Sample Paper for JEE-Mains

Subject: Physics [Paper-4]

Topics Covered

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EMI & A.C. &
Electromagnetic Wave
Ray & Wave Optics
Semiconductors

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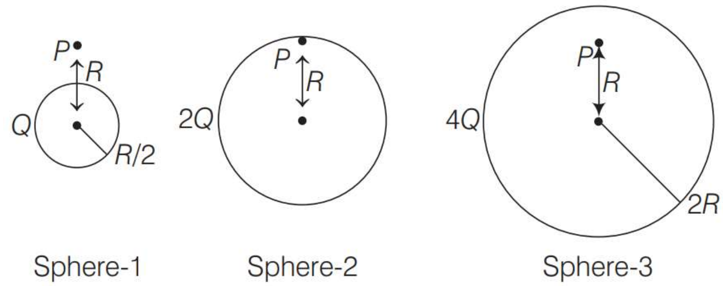
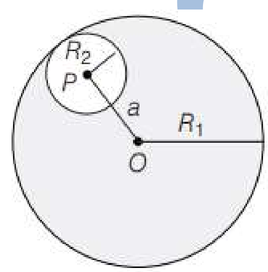
Only one option is correct.

1. Charges Q, $2Q$ and $4Q$ are uniformly distributed in three dielectric solid spheres 1, 2 and 3 of radii $R/2$, R and $2R$ respectively, as shown in figure. If magnitudes of the electric fields at point P at a distance R from the centre of spheres 1, 2 and 3 are E_1, E_2 and E_3 respectively, then **[Electric Field due to Solid Sphere]**



(a) $E_1 > E_2 > E_3$ (b) $E_3 > E_1 > E_2$ (c) $E_2 > E_1 > E_3$ (d) $E_3 > E_2 > E_1$

2. Consider a uniform spherical charge distribution of radius $R1$ centred at the origin O. In this distribution, a spherical cavity of radius R_2, centred at P with distance $OP= a= R_1 - R_2$ (see figure) is made. If the electric field inside the cavity at position **r** is **E (r)**, then the correct statements is **[Gauss's Law]**



(a) **E** is uniform, its magnitude is independent of R_2 but its direction depends on **r**

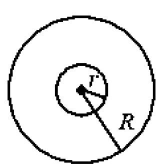
(b) **E** is uniform, its magnitude depends on R_2 and its direction depends on **r**

(c) **E** is uniform, its magnitude is independent of 'a' but its direction depends on **a**

(d) **E** is uniform and both its magnitude and direction depend on **a**

3. A charge Q is distributed over two concentric conducting thin spherical shells radii r and R ($R > r$). If the surface charge densities on the two shells are equal, the electric potential at the common centre is :

[Electric Potential due to Hollow Sphere]



(a) $\frac{1}{4\pi\varepsilon_0}\frac{(R+r)}{2(R^2+r^2)}Q$ (b) $\frac{1}{4\pi\varepsilon_0}\frac{(2R+r)}{(R^2+r^2)}Q$

(c) $\frac{1}{4\pi\varepsilon_0}\frac{(R+2r)Q}{2(R^2+r^2)}$ (d) $\frac{1}{4\pi\varepsilon_0}\frac{(R+r)}{(R^2+r^2)}Q$

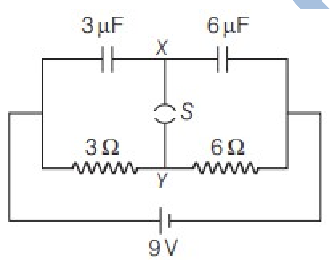
4. A capacitor C is fully charged with voltage V_0. After disconnecting the voltage source, it is connected in parallel with another uncharged capacitor of capacitance $C/2$. The energy loss in the process after the charge is distributed between the two capacitors is : **[Redistribution of Charge Between Parallel Plate Capacitors]**

(a) $\frac{1}{2}CV_0^2$ (b) $\frac{1}{3}CV_0^2$ (c) $\frac{1}{4}CV_0^2$ (d) $\frac{1}{6}CV_0^2$

5. The parallel combination of two air filled parallel plate capacitors of capacitance C and nC is connected to a battery of voltage, V. When the capacitors are fully charged, the battery is removed and after that a dielectric material of dielectric constant K is placed between the two plates of the first capacitor. The new potential difference of the combined system is: **[Parallel Plate Capacitor with Dielectric]**

