When the potential difference across the capacitors...

JEE Main PHYSICS Special

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Subject expert

Dr. RK's Classes

MODEL QUESTIONS

1. The ratio of surface tensions of mercury and water is given to be 7.5 while the ratio of their densities is 13.6. Their contact angles, with glass, are close to 135° and 0°, respectively. It is observed that mercury gets depressed by an amount h in a capillary tube of radius r_1, while water rises by the same amount h in a capillary tube of radius r_2. The ratio, (r_1/r_2), is then close to

1) 2/3 2) 3/5
3) 2/5 4) 4/5

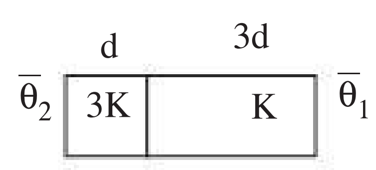
2. A rod, length L at room temperature and uniform area of cross section A, is made of a metal having coefficient of linear expansion α/°C. It is observed that an external compressive force F, is applied on each of its ends, prevents any change in the length of the rod, when its temperature rises by ΔTK. Young's modulus, Y, for this metal is

1) $\frac{F}{2A\alpha\Delta T}$ 2) $\frac{F}{A\alpha(\Delta T-273)}$
3) $\frac{F}{A\alpha\Delta T}$ 4) $\frac{2F}{A\alpha\Delta T}$

3. When M_1 gram of ice at -10°C (specific heat = 0.5 cal g^{-1} °C^{-1}) is added to M_2 gram of water at 50°C, finally no ice is left and the water is at 0°C. The value of latent heat of ice, in cal g^{-1} is

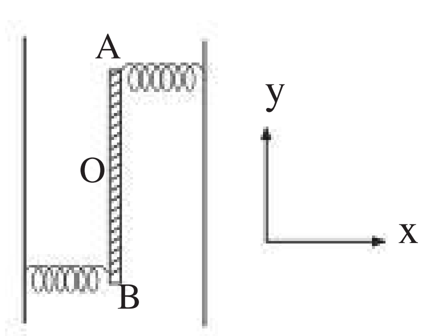
1) $\frac{5M_1}{M_2}-50$ 2) $\frac{50M_2}{M_1}$
3) $\frac{50M_2}{M_1}-5$ 4) $\frac{5M_2}{M_1}-5$

4. Two materials having coefficients of thermal conductivity 3K and K and thickness d and 3d, respectively, are joined to form a slab as shown in the figure. The temperatures of the outer surfaces are θ_2 and θ_1 respectively ($\theta_2 > \theta_1$). The temperature at the interface is:



1) $\frac{\theta_2+\theta_1}{2}$ 2) $\frac{\theta_1}{10}+\frac{9\theta_2}{10}$
3) $\frac{\theta_1}{3}+\frac{2\theta_2}{3}$ 4) $\frac{\theta_1}{6}+\frac{5\theta_2}{6}$

5. Two light identical springs of spring constant k are attached horizontally at the two ends of a uniform horizontal rod AB of length *l* and mass m. The rod is pivoted at its centre 'O' and can rotate freely in horizontal plane. The other ends of the two springs are fixed to rigid supports as shown in figure. The rod is gently pushed through a small angle and released. The frequency of resulting oscillation is

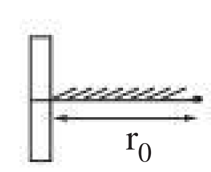


1) $\frac{1}{2\pi}\sqrt{\frac{6k}{m}}$ 2) $\frac{1}{2\pi}\sqrt{\frac{2k}{m}}$
3) $\frac{1}{2\pi}\sqrt{\frac{k}{m}}$ 4) $\frac{1}{2\pi}\sqrt{\frac{3k}{m}}$

6. Let a total charge 2Q be distributed in a sphere of radius R, with the charge density given by ρ(r) = kr, where r is the distance from the centre. Two charges A and B, of –Q each, are placed on diametrically opposite points, at equal distance, a, from the centre. If A and B do not experience any force, then

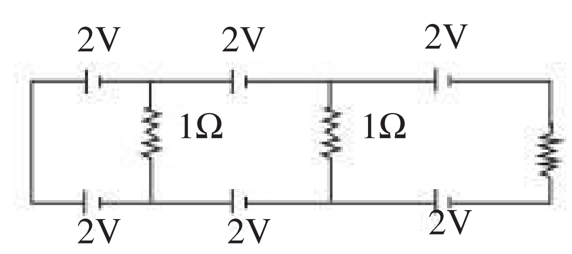
1) $a=\frac{3R}{2^{1/4}}$ 2) $a=\frac{R}{\sqrt3}$
3) $a = 8^{-1/4}$ R 4) $a = 2^{-1/4}$ R

