=$

$\left(\frac{\mu_0I}{2\pi^2R}\right)\times 2\times(\cos\theta)\int_0^{\pi/2}=\frac{\mu_0I}{\pi^2R}$

$B=\sqrt{Bx^2+By^2}=\frac{\mu_0I}{\pi^2R}$ **Ans: 3**

82. If a wire is streched to make it 0.1% longer, its resistance will:

1) decrease by 0.2%
2) decrease by 0.05%
3) increase by 0.05%
4) increase by 0.2 %

Sol: $R=\frac{lL}{A}=\frac{lL^2}{v}$ where v is the volume of wire

$R\propto L^2 \quad \frac{\Delta R}{R}=2\frac{\Delta L}{L}$

⇒ % change in resistance of wire = 2 (% change in L)

= 2 (0.1 %), = + 0.2 % **Ans: 4**

83. A thin horizontal circular disc is rotating about a vertical axis passing through its centre. An insect is at rest at a point near the rim of the disc. The insect now moves along a diameter of the disc to reach its other end. During the journey of the insect, the angular

speed of the disc?

1) Continuously increase
2) first increase and then decrease
3) remains unchanged
4) continuously decrease

Sol: Since there is no external torque acting on system, angular momentum of the system is constant. As the insect moves from A to B, moment of inertia of system first decreases then increases. Since $\omega = L/I$, ω first increases then decreases. **Ans: 2**

84. 100g of water is heated from 30°C to 50°C Ignoring the slight expansion of the water, the change in its internal energy is (specific heat of water is 418 J/Kg/K)

1) 84 kj 2) 2.1 kJ 3) 4.2 kj 4) 8.4 kJ

Sol. M = 0.1 kg

$d\theta = 2\theta$, $du = MCd\theta$

= 0.1 (4184) (20), = 8368 J

= 8.4 KJ **Ans: 4**

85. An object, moving with a speed of 6.25 m/s, is decelerated at a rate give-n by $dv/dt = -2.5\sqrt{v}$. Where v is the in-stantaneous speed. The time taken by the object, to come to rest, would be

1) 4s 2) 8s 3) 1s 4) 2s

Sol: u = 6.25ms–1

$$\frac{dv}{dt} = -2.5\sqrt{V} \qquad \int \frac{du}{\sqrt{V}} = -2.5\int dt$$

$$2\left[V^{\frac{1}{2}}\right]_{v=6.25}^{0} = -2.5[t]_{t=0}^{t=T}$$

2[0–2.5]= –2.5 [T], T = 2 sec **Ans: 4**

86. Water is flowing continuously from a tap having an internal diameter 8×10^{-3}m. The water velocity as it leaves the tap is 0.4 ms–1. The diameter of the water stream at a distance 2×10^{-3}m below the tap is close to

1) 9.6×10^{-3}m 2) 3.6×10^{-3}m
3) 5.0×10^{-3}m 4) 7.5×10^{-3}m

Sol: $r_1 = 8 \times 10^{-3}$ m

$v_1 = 0.4\ ms^{-1}$, h = 0.2 m

$$l g h + \frac{1}{2} l v_1^2 = \frac{1}{2} l V_2^2$$

$$V_2^2 = V_1^2 + 2gh = 4.16$$

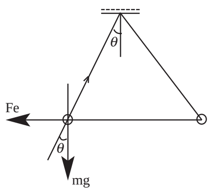
from principle of continuity $A_1V_1 = A_2V_2$

$$r_1^2 v_1 = r_2^2 v_2 \qquad \frac{r_1\sqrt{V_1}}{\sqrt{V_2}} = r_2$$

$\Rightarrow r_2 = 3.6 \times 10^{-3}$ m **Ans: 2**

87. Two identical charged spheres suspended from a common point by two massless strings of length l are initially a distance d ($d<<l$) apart because of their mutual repulsion. The charge begins to leak from both the spheres at a constant rate. As a result the charges approach each other with a velocity u. Then as a function of distance x between them,

1) $v \propto x^{1/2}$ 2) $v \propto x$
3) $v \propto x^{-1/2}$ 4) $v \propto x^{-}$



Sol: $T\cos\theta = m g$, $T\sin\theta = Fe$

$\tan\theta = Fe/mg \Rightarrow Fe = mg\tan\theta$

$$\frac{kq^2}{x^2} = mg = \frac{x\,x/2}{l}$$

$\therefore q^2 \propto x^3$

$$-\left(\frac{dq}{dt}\right)2q \propto 3x^2\left(-\frac{dx}{dt}\right)$$

$$V \propto \left(-\frac{dq}{dt}\right)\frac{q}{x^2} \propto x^{3/2-2} \propto x^{-1/2}$$

Ans: 3

88. A mass M, attached to a horizontal spring, excutes S.H.M. with amplitude A_1. When the mass M passes through its mean position then a smaller mass m is placed over it and both of them move together with amplitude A_2. The ratio of (A_1/A_2) is

1) $\left(\frac{M}{M+m}\right)^{\frac{1}{2}}$ 2) $\left(\frac{M+m}{M}\right)^{\frac{1}{2}}$

3) $\frac{M}{M+m}$ 4) $\frac{M+m}{M}$

Sol: $\omega = \sqrt{\frac{K}{M}} \qquad \frac{\omega_1}{\omega_2} = \sqrt{\frac{m+M}{M}}$

$P_1 = P_2$, $M_1A_1W_1 = M_2A_2W_2$

$$\frac{A_1}{A_2} = \frac{M+m}{M}\sqrt{\frac{M}{M+m}} = \sqrt{\frac{M+m}{M}}$$

Ans: 2

89. Two bodes of masses m and 4m are placed at a distance r. The gravitational potential at a point on the line joining them where the gravitational field is zero is

1) $-\frac{6Gm}{r}$ 2) $-\frac{9Gm}{r}$

3) zero 4) $-\frac{4Gm}{r}$

Sol: $\frac{Gm}{x^2} = \frac{G(4m)}{(r-x)^2} \qquad \frac{1}{x} = \frac{2}{r-x}$

x = r/3

$$v_{net\,at\,p} = \frac{-Gm}{r/3} - \frac{G(4m)}{2r/3}$$

= – 9Gm/r **Ans: 2**

90. A pulley of radius 2m is rotated about its axis by a force $F = (20t - 5t^2)$ newton (where t is measured in seconds) applied tangentially. If the moment of inertia of the pulley about its axis of rotation is 10 kg m_2, the number of rotations made by the pulley before its direction of motion if reversed, is

1) more than 6 but less than 9
2) more than 9 3) less than 3
4) more than 3 but less than 6

Sol: Direction of motion is reversed ⇒ the pulley comes to momentary rest

$\tau = FR = (20t - 5t^2) \times 2 = I\alpha$

$$t\alpha = \frac{(20t - 5t^2)}{5} = \frac{dw}{dt} \qquad \int_{t=0}^{t^2}(4t - t^2)dt = \int_0^w dw$$

$$w = \frac{4t^2}{2} - \frac{t^3}{3}$$ When it comes to rest

w = 0, ⇒ t = 0 & t = 6s

$$\frac{d\theta}{dt} = 2t^2 - \frac{t^3}{3}s \qquad \theta = 2\frac{t^3}{3} - \frac{1}{12}t^4$$

$$= 2\times6^2\times2 - \frac{1}{12}\times6^2\times6\times6^3$$

$= 6^2 (4–3)= 6^2 = 36$

$$= \frac{36}{2\times3.14}$$ revolutions =

11.46/2 revolution = 5.73 **Ans: 4**