Resonance®
Educating for better tomorrow

JEE (MAIN) 2024

QUESTIONS & SOLUTIONS

SHIFT-1

DATE & DAY: 01st February 2024 & Thursday

PAPER-1

Duration: 3 Hrs.
Time: 09:00 - 12:00 IST

SUBJECT: PHYSICS

REGISTERED & CORPORATE OFFICE (CIN: U80302RJ2007PLC024029):
CG Tower, A-46 & 52, IPIA, Near City Mall, Jhalawar Road, Kota (Rajasthan) - 324005
0744-2777777 | 73400 10345 | contact@resonance.ac.in | www.resonance.ac.in | Follow Us: @ResonanceEdu | @Resonance_Edu

PART : PHYSICS

1. With rise in temperature, the Young's modulus of elasticity :

(1) changes erratically (2) decreases

(3) increases (4) remains unchanged

Ans. (1)

Sol. Conceptual Base

2. If R is the radius of the earth and the acceleration due to gravity on the surface of earth is $g = \pi^2 m/s^2$, then the length of the second's pendulum at a height h = 2R from the surface of earth will be. :

(1) $\frac{2}{9}$ m (2) $\frac{1}{9}$ m (3) $\frac{4}{9}$ (4) $\frac{8}{9}$ m

Ans (4)

Sol. $T = 2\pi\sqrt{\frac{\ell}{g}}$

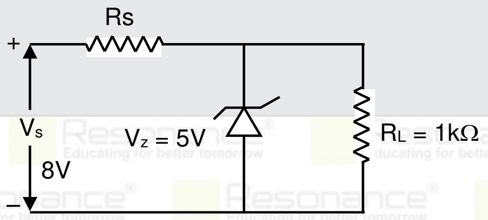
$g = \frac{GM}{R^2}$

$g' = \frac{GM}{(R+2R)^2} = \frac{g}{9}$

$T = 2\pi\sqrt{\frac{\ell}{g}} \Rightarrow 2 = 2\pi\sqrt{\frac{\ell}{g/9}} \Rightarrow \frac{1}{\pi^2} = \frac{9\ell}{g}$

$\ell = \frac{1}{9}$ meter

3. In the given circuit if the power rating of Zener diode is 10mW, the value of series resistance R_s to

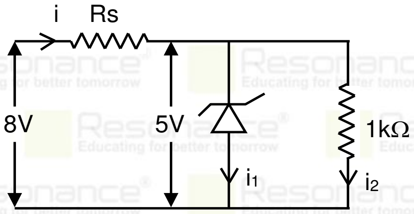


(1) 5 kΩ (2) 10 Ω (3) 1 kΩ (4) 10 kΩ

NTA Ans. (2)

Reso Ans. (Bonus)

Sol.



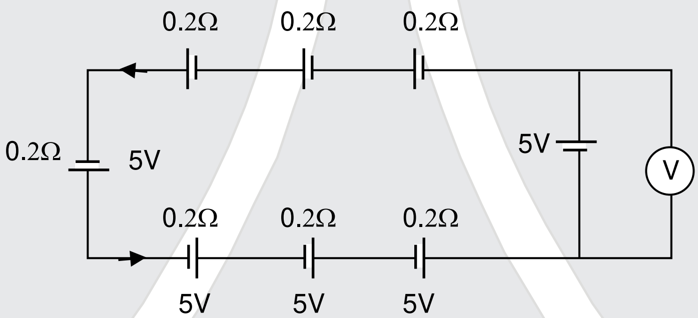
$i = i_1 + i_2 = \frac{P_1}{V_1} + \frac{V_2}{1k\Omega}$