7. A positive point charge is released from rest at a distance r_0 from a positive line charge with uniform density. The speed (v) of the point charge, as a function of instantaneous distance r from line charge, is proportional to



1) $v\propto e^{+r/r_0}$ 2) $v\propto \ln\left(\frac{r}{r_0}\right)$
3) $v\propto\left(\frac{r}{r_0}\right)$ 4) $v\propto\sqrt{\ln\left(\frac{r}{r_0}\right)}$

8. In the circuit the current in each resistance is



1) 0.5 A 2) 0 A
3) 1 A 4) 0.25 A

9. The magnitude of the magnetic field at the centre of an equilateral triangular loop of side 1 m which is carrying a current of 10 A is: [Take $_0$ = 4π 10^{-7} NA^{-2}]

1) 18 T 2) 3 T
3) 1 T 4) 9 T

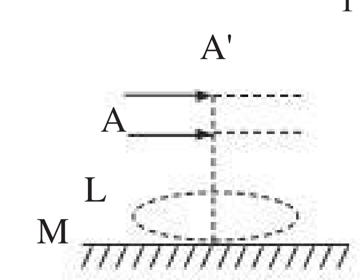
10. An ideal capacitor of capacitance 0.2 F is charged to a potential difference of 10 V. The charging battery is then disconnected. The capacitor is then connected to an ideal inductor of self inductance 0.5 mH. The current at a time when the potential difference across the capacitor is 5 V, is

1) 0.17 A
2) 0.15 A 3) 0.34 A
4) 0.25 A

11. Magnetic field in a plane electromagnetic wave is given by $\vec B=B_0\sin(kx+\omega t)\hat jT$. Expression for corresponding electric field will be : (where c is speed of light)

1) $\vec E=B_0c\sin(kx+\omega t)\hat k\ V/m$
2) $\vec E=\frac{B_0}{c}\sin(kx+\omega t)\hat k\ V/m$
3) $\vec E-B_0c\sin(kx+\omega t)\hat k\ V/m$
4) $\vec E=B_0c\sin(kx-\omega t)\hat k\ V/m$

12. A thin convex lens L (refractive index = 1.5) is placed on a plane mirror M. When a pin is placed at A, such that OA = 18 cm, its real inverted image is formed at A itself, as shown in figure. When a liquid of refractive index $_1$ is put between the lens and the mirror, the pin has to be moved to A', such that OA' = 27cm, to get its inverted real image at A' itself. The value of $_1$ will be



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

13. Mobility of electrons in a semiconductor is defined as the ratio of their drift velocity to the applied electric field. If, for an n-type semiconductor, the density of electrons is 10^{19} m^{-3} and their mobility is 1.6 m^2/(V.s) then the resistivity of the semiconductor (since it is an n-type semiconductor contribution of holes is ignored) is close

1) 2 Ωm 2) 0.4 Ωm
3) 4 Ωm 4) 0.2 Ωm

Solutions

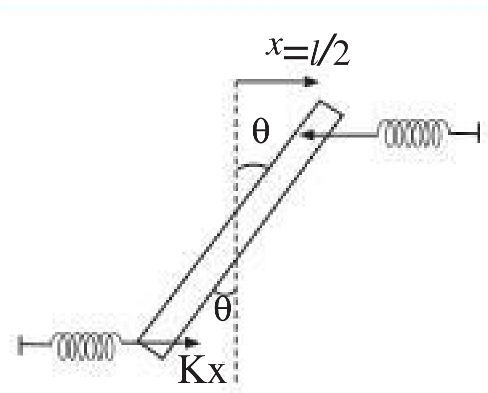
1. 3;
$$h=\frac{2S_1\cos\theta}{r_1\rho_1 g}$$
$$h=\frac{2S_2\cos\theta_2}{r_2\rho_2 g}\Rightarrow\frac{r_1}{r_2}=\frac{2}{5}$$

2. 3;
Young's modulus
$$y=\frac{stress}{strain}=\frac{F/A}{(\Delta\ell/\ell)}=\frac{F}{A(\alpha\Delta T)}$$

3. 3;
Heat lost = Heat gain
⇒ M_2 1 50 = M_1 0.5 10 + $M_1.L_f$
$$L_f=\frac{50M_2-5M_1}{M_1}=\frac{50M_2}{M_1}-5$$

