Find the magnetic field at the centre of..

Dr. Ch.RamaKrishna
Subject expert

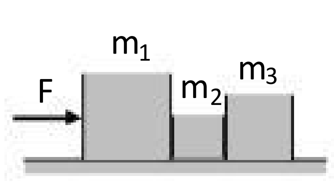
JEE Main PHYSICS *Special*

MODEL QUESTIONS

1. Vernier scale of Vernier calipers has 50 divisions which coincide with 49 main scale divisions. Find the Vernier constant. Given: there are 20 main scale divisions cm^{-1}.
1) 100 μm 2) 1000 μm
3) 10 μm 4) 1 μm

2. A particle moves according to the law a = –ky. Find the velocity as a function of distance y, v_0 is initial velocity.
1) $v^2 = v_0^2 - ky^2$
2) $v^2 = v_0^2 - 2ky$
3) $v^2 = v_0^2 - 2ky^2$
4) $v^2 = v_0 - ky$

3. Three blocks of mass m_1, m_2 and m_3 are lying in contact with each other on a horizontal frictionless plane as shown in the figure. If a horizontal force F is applied on m1 then the force at the constant plane of m_1 and m_2 will be

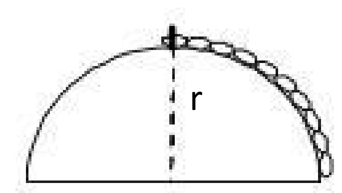


1) $\frac{F(m_2+m_3)}{(m_1+m_2+m_3)}$
2) $\frac{m_1+F}{(m_1+m_2+m_3)}$
3) m_1F
4) $\frac{F(m_1+m_2)}{(m_1+m_2+m_3)}$

4. A particle is projected upwards. The times corresponding to height h while ascending and while descending are t_1 and t_2 respectively. The velocity of projection will be
1) gt_1 2) gt_2
3) $g(t_1+t_2)$ 4) $\frac{g(t_1+t_2)}{2}$

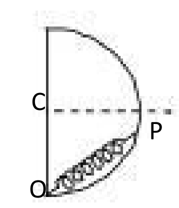
5. Two particles of equal mass have velocities $\vec{v}_1 = 2\hat{i}$ m/s and $\vec{v}_2 = 2\hat{j}$ m/s. First particle has an acceleration $\vec{a}_1 = (3\hat{i}+3\hat{j})\frac{m}{s^2}$ while the acceleration of the other particle is zero. The centre of mass of the two particles moves in a
1) circle 2) parabola
3) straight line 4) ellipse

6. A chain of length l is placed on a smooth spherical surface of radius r with one of its ends fixed at the top of the surface. Length of chain is assumed to be $l < \pi r/2$. Acceleration of each element of chain when upper end is released is



1) $\frac{lg}{r}\left(1-\cos\frac{r}{l}\right)$ 2) $\frac{rg}{l}\left(1-\cos\frac{l}{r}\right)$
3) $\frac{lg}{r}\left(1-\sin\frac{r}{l}\right)$ 4) $\frac{rg}{l}\left(1-\sin\frac{l}{r}\right)$

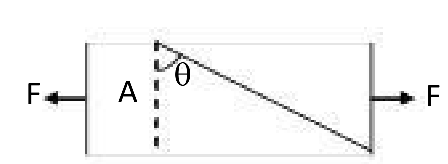
7. A smooth semicircular wire track of radius R is fixed in a vertical plane. One end of a massless spring of natural length 3R/4 is attached to the lowest point O of the wire track. A small ring of mass m which can slide on the track is attached to the other end of the spring. The ring is held stationary at point P such that the spring makes an angle 60° with the vertical. Spring constant K = mg/R. The spring force is



1) $\frac{mg}{3}$ 2) mg
3) $\frac{mg}{2}$ 4) $\frac{mg}{4}$

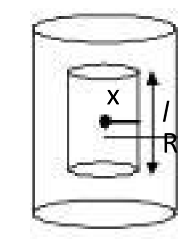
8. Find the work done to take a particle of mass m from surface of the earth to a height equal to 2R
1) 2 mg R 2) $\frac{mgR}{2}$
3) 3 mg R 4) $\frac{2mgR}{3}$

9. A bar of cross-section A is subjected to equal and opposite tensile forces F at its ends. Consider a plane through the bar making an angle θ with a plane at right angles to the bar. Then shearing stress will be maximum if θ



1) 0° 2) 30°
3) 45° 4) 90°

10. Uniformly charged long cylinder has volume charge density ρ. Find the electric field at a distance $x < R$ from the axis of the cylinder