$i = 5mA + 2mA = 7\ mA$

$\therefore\ Rs = \frac{8-5}{7}\times 10^3 = \frac{3}{7}\times 10^3\Omega$

nearest answer = 1 kΩ

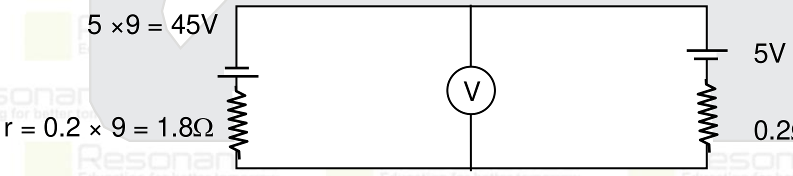
4. The reading in the ideal voltmeter (V) shown in the given circuit diagram is :



(1) 5V (2) 10V (3) 0V (4) 3V

Ans. **(3)**

Sol.



$V = \frac{E_2 r_1 - E_1 r_2}{r_1 + r_2}$

$V = \frac{5\times 1.8 - 45\times 0.2}{1.8+0.2}$

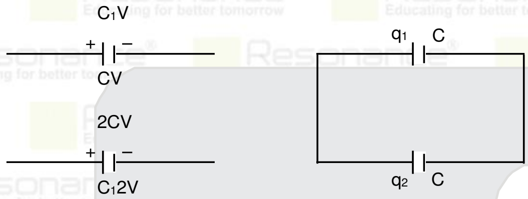
V= 0

5. Two identical capacitors have same capacitance C. One of them is charged to the potential V and other to the potential 2V. The negative ends of both are connected together. When the positive ends are also joined together, the decrease in energy of the combined system is :

(1) $\frac{1}{4}CV^2$ (2) $2\ CV^2$ (3) $\frac{1}{2}CV^2$ (4) $\frac{3}{4}CV^2$

Ans. (1)

Sol.



$$\frac{q_1}{c} = \frac{q_2}{c} \Rightarrow q_1 = q_2 = \frac{CV + 2CV}{2} = \frac{3}{2}CV$$

Energy loss $\Delta E = \frac{\Delta q_1^2}{2C} + \frac{\Delta q_2^2}{2C}$

$$\Delta E = \frac{\left(CV - \frac{3}{2}Cv\right)^2}{2C} + \frac{\left(2CV - \frac{3}{2}Cv\right)^2}{2C}$$

$$\Delta E = \frac{1}{8}CV^2 + \frac{1}{8}Cv^2$$

$$\Delta E = \frac{1}{4}CV^2$$

6. Two moles a monoatomic gas is mixed with six moles of a diatomic gas. The molar specific heat of the mixture at constant volume is :

(1) $\frac{9}{4}R$ (2) $\frac{7}{4}R$ (3) $\frac{3}{2}R$ (4) $\frac{5}{2}R$

Ans. (1)

Sol. $C_{v\ mix} = C_{V_{mix}} = \frac{n_1C_{V_1} + n_2C_{V_2}}{n_1 + n_2}$

$n_1 = 2,\ C_{v1} = \frac{3R}{2}$ (monoatomic)

$n_2 = 6,\ C_{v2} = \frac{5R}{2}$ (Diatomic)

$$\mathbf{C_{v\ mix}} = \frac{2\times\frac{3R}{2} + 6\times\frac{5R}{2}}{8} = \frac{3R + 15R}{8} = \frac{18R}{8} = \frac{9}{4}R$$

7. A ball of mass 0.5 kg is attached to string of length 50 cm. The ball is rotated on a horizontal circular path about its vertical axis. The maximum tension that the string can bear is 400 N. The maximum possible value of angular velocity of the ball in rad/s is :

(1) 1600 (2) 40 (3) 1000 (4) 20

Ans. **(2)**

Sol. $T = mg\cos\theta + m\omega^2 r$

$T_{max} = mg + m\omega^2 r$

$\omega = \sqrt{\dfrac{400-5}{0.5\times 50\times 10^{-2}}} = 40$

8. A parallel plate capacitor has a capacitance C = 200pF. It is connected to 230V ac supply with an angular frequency 300 rad/s. The rms value of conduction current in the circuit and displacement current in the capacitor respectively are :