(a) $\frac{nV}{K+n}$ (b) V (c) $\frac{V}{K+n}$ (d) $\frac{(n+1)V}{(K+n)}$

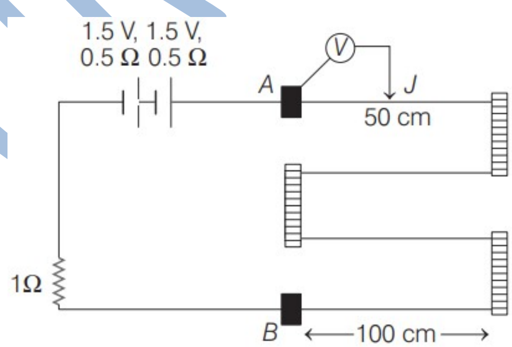
6. A circuit is connected as shown in the figure with the switch S open. When the switch is closed, the total amount of charge that flows from Y to X is **[R-C Circuit]**



(a) zero (b) 54 μC (c) 27 μC (d) 81μC

7. In the circuit shown, a four-wire potentiometer is made of a 400 cm long wire, which extends between A and B. The resistance per unit length of the potentiometer wire is r = 0 01. Ω/cm. If an ideal voltmeter is connected as shown with jockey J at 50 cm from end A, the expected reading of the voltmeter will be

[Potentiometer]



(a) 0.20 V (b) 0.75 V (c) 0.25 V (d) 0.50 V

8. On interchanging the resistances, the balance point of a meter bridge shifts to the left by 10 cm. The resistance of their series combination is 1kΩ. How much was the resistance on the left slot before interchanging the resistances? **[Meter Bridge]**

(a) 990 Ω (b) 910 Ω (c) 900 Ω (d) 550 Ω

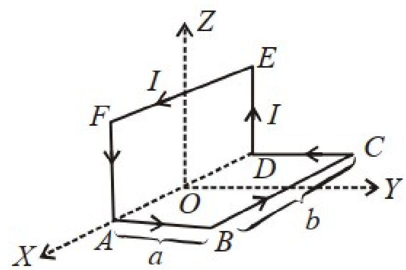
9. A galvanometer having a coil resistance of 100 Ω gives a full scale deflection when a current of 1 mA is passed through it. The value of the resistance which can convert this galvanometer into ammeter giving a full scale deflection for a current of 10 A, is **[Galvanometer]**

(a) 0.01 Ω (b) 2 Ω (c) 0.1 Ω (d) 3 Ω

10. A particle of charge *q* and mass *m* is moving with a velocity $-v\hat{i}\,(v \neq 0)$ towards a large screen placed in the Y-Z plane at a distance *d*. If there is a magnetic fiel $\overline{B} = B_0\hat{k}$, the minimum value of *v* for which the particle will not hit the screen is: **[Motion of Charged Particles in Uniform Magnetic Field]**

(a) $\frac{qdB_0}{3m}$ (b) $\frac{2qdB_0}{m}$ (c) $\frac{qdB_0}{m}$ (d) $\frac{qdB_0}{2m}$

11. A wire carrying current *I* is bent in the shape *ABCDEFA* as shown, where rectangle *ABCDA* and *ADEFA* are perpendicular to each other. If the sides of the rectangles are of lengths *a* and *b*, then the magnitude and direction of magnetic moment of the loop *ABCDEFA* is : **[Magnetic Moment of Current Carrying Loop]**



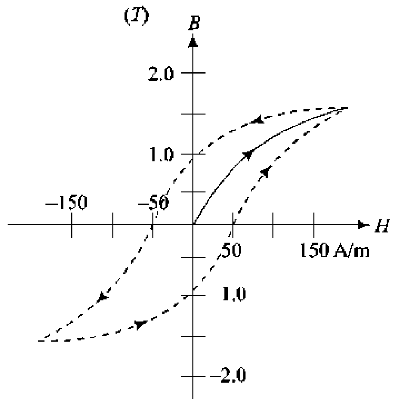
(a) $abI, along\left(\frac{\hat{j}}{\sqrt{2}}+\frac{\hat{k}}{\sqrt{2}}\right)$ (b) $\sqrt{2}abI, along\left(\frac{\hat{j}}{\sqrt{2}}+\frac{\hat{k}}{\sqrt{2}}\right)$

(c) $\sqrt{2}abI, along\left(\frac{\hat{j}}{\sqrt{5}}+\frac{2\hat{k}}{\sqrt{5}}\right)$ (d) $abI, along\left(\frac{\hat{j}}{\sqrt{5}}+\frac{2\hat{k}}{\sqrt{5}}\right)$

12. A small bar magnet placed with its axis at 30° with an external field of 0.06 T experiences a torque of 0.018 Nm The minimum work required to rotate it from its stable to unstable equilibrium position is : **[Bar Magnet in Uniform Magnetic Field]**