4. 2; At steady state:
$$\left(\frac{\Delta q}{\Delta t}\right)_1=\left(\frac{\Delta q}{\Delta t}\right)_2$$
$$\frac{3kA(\theta_2-\theta)}{d}=\frac{kA(\theta-\theta_1)}{3d}$$
$$\Rightarrow\theta=\frac{\theta_1+9\theta_2}{10}$$

5. 1;



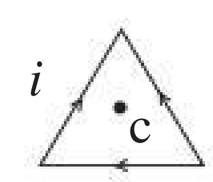
$$\tau=-2Kx\frac{l}{2}\cos\theta$$
$$\Rightarrow\tau=\left(\frac{Kl^2}{2}\right)\theta=-C\theta$$
$$\Rightarrow f=\frac{1}{2\pi}\sqrt{\frac{C}{I}}=\frac{1}{2\pi}\sqrt{\frac{\frac{Kl^2}{2}}{\frac{Ml^2}{12}}}$$
$$\Rightarrow f=\frac{1}{2\pi}\sqrt{\frac{6K}{M}}$$

6. 3;
$$E4\pi a^2=\frac{\int_0^a kr4\pi r^2dr}{e_0}$$
$$E=\frac{K4\pi a^4}{4\ \ 4\pi\varepsilon_0}$$
$$2Q=\int_0^R kr4\pi r^2dr$$
$$K=\frac{2Q}{\pi R^4}$$
$$QE=\frac{1}{4\pi\varepsilon_0}\frac{QQ}{(2a)^2}$$
R = $a8^{1/4}$

7. 4;
$$\frac{1}{2}mV^2=-q(V_f-V_i)$$
$$E=\frac{\lambda}{2\pi\varepsilon_0 r}$$
$$\Delta V=\frac{\lambda}{2\pi\varepsilon_0}\ln\left(\frac{r_0}{r}\right)$$
$$\frac{1}{2}mv^2=\frac{-q\lambda}{2\pi\varepsilon_0}\ln\frac{r_0}{r}$$
$$V\propto\sqrt{ln\left(\frac{r}{r_0}\right)}$$

8. 2; Potential difference across each resistor is zero.

9. 2;



i = 10A ; l = 1m
$$_0=4\pi\ \ 10^{-7}\frac{N}{A^2}$$
$$B=\frac{_0 I}{4\pi\frac{\sqrt3 l}{2}}\ \ 3$$
$$=\frac{_0 i\sqrt3}{2\pi l}=\frac{4\pi\ \ 10^{-7}\ \ 10\ \ \sqrt3}{2\pi\ \ 1}$$
$$=20\sqrt3\ \ 10^{-7}=3\ T$$

10. 1; From energy conservation
½ × 0.2 × 10^6× 10^2 + 0 = ½ × 0.2 × 10^{-6} × 5^2 + ½ × 0.5 × $10^{-3}1^2$
$$I=\frac{\sqrt3}{10}A=0.17A$$

11. 1; Electric field amplitude is related to B_0 with speed of EM wave is c = E_0/B_0 ⇒ E_0 = cB_0
As wave is traveling along -x direction so vector $\vec E$ $\vec B$ must be along the direction of propagation of EM wave i.e. along $-\hat i$ direction. So here electric field can be given as
$$\vec E=E_0\sin(kx+\omega t)\hat k\ V/m$$
$$\vec E=B_0c\sin(kx+\omega t)\hat k\ V/m$$

12. 2; For image to form at object itself, says must retrace their path back to object. Hence must incident on mirror normally.
Case 1: Object will be at focus of lens
$$\frac{1}{f}=(\ \ -1)\left(\frac{1}{R}-\frac{1}{-R}\right)=\frac{1}{-18}$$
⇒ R = 18 cm
Case2 : Retraction at 1^{st} surface:
$$\frac{1}{-27}-\frac{1.5}{V_1}=\frac{1-1.5}{R}\ ....(i)$$
2^{nd} retraction
$$\frac{1.5}{V_1}-\frac{}{\infty}=\frac{1.5-u}{-R}\ ....(ii)$$
From (i), (ii)
$$=\frac{4}{3}$$

13. 2; j = σE = nev_d
$$\sigma=ne\frac{v_d}{E}=ne$$
$$\frac{1}{\sigma}=\sigma=\frac{1}{n_e e\ \ _e}$$
$$=\frac{1}{10^{19}\ \ 1.6\ \ 10^{-19}\ \ 1.6}=0.4\Omega m$$