(1) 1.38 μA and 1.38 μA (2) 14.3 μA and 143 μA

(3) 13.8 μA and 138 μA (4) 13.8 μA and 13.8 μA

Ans. **(4)**

Sol. $i = \dfrac{V}{X_C}$

$= \omega CV$

$= 200 \times 10^{-12} \times 230 \times 300$

$= 13.6 \times 10^{-6}$ A

9. The pressure and volume of an ideal gas are related as $PV^{\frac{3}{2}} = K$ (Constant). The work done when the gas is taken from state A (P_1, V_1, T_1) to state B (P_2, V_2, T_2) is :

(1) $2(P_1V_1 - P_2V_2)$ (2) $2(P_2V_2 - P_1V_1)$

(3) $2(\sqrt{P_1}V_1 - \sqrt{P_2}V_2)$ (4) $2(P_2\sqrt{V_2} - P_1\sqrt{V_1})$

NTA Ans. (1)

Reso Ans. (1) and (2)

Sol. $PV^{\frac{3}{2}} = c$

Work done $= \dfrac{P_2V_2 - P_1V_1}{1-x} = \dfrac{P_2V_2 - P_1V_1}{1-\frac{3}{2}} = 2(P_1V_1 - P_2V_2)$ [Work done by gas]

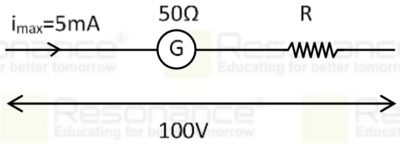
If work done by external $= 2(P_2V_2 - P_1V_1)$

10. A galvanometer has a resistance of 50Ω and it allows maximum current of 5mA. It can be converted into voltmeter to measure upto 100V by connecting in series a resistor of resistance.

(1) 5975 Ω (2) 20050Ω (3) 19950Ω (4) 19500Ω

Ans. **(3)**

Sol.



i_{max} (R+50) =100

5×10^{-3} (R + 50) = 100

R + 50 = 20 × 1000

R = 19950 Ω

11. The de Broglie wavelengths of a proton and an α particle are λ and 2λ respectively. The ratio of the velocities of proton and α particle will be :

(1) 1 : 8 (2) 1 : 2 (3) 4 : 1 (4) 8 : 1

Ans. **(4)**

Sol. $\lambda = \frac{h}{p}$

$p = \frac{h}{\lambda}$

$\Rightarrow mv = \frac{h}{\lambda}$

$\Rightarrow v = \frac{h}{m\lambda}$

$\Rightarrow \frac{v_p}{v_\alpha} = \frac{m_\alpha}{m_p} \cdot \frac{\lambda_\alpha}{\lambda_p}$

$\Rightarrow \frac{v_p}{v_\alpha} = \frac{4m}{m} \frac{2\lambda}{\lambda}$

$\Rightarrow \frac{v_p}{v_\alpha} = 8$

12. 10 divisions on the min scale of a Vernier calliper coincide with 11 divisions on the Vernier scale. If each division on the main scale is of 5 mints, the least count of the instrument is

(1) $\frac{1}{2}$ (2) $\frac{10}{11}$ (3) $\frac{50}{11}$ (4) $\frac{5}{11}$

Ans. **(4)**

Sol. $LC = \left(1 - \frac{n-1}{n}\right) MSD$

$LC = \left(\frac{1}{11}\right) \times 5 = \frac{5}{11}$ unit

13. In series LCR circuit, the capacitance is changed from C to 4C. To keep the resonance frequency unchanged, the new inductance should be :

(1) reduced by $\frac{1}{4}$ L (2) increased by 2L

(3) reduced by $\frac{3}{4}$ L (4) increased to 4L

Ans. (3)