(a) 6.4×10^{-2} J (b) 9.2×10^{-3} J (c) 7.2×10^{-2} J (d) 11.7×10^{-3} J

13. The figure gives experimentally measured B vs. H variation in a ferromagnetic material. The retentivity, co-ercivity and saturation, respectively, of the material are: **[Hysteresis Curve of Ferromagnetic Material]**



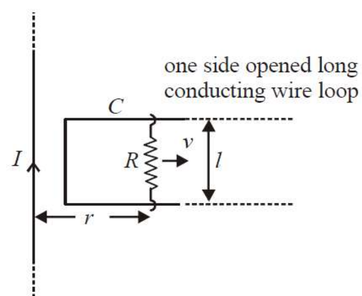
(a) 1.5 T, 50 A/m and 1.0 T
(b) 1.5 T, 50 A/m and 1.0 T
(c) 150 A/m, 1.0 T and 1.5 T
(d) 1.0 T, 50 A/m and 1.5 T

14. Consider a circular coil of wire carrying constant current I, forming a magnetic dipole. The magnetic flux through an infinite plane that contains the circular coil and excluding the circular coil area is given by ϕ_i .The magnetic flux through the area of the circular coil area is given by ϕ_0. Which of the following option is correct?

[Concept of Magnetic Flux]

(a) $\phi_i = \phi_0$
(b) $\phi i > \phi_0$
(c) $\phi_i < \phi_0$
(d) $\phi_i = -\phi_0$

15. An infinitely long straight wire carrying current I, one side opened rectangular loop and a conductor C with a sliding connector are located in the same plane, as shown in the figure. The connector has length l and resistance R. It slides to the right with a velocity v. The resistance of the conductor and the self inductance of the loop are negligible. The induced current in the loop, as a function of separation r, between the connector and the straight wire is : **[Motional emf or Faraday's Law]**



(a) $\frac{\mu_o Ivl}{4\pi Rr}$
(b) $\frac{\mu_o Ivl}{\pi Rr}$
(c) $\frac{2\mu_o Ivl}{\pi Rr}$
(d) $\frac{\mu_o Ivl}{2\pi Rr}$

16. An AC circuit has $R = 100\ \Omega$, $C = 2\ \mu F$ and $L = 80$ mH, connected in series. The quality factor of the circuit is :

[Quality Factor in LCR Circuit]

(a) 2
(b) 0.4
(c) 20
(d) 400

17. The electric field of a plane electromagnetic wave is given by $\vec{E} = E_0(\hat{x} + \hat{y})\sin(kz - \omega t)$ Its magnetic field will be given by : **[Mathematic Equation of Electromagneting Wave]**

(a) $\frac{E_0}{C}(-\hat{x} + \hat{y})\sin(kz - \omega t)$ (b) $\frac{E_0}{C}(\hat{x} + \hat{y})\sin(kz - \omega t)$

(c) $\frac{E_0}{C}(\hat{x} - \hat{y})\sin(kz - \omega t)$ (d) $\frac{E_0}{C}(\hat{x} - \hat{y})\cos(kz - \omega t)$

18. Choose the **correct** option relating wavelengths of different parts of electromagnetic wave spectrum :

[Wavelength of Electromagneting Wave]

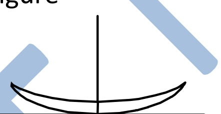
(a) $\lambda_{visible} < \lambda_{micro\ wave} < \lambda_{radio\ waves} < \lambda_{X-ray}$ (b) $\lambda_{radio\ waves} > \lambda_{micro\ wave} > \lambda_{visible} > \lambda_{X-ray}$

(c) $\lambda_{X-ray} < \lambda_{micro\ wave} > \lambda_{radio\ wave} > \lambda_{visible}$ (d) $\lambda_{visible} > \lambda_{X-ray} > \lambda_{radio\ waves} > \lambda_{micro\ wave}$

19. In an experiment to determine the focal length (*f*) of a concave mirror by the *u-v* method, a student places the object pin *A* on the principal axis at a distance *x* from the pole *P*. The student looks at the pin and its inverted image from a distance keeping his/her eye in line with *PA*. When the student shifts his/her eye towards left, the image appears to the right of the object pin. Then **[Image formation due to Mirror]**

(a) *x* < *f* (b) *f* < *x* < 2*f* (c) *x* = 2f (d) *x* > 2*f*

20. The convex surface of a thin concovo-convex lens of glass of refractive index 1.5 has a radius of curvature 20 cm. The concave surface has a radius of curvature 60 cm.The convex side is silvered and placed on a horizontal surface as shown in figure **[Silvering of Lens]**



If the concave part is filling with water (μ= 4/3),where should a pin be placed on the axis so that its image is formed at the same place ?