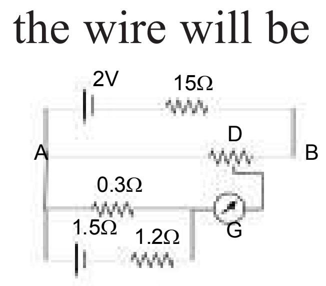


1) $\frac{\rho x}{\varepsilon_0}$ 2) $\frac{\rho x}{2\varepsilon_0}$
3) $\frac{\rho x}{3\varepsilon_0}$ 4) $\frac{\rho x}{4\varepsilon_0}$

11. $E = 20\hat{i} + 30\hat{j}$ exists in space. If the potential at the origin is taken to be zero, find the potential at P(3, 2).
1) –150 V 2) –100 V
3) +150 V 4) –120 V

12. The electric field strength due to a ring of radius R at a distance x from its centre on the axis of ring carrying charge Q is given by $E = \frac{1}{4\pi\varepsilon_0}\frac{Qx}{(R^2+x^2)^{3/2}}$. At what distance from the centre will the electric field be maximum?
1) x = R 2) x = R/2
3) x = R/√2 4) $x = \sqrt{R/2}$

13. In the following circuit the resistance of wire AB is 10Ω and its length is 1 m. Rest of the quantities are given in the diagram. The potential gradient on the wire will be



1) 0.08 V/m 2) 0.008 V/m
3) 0.8 V/m 4) 8.0 V/m

14. A thin disc (or dielectric) having radius r and charge q distributed uniformly over the disc is rotated n rotations per second about its axis. Find the magnetic field at the centre of the disc.
1) $\frac{\mu_0 qn}{a}$ 2) $\frac{\mu_0 qn}{2a}$
3) $\frac{\mu_0 qn}{4a}$ 4) $\frac{3\mu_0 qn}{4a}$

15. The coercive force for a certain permanent magnet is 4 × 10^4 Am^{-1}. This magnet is placed in a long solenoid having 20 turns per cm. What current be passed to completely demagnetize it?
1) 10A 2) 20A
3) 40A 4) 25 A

16. A long wire carries a current 5 A. The energy stored in the magnetic field inside a volume 1 mm^3 at a distance 10 cm from the wire is
1) $\frac{\pi}{4}\times10^{-13}$ J 2) $\frac{\pi}{2}\times10^{-13}$ J
3) $\pi\times10^{-13}$ J 4) $\frac{\pi}{8}\times10^{-13}$ J

17. Magnetic flux during time interval τ varies through a stationary loop of resistance R as ϕ_B = at (τ- t). Find the amount of heat generated during that time. Neglect the inductance of the loop.
1) $\frac{a^2\tau^3}{R}$ 2) $\frac{a^2\tau^2}{2R}$
3) $\frac{a^2\tau^3}{3R}$ 4) $\frac{a^2\tau^3}{4R}$

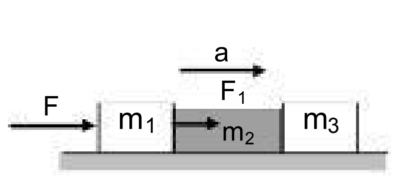
18. An alternating current is given by $i = i_1\cos\omega t + i_2\sin\omega t$. The rms current is given by
1) $\frac{i_1+i_2}{\sqrt{2}}$ 2) $\frac{|i_1+i_2|}{\sqrt{2}}$
3) $\sqrt{\frac{i_1^2+i_2^2}{2}}$ 4) $\sqrt{\frac{i_1^2+i_2^2}{\sqrt{2}}}$

Solutions

1) 3; $V = \frac{1}{50}\times$ (value of 1 MSD)
$= \frac{1}{50}\times\frac{1}{20} = 0.001$cm

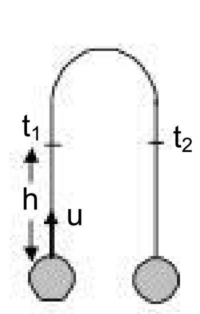
2) 1; $a = \frac{dv}{dt} = \frac{dv}{dy}\cdot\frac{dy}{dt}$
$\int_{v_0}^{v} v\,dv = \int_0^y -ky\,dy \Rightarrow v_0^2 - v^2 = ky^2$

3) 1;



$a = \frac{F}{m_1+m_2+m_3}$; $F_1 = (m_2+m_3)a$
$F_1 = \frac{m_2+m_3}{m_1+m_2+m_3}F$

4) 4;



$\frac{2u}{g} = t_1 + t_2$

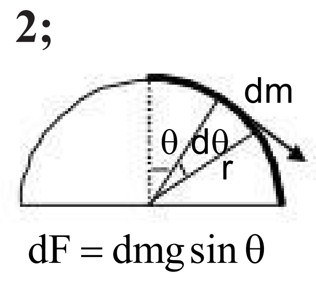
5) 3;
$\vec{v}_{COM} = \frac{m_1\vec{v}_1 + m_2\vec{v}_2}{m_1+m_2}$
$= \frac{\vec{v}_1+\vec{v}_2}{2}(m_1 = m_2)$
$= (\hat{i}+\hat{j})$m/s

Similarly

$\vec{a}_{COM} = \frac{\vec{a}_1+\vec{a}_2}{2} = \frac{3}{2}(\hat{i}+\hat{j})m/s^2$

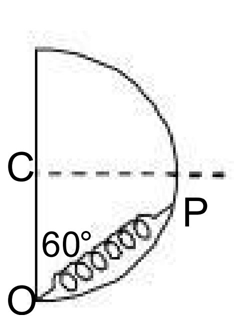
Since $\vec{v}_{COM}$ is parallel to $\vec{a}_{COM}$ the path will be a straight line.