Sol. $W_r = \frac{1}{\sqrt{LC}} = \text{Constant}$

LC = Constant

If $C \to 4C$

Then $L \to \frac{L}{4}$

Reduced by $\frac{3}{4}L$

14. The radius (r), length (ℓ) and resistance (R) of a metal wire was measured in the laboratory as

$r = (0.35 \pm 0.05)$ cm

$R = (100 \pm 10)$ ohm

$\ell = (15 \pm 0.2)$ cm

The percentage error in resistivity of the material of the wire is :

(1) 25.6% (2) 39.9% (3) 37.3 % (4) 35.6 %

Ans. (2)

Sol. $R = \frac{\rho\ell}{\pi r^2}$

$\rho = \frac{\pi r^2 R}{\ell}$

$\frac{\Delta\rho}{\rho} \times 100\% = \left(\frac{2\Delta r}{r} \times 100 + \frac{\Delta R}{R} \times 100 + \frac{\Delta \ell}{\ell} \times 100\right)\%$

$\frac{\Delta\rho}{\rho} \times 100\% = 2z + x + y$

$= \left(2 \times \frac{0.05}{0.35} + \frac{10}{100} + \frac{0.2}{15}\right) \times 100$

$= 39.9\%$

15. The dimensional formula of angular impulse is :

(1) $[ML^{-2}T^{-1}]$ (2) $[M L^2T^{-2}]$ (3) $M L T^{-1}]$ (4) $[M L^2T^{-1}]$

Ans. (4)

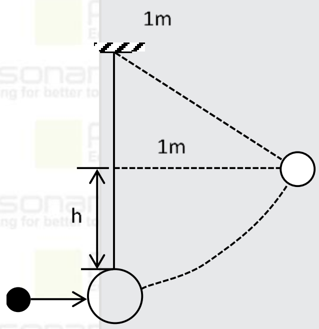
Sol. $L = mvr = [MLT^{-1}L] = [ML^2T^{-1}]$

16. A simple pendulum of length l m has a wooden bob of mass 1 kg. It is struck by a bullet of mass 10^{-2} kg moving with a speed of 2×10^2 ms^{-1}. The bullet gets embedded into the bob. The height to which the bob rises before swinging back is . (use g = 10m/s^2)

(1) 0.30 m (2) 0.20 m (3) 0.35 m (4) 0.40 m

Ans. (2)

Sol.



COLM (conservation & linear momentum)

$10^{-2} \times 2 \times 10^2 = (1 + 10^{-2})\ V$

$\Rightarrow V \approx 2$ m/s

By COE

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

$h = \frac{v^2}{2g} = 0.2$ m

17. A particle moving in a circle of radius R with uniform speed takes time T to complete one revolution. If this particle is projected with the same sped at an angle θ to the horizontal, the maximum height attained by it is equal to 4R. The angle of projection θ is then given by :

(1) $\sin^{-1}\left[\frac{2gT^2}{\pi R^2 R}\right]^{\frac{1}{2}}$ (2) $\sin^{-1}\left[\frac{\pi^2 R}{2gT^2}\right]^{\frac{1}{2}}$

(3) $\cos^{-1}\left[\frac{2gT^2}{\pi^2 R}\right]^{\frac{1}{2}}$ (4) $\cos^{-1}\left[\frac{\pi^2 R}{2gT^2}\right]^{\frac{1}{2}}$

Ans. (1)

Sol. $T = \frac{2\pi R}{v} \Rightarrow v = \frac{2\pi R}{T}$

$h_{projectile} = \frac{v^2 \sin^2\theta}{2g}$

$h_{max} = 4R$

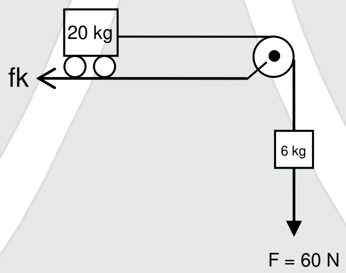
$4R = \frac{\left(\frac{4\pi^2 R^2}{T^2}\right)\sin^2\theta}{2g}$

