Sample Paper 4

ANSWER KEYS																			
1	(b)	**7**	(d)	**13**	(a)	**19**	(a)	**25**	(d)	**31**	(c)	**37**	(b)	**43**	(d)	**49**	(c)	**55**	(c)
2	(a)	**8**	(d)	**14**	(c)	**20**	(a)	**26**	(c)	**32**	(b)	**38**	(b)	**44**	(a)	**50**	(c)		
3	(b)	**9**	(a)	**15**	(a)	**21**	(b)	**27**	(b)	**33**	(b)	**39**	(b)	**45**	(c)	**51**	(c)		
4	(b)	**10**	(b)	**16**	(c)	**22**	(c)	**28**	(a)	**34**	(a)	**40**	(b)	**46**	(c)	**52**	(b)		
5	(b)	**11**	(a)	**17**	(a)	**23**	(a)	**29**	(a)	**35**	(a)	**41**	(a)	**47**	(a)	**53**	(a)		
6	(d)	**12**	(a)	**18**	(a)	**24**	(a)	**30**	(c)	**36**	(c)	**42**	(c)	**48**	(b)	**54**	(d)		

SOLUTIONS

1. **(b)** Mutual Inductance of two coils

$M = \sqrt{L_1 L_2} = \sqrt{2mH \times 8mH} = 4mH$

2. **(a)**

3. **(b)** $V = 50 \times 2 \sin 100\pi \cos 100\pi t = 50 \sin 200\pi t$

$\Rightarrow V_0 = 50$ *Volts* and $\nu = 100$ *Hz*

4. **(b)** Efficiency of the transformer

$$\eta = \frac{P_{output}}{P_{input}} \times 100 = \frac{100}{220 \times 0.5} \times 100 = 90.9\%$$

5. **(b)** $$e = \frac{-(\phi_2 - \phi_1)}{t} = \frac{-(0 - NBA)}{t} = \frac{NBA}{t}$$

$$t = \frac{NBA}{e} = \frac{50 \times 2 \times 10^{-2} \times 10^{-2}}{0.1} = 0.1\ s$$

6. **(d)** The self inductance of a long solenoid is given by

$L = \mu_r \mu_0 n^2 A l$

Self inductance of a long solenoid is independent of the current flowing through it.

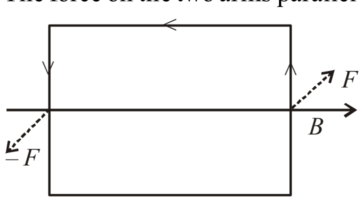
7. **(d)** As magnetic moment = pole strength x length and length is halved without affecting pole strength, therefore, magnetic moment becomes half.

8. **(d)** The strength of the earth's magnetic field is not constant. It varies from one place to other place on the surface of earth. Its value being of the order of 10^{-5} T.

9. **(a)** $$F = \frac{\mu_0}{4\pi} \times \frac{2 i_1 i_2}{r}$$

$= 50 \times 10^{-7}$ N/m. Here F is force per unit length.

10. **(b)** The force on the two arms parallel to the field is zero.



$\therefore$ Force on remaining arms $= -F$

11. **(a)** As we known that the resistance of wire is $R = \rho \frac{l}{A}$

For maximum value of R, l must be higher and A should be lower and it is possible only when the battery is connected across area of cross section $= 1cm \times \left(\frac{1}{2}\right)$ cm.

12. **(a)** r = mv/Bq is same for both.

13. **(a)** In the parallel combination,

$$\frac{\varepsilon_{eq}}{r_{eq}} = \frac{\varepsilon_1}{r_1} + \frac{\varepsilon_2}{r_2} + ... + \frac{\varepsilon_n}{r_n}$$

$$\frac{1}{r_{eq}} = \frac{1}{r_1} + \frac{1}{r_2} + ... + \frac{1}{r_n}$$

$(\because \varepsilon_1 = \varepsilon_2 = \varepsilon_3 = ... = \varepsilon_n = \varepsilon$ and $r_1 = r_2 = r_3 = ...\ r)$

$$\therefore \frac{\varepsilon_{eq}}{r_{eq}} = \frac{\varepsilon}{r} + \frac{\varepsilon}{r} + ... + \frac{\varepsilon}{r} = n\frac{\varepsilon}{r} \quad .... (i)$$

$$\frac{\varepsilon}{r_{eq}} = \frac{1}{r} + \frac{1}{r} + ... + \frac{1}{r} = \frac{n}{r} \quad r_{eq} = r/n \quad ....(ii)$$

From (i) and (ii)

$$\varepsilon_{eq} = n\frac{\varepsilon}{r_{eq}} \times r_{eq} = n \times \frac{\varepsilon}{r} \times \frac{\varepsilon}{r} = \varepsilon$$

14. **(c)** If a heater boils m kg water in time t_1 and another heater boils the same water in t_2, then both connected in series will boil the same water in time $t_s = t_1 + t_2$ and if in parallel $t_p = \frac{t_1 t_2}{t_1 + t_2}$ [Use time taken $\propto$ Resistance]

15. **(a)**

16. **(c)** In a round trip, displacement is zero. Hence, work done is zero.