6) 2;



$dF = dmg\sin\theta$
$F = \frac{m}{l}rg\int_0^{\alpha}\sin\theta\,d\theta$
$a = \frac{F}{m} = \frac{rg}{l}\left(1-\cos\frac{l}{r}\right)$

7) 4;



Extension of the spring
$x = R - \frac{3R}{4} = \frac{R}{4}$
$F = Kx = \frac{mg}{R}\left(\frac{R}{4}\right) = \frac{mg}{4}$

8) 4; $W = \Delta PE = GMm\left[\frac{1}{R} - \frac{1}{3R}\right]$
$= \frac{2GMm}{3R} = \frac{2}{3}gmR$

9) 3;
Shear stress $= \frac{F\sin\theta}{A/\cos\theta} = \frac{F\sin2\theta}{2A}$
Shear stress will be maximum if sin 2θ = 1 or 2θ =90° i.e. θ = 45°.

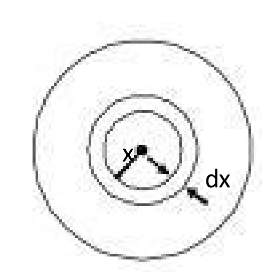
10) 2;
Assume a hypothetical cylinder of radius x and length l. Apply Gauss's law $\oint E\cdot ds = \frac{q_{in}}{\varepsilon_0}$ or
$\oint E\cdot ds = \frac{\pi x^2 l\rho}{\varepsilon_0}$
$E(2\pi xl) = \frac{\pi x^2 l\rho}{\varepsilon_0} \Rightarrow E = \frac{\rho x}{2\varepsilon_0}$

11) 4;
$V = V_x + V_y = \int_0^3 -E_x dx + \int_0^2 -E_y dy$
$= \int_0^3 -20\,dx + \int_0^2 -30\,dx = -60 - 60 = -120V$

12) 3; $E = \frac{1}{4\pi\varepsilon_0}\frac{Qx}{(R^2+x^2)^{3/2}}$
For maximum electric field
$\frac{dE}{dx} = 0$ $x = \frac{R}{\sqrt{2}}$

13) 3;
$\phi = \frac{V_{AB}}{L} = \frac{iR_{AB}}{L} = \frac{2}{25}\times\frac{10}{1}$
$\phi = 0.8$ V/m

14) 1;Surface charge density $\sigma = \frac{q}{\pi a^2}$
Charge on the hypothetical ring
$= \frac{q}{\pi a^2}2\pi x dx$
$dI = \frac{q}{T} = \frac{q}{1/n} = nq$



Magnetic field due to the element
$dB = \frac{\mu_0 dI}{2x} = \frac{\mu_0 2xdxqn}{a^2(2x)} = \frac{\mu_0 qndx}{a^2}$
$B = \int dB = \frac{\mu_0 qn}{a^2}\int_0^a dx = \frac{\mu_0 qn}{a^2}[x]_0^a = \frac{\mu_0 qn}{a}$

15) 2; H = nI
$\therefore n = 20cm^{-1} = 2000m^{-1}$
$I = \frac{4\times10^4}{2000} = 20A$

16) 4; u (energy per unit volume)
$= \frac{B^2}{2\mu_0}$ and energy $U = \frac{B^2}{2\mu_0}\times$ vol.
$U = \left(\frac{\mu_0 I}{2\pi d}\right)^2\times\frac{1}{2\mu_0}\times$ vol.
$= \frac{\mu_0 i^2}{8\pi^2 d^2}\times$ vol. $= \frac{\pi}{8}\times10^{-13}$J

17) 3; $i = \frac{d\phi}{dt}/R = \frac{a(\tau-2t)}{R}$
Heat produced .
$H = \int_0^{\tau} i^2 R dt = \int_0^{\tau}\frac{a^2(\tau-2t)^2}{R} = \frac{a^2\tau^3}{3R}$

18) 3; $i_{rms} = \frac{i_0}{\sqrt{2}}$
$i = i_1\sin\left(\omega t + \frac{\pi}{2}\right) + i_2\sin\omega t$
$i_0 = \sqrt{i_1^2 + i_2^2}$