$\sin^2\theta = \frac{2gT^2}{\pi^2 R}$

$\theta = \sin^{-1}\left(\frac{2gT^2}{\pi^2 R}\right)^{1/2}$

18. Consider a block and trolley system as shown in figure. If the coefficient of kinetic friction between the trolley and the surface is 0.04, the acceleration of the system in ms^{-2} is :

(Consider that the string is massless and unstretchable and the pulley is also massless and frictionless)



(1) 3 (2) 4 (3) 2 (4) 1.2

NTA Ans. (3)
Reso Ans. (Bonus)

Sol. $a = \frac{\text{Net force along string}}{\text{total mass}}$

$a = \frac{(6\times10)-(20\times10)\times0.04}{20+6}$

$a = \frac{52}{26} = 2\ m/s^2$ (Figure doubtful)

Alternate :
As per given figure, solution is

$a = \frac{\text{Net force along string}}{\text{total mass}}$

$a = \frac{60+(6\times10)-(20\times10)\times0.04}{20+6}$

$a = 4.3\ m/s^2$

19. The minimum energy required by a hydrogen atom in ground state to emit radiation in Balmer series is nearly:

(1) 1.5 eV (2) 13.6 eV (3) 1.9 eV (4) 12.1 eV

Ans. **(4)**

Sol. H-atom in G.S.

E_{min} to emit in n = 3

$\Delta E = E_3 - E_1 = -1.51 + 13.6 = 12.1$ eV

20. A monochromatic light of wavelength 6000 Å is incident on the single slit of width 0.01 mm. If the diffraction pattern is formed at the focus of the convex lens of focal length 20 cm, the linear width of the central maximum is :

(1) 60 mm (2) 24 mm (3) 120 mm (4) 12 mm

Ans. **(2)**

Sol. width $= 2\dfrac{f\lambda}{d}$

$$= 2\frac{0.2\times6000\times10^{-10}}{0.01\times10^{-3}} = \frac{2.4\times10^{-7}}{10^{-5}}$$

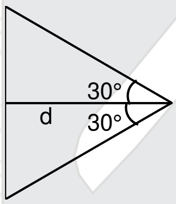
Width $= 24 \times 10^{-3} = 24$ mm

21. A regular polygon of 6 sides is formed by bending a wire of length 4π meter. If an electric current of $4\pi\sqrt{3}$ A is flowing through the sides of the polygon, the magnetic field at the centre of the polygon would be $x \times 10^{-7}$ T. The value of x is ____

Ans. **72**

Sol. d = a cos30°

$$= \frac{\sqrt{3}a}{2}$$



$$B_c = 6\times\frac{\mu_0 i}{4\pi\left(\frac{\sqrt{3}a}{2}\right)}(\sin 30° + \sin30°)$$

$$= 6\times\frac{\mu_0 i}{4\pi\frac{\sqrt{3}}{2}a} = 6\times\frac{\mu_0 i}{4\pi\frac{\sqrt{3}}{2}a}\left(2\times\frac{1}{2}\right)$$

$$B_c = \frac{\sqrt{3}\,\mu_0 i}{\pi a}$$

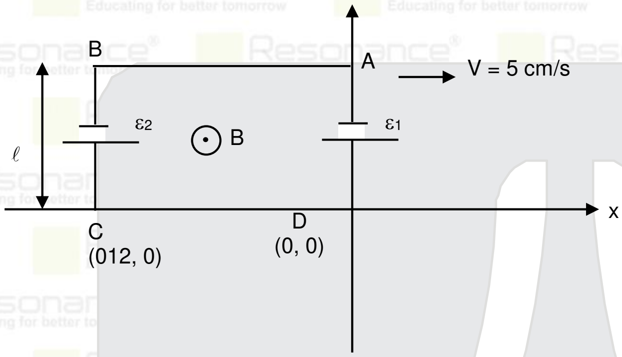
$$= \frac{\sqrt{3}\mu_0\times4\pi\sqrt{3}}{\pi\times\frac{4\pi}{6}} = 72\times10^{-7}\text{ T}$$