(a) 15 cm from the lens on the axis (b) 13.9 cm from the lens on the axis

(c) 7.5 cm from the lens on the axis (d) None of these

21. The focal lengths of the objective and the eyepiece of a compound microscope are 2.0 cm and 3.0 cm respectively. The distance between the objective and the eyepiece is 15.0 cm. The final image formed by the eyepiece is at infinity. The two lenses are thin. The distance in cm of the object and the image produced by the objective, measured from the objective lens, are respectively **[Compound Microscope]**

(a) 2.4 and 12.0 (b) 2.4 and 15.0

(c) 2.0 and 12.0 (d) 2.0 and 3.0

22. In a Young's double slit experiment, the separation between the two slits is *d* and the wavelength of the light is λ. The intensity of light falling on slit 1 is four times the intensity of light falling on slit 2. Choose the correct choice. **[YDSE]**

(a) If *d* = λ , the screen will contain three maximum.

(b) If $\lambda < d < 2\lambda$,at least one more maximum (besides the central maximum) will be observed on the screen

(c) If the intensity of light falling on slit 1 is reduced so that it becomes equal to that of slit 2, the intensities of the observed dark and bright fringes will increase

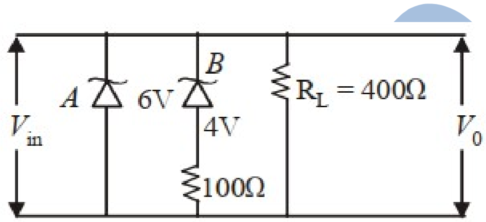
(d) If the intensity of light falling on slit 2 is increased so that it becomes equal to that of slit 1, the intensities of the observed dark and bright fringes will increase.

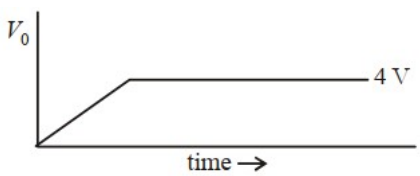
23. Two Polaroid's P_1 and P_2 are placed with their axis perpendicular to each other. Unpolarised light I_0 is incident on P_1. A third Polaroid P_3 is kept in between P_1 and P_2 such that its axis makes an angle θ with that of P_1. The intensity of transmitted light through P_2 is **[Polarisation]**

(a) $\frac{I_0}{2}\cos^2\theta\sin^2\theta$ (b) $\frac{I_0}{4}\cos^2\theta\sin^2\theta$

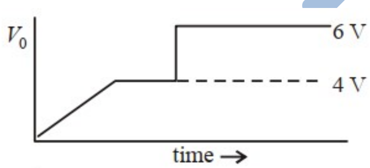
(c) $\frac{I_0}{2}\cos^2\theta$ (d) $\frac{I_0}{8}\cos^2\theta\sin^2\theta$

24. Two Zener diodes (A and B) having breakdown voltages of 6 V and 4 V respectively, are connected as shown in the circuit below. The output voltage V_0 variation with input voltage linearly increasing with time, is given by : (V_{input} = 0 V at t = 0) (figures are qualitative) **[Zener Diode]**

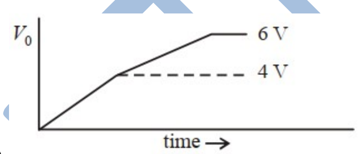




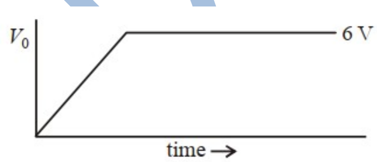
(a)



(b)

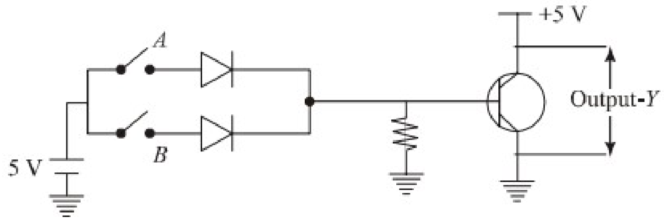


(c)



(d)

25. Boolean relation at the output stage – Y for the following circuit is :- **[Logic gates]**



(a) $\overline{A}+\overline{B}$ (b) A + B (c) A.B (d) $\overline{A}\cdot\overline{B}$

Ans. d

Answer Key

1- c	2- d	3- d	4- d	5- d
6- c	7- c	8- d	9- a	10- c
11- b	12- c	13- d	14- d	15- d
16- a	17- a	18- b	19- b	20- b
21- a	22- b	23- a	24- c	25- d