x = 72

22. A rectangular loop of sides 12 cm and 5 cm, with its sides parallel to the x-axis and y-axis respectively, moves with a velocity of 5 cm/s in the positive x-axis direction, in a space containing a variable magnetic field in the positive z-direction. The field has a gradient of 10^{-3}T/cm along the negative x-direction and it is decreasing with time at the rate of 10^{-3} T/s. If the resistance of the loop is $6m\Omega$, the power dissipated by the loop as heat is ______ × 10^{-9} W.

Ans. 216

Sol.



B_0 is the magnetic field at origin

$$\frac{dB}{dx} = \frac{10^{-3}}{10^{-2}}$$

$$\int_{B_0}^{B} dB = -\int_0^x 10^{-1} dx$$

$B - B_0 = -10^{-1}x$

$$B = \left(B_0 - \frac{x}{10}\right)$$

Motional emf in AB = 0

Motional emf in CD = 0

Motional emf in AD = $\varepsilon_i = B_0 \ell v$

Magnetic field on rod BC B

$$= \left(B_0 - \frac{(-12\times10^{-2})}{10}\right)$$

motional emf in BC = $\varepsilon_2 = \left(B_0 + \frac{12\times10^{-2}}{10}\right)\ell \times v$

$\varepsilon_{eqi} = \varepsilon_2 - \varepsilon_1 = 300 \times 10^{-7}$

For time variation

$(\varepsilon_{eqi})' = A\frac{dB}{dt} = 60 \times 10^{-7}$ V

$(\varepsilon_{eqi})_{net} = (\varepsilon_{eqi}) + (\varepsilon_{eqi})' = 360 \times 10^{-7}$ V

$$\text{Power} = \frac{(\varepsilon_{eq})^2_{net}}{R} = 216 \times 10^{-9} \text{ W}$$

23. The distance between object and its 3 times magnified virtual image as produced by a convex lens is 20 cm. The focal length of the lens used is ______ cm.

Ans. **15.00**

Sol. $m = \frac{v}{u} = 3$

$v = 3u$

$v - u = 20$ cm

$2u = 20$ cm $\Rightarrow u = 10$ cm

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u} = -\frac{1}{3u} = \frac{1}{v} - \frac{2}{3u}$$

$$f = \frac{3(10)}{2} = 15 \text{ cm}$$

24. Two identical charged spheres are suspended by string of equal lengths. The strings make and angle θ with each other. When suspended in water the angle remains the same. If density of the material of the sphere is 1.5 g/cc, the dielectric constant of water will be _____ (Take density of water = 1 g/cc)

Ans. **03.00**

Sol. $\tan\theta = \frac{F_E}{\rho v g}$

θ is same

$$\therefore \frac{F_E}{\rho V g} = \frac{F_E'}{(\rho - \rho_w)Vg}$$

$$\Rightarrow \frac{F_E}{(1.5)} = \frac{F_E}{K(1.5-1)} \Rightarrow K = 3$$

25. The radius of a nucleus of mass number 64 is 4.8 Fermi. Then the mass number of another nucleus having radius of 4 Fermi is $\frac{1000}{x}$, where x is ______ .

Ans. **27.00**

Sol. Density of nucleus is constant

$$\therefore \frac{\text{mass}}{\text{volume}} = \frac{\text{Atomic number}}{R^3} = \text{constant}$$

$$\therefore \frac{A_1}{R_1^3} = \frac{A_2}{R_2^3}$$

$$\Rightarrow \quad A_2 = \left(\frac{R_2}{R_1}\right)^3 A_1$$

$$\Rightarrow \quad A_2 = \left(\frac{4}{4.8}\right)^3 64$$

$$\Rightarrow \quad A_2 = 37.037 = \frac{1000}{x} \Rightarrow x = 27$$

26. The identical spheres each of mass 2M are placed at the corners of a right angled triangle with mutually perpendicular sides equal to 4m each. Taking point of intersection of these two sides as origin, The magnitude of position vector of the centre of mass of the system is $\frac{4\sqrt{2}}{x}$ where the value of x is ____

Ans. **03.00**

Sol. $\vec{r}_{cm} = \frac{m_1\vec{r}_1 + m_2\vec{r}_2 + m_3\vec{r}_3}{m_1 + m_2 + m_3} = \frac{2M(4\hat{i}) + 2M(4\hat{j}) + 2M(0)}{2M + 2M + 2M}$

$\vec{r}_{cm} = \frac{4}{3}\hat{i} + \frac{4}{3}\hat{j}$

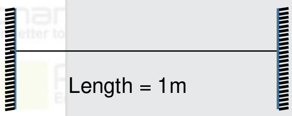
$|\vec{r}| = \frac{4\sqrt{2}}{3}$

x = 3

27. A tuning fork resonates with a sonometer wire of length 1m stretched with a tension of 6N. When the tension in the wire is changed to 54 N. The same tuning fork produces 12 beats per second with it. The frequency of the tuning fork is ________ Hz.

Ans. **06.00**

Sol.



$f = \frac{1}{2}\sqrt{\frac{T}{\mu}}$

$f_1 = \frac{1}{2}\sqrt{\frac{6}{\mu}}$ $\quad f_2 = \frac{1}{2}\sqrt{\frac{54}{\mu}}$

$\frac{f_1}{f_2} = \frac{1}{3}$ $\quad f_2 - f_1 = 12$

$f_2 = 3f_1$

$3f_1 - f_1 = 12$

$f_1 = 6$ Hz

28. A plane is in level flight at constant speed and each of its two wings has an area of 40 m^2. If the speed of the air is 180 km/h over the lower wing surface and 252 km/h over the upper wing surface, the mass of the plane is _____ kg. (Take air density to be 1 kg m^{-3} and g = 10 ms^{-2})

Ans. **9600**

Sol. A = 40 m^2 Total area = 80 m^2

$$F = \frac{1}{2}\times\rho(V_1^2 - V_2^2)A_{total}$$

$$mg = \frac{1}{2}\times 1\times(70^2 - 50^2)\times 80$$

mg = 96000

m = 9600 kg

29. The current in a conductor is expressed as I = $3t^2 + 4t^3$, where I is in Ampere and t is in second. The amount of electric charge that flows through a section of the conductor during t = 1 sec to t = 2 sec is _____C.

Ans. **22.00**

Sol. $I = \frac{dQ}{dt} = 3t^2 + 4t^3$

$$\int dQ = \int_1^2 \left(3t^2 + 4t^3\right)dt$$

$$Q = \left.\frac{3t^3}{3} + \frac{4t^4}{4}\right|_1^2 = \left.\left(t^3 + t^4\right)\right|_1^2$$

= (8 + 16) – (1 + 1)

= 24 – 2 = 22 C

30. A particle is moving in one dimension (along x axis) under the action of a variable force. It's initial position was 16 m right of origin. The variation of its position (x) with time (t) is given as x = – $3t^3 + 18t^2 + 16t$, where x is in m and t is in s. The velocity of the particle when its acceleration becomes zero is _____ m/s.

Ans. **52.00**

Sol. $x = -3t^3 + 18t^2 + 16t$

$v = -9t^2 + 36t + 16$

$a = -18t + 36$

a = 0 when t = 2 sec

t = 2, $v = -9(2)^2 + 36(2) + 16$

v = 52 m/s