17. **(a)** Due to increases in resistance *R* the current through the wire will decrease and hence the potential gradient also decreases, which results in increase in balancing length. So. *J* will shift towards *B*.

18. **(a)**

19. **(a)** Figure indicates the presence of some positive charge to the left of A.

$\therefore$ $E_A > E_B$ ($\because r_A < r_B$)

20. **(a)** **Given :** Length of the dipole $(2l) = 10cm = 0.1m$ or $l = 0.05m$

Charge on the dipole (q) = 500 μC = 500×10^{-6} C and distance of the point on the axis from the mid-point of the dipole (r) = 20 + 5 = 25 cm = 0.25 m.

We know that the electric field intensity due to dipole on the given point (E)

$$= \frac{1}{4\pi\varepsilon_0} \times \frac{2(q.2l)r}{(r^2 - l^2)^2}$$

$$= 9 \times 10^9 \times \frac{2(500 \times 10^{-6} \times 0.1) \times 0.25}{[(0.25)^2 - (0.05)^2]^2}$$

$$= 6.25 \times 10^7 \; N/C \; (k = 1 \text{ for air})$$

21. **(b)**

22. **(c)** $C = \frac{2 \times 2}{2+2} + 2 = 3 \, \mu F$

23. **(a)** According to Gauss's theorem

$$\phi = \frac{\Sigma q_{en}}{\varepsilon_0}$$

So, net charge enclosed by the surface is zero if the net electric flux through a closed surface is zero.

24. **(a)** PE, $U_0 = Q^2/2C$

When a slab of dielectric constant k is inserted, then $C' = Ck$

$$U' = \frac{Q^2}{2C'} = \frac{Q^2}{2Ck} = \frac{U_0}{k}$$

25. **(d)**

26. **(c)** Let n be the number of electrons missing.

$$F = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q^2}{d^2} \Rightarrow q = \sqrt{4\pi\varepsilon_0 d^2 F} = ne$$

$$\therefore \quad n = \sqrt{\frac{4\pi\varepsilon_0 F d^2}{e^2}}$$

27. **(b)** As given that, $v = 50$ Hz, $I_{rms} = 5A$

$$t = \frac{1}{300} s$$

As we know that $I_{rms} = \frac{I_0}{\sqrt{2}}$

I_0 = Peak value $= \sqrt{2}.I_{rms} = \sqrt{2} \times 5$

$I_0 = 5\sqrt{2}A$

at, $t = \frac{1}{300}$ sec, $I = I_0 \sin\omega t = 5\sqrt{2} \sin 2\pi vt$

$$= 5\sqrt{2} \sin 2\pi \times 50 \times \frac{1}{300}$$

$$I = 5\sqrt{2} \sin\frac{\pi}{3} = 5\sqrt{2} \times \frac{\sqrt{3}}{2} = 5\sqrt{3/2} \text{ Amp} \left(\therefore \sin\frac{\pi}{3} = \frac{\sqrt{3}}{2}\right)$$

$$I = \left(5\sqrt{\frac{3}{2}}\right) A$$

28. **(a)**

29. **(a)** Gaussian surface cannot pass through any discrete charge because electric field due to a system of discrete charges is not well defined at the location of the charges. But the Gaussian surface can pass through a continuous charge distribution.

30. **(c)** Electric potential inside a conductor is constant and it is equal to that on the surface of the conductor.

31. **(c)** The capacitance of parallel plate capacitor filled with dielectric of thickness d_1 and dielectric constant K_1 is

$$C_1 = \frac{K_1\varepsilon_o A}{d_1}$$

Similarly, capacitance of parallel plate capacitor filled with dielectric of thickness d_2 and dielectric constant K_2 is

$$C_2 = \frac{K_2\varepsilon_o A}{d_2}$$

Since both capacitors are in series combination, then the equivalent capacitance is

$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2}$$

or $$C = \frac{C_1 C_2}{C_1 + C_2} = \frac{\frac{K_1\varepsilon_0 A}{d_1} \frac{K_2\varepsilon_0 A}{d_2}}{\frac{K_1\varepsilon_0 A}{d_1} + \frac{K_2\varepsilon_0 A}{d_2}}$$

$$C = \frac{K_1 K_2 \varepsilon_0 A}{K_1 d_2 + K_2 d_1} \quad \text{...(i)}$$

So multiply the numerator and denominator of equation (i) with $(d_1 + d_2)$

$$C = \frac{K_1 K_2 \varepsilon_0 A}{(K_1 d_2 + K_2 d_1)} \times \frac{(d_1 + d_2)}{(d_1 + d_2)}$$

$$= \frac{K_1 K_2 (d_1 + d_2)}{(K_1 d_2 + K_2 d_1)} \times \frac{\varepsilon_0 A}{(d_1 + d_2)} \quad \text{...(ii)}$$

So, the equivalent capacitances is

$$C = \frac{K\varepsilon_0 A}{(d_1 + d_2)} \quad \text{...(iii)}$$

Comparing, (ii) and (iii), the dielectric constant of new capacitor

$$K = \frac{K_1 K_2 (d_1 + d_2)}{K_1 d_2 + K_2 d_1}$$

32. **(b)**

33. **(b)** Electric field is always zero inside a conductor.
If there is any excess of charge on a hollow conductor it always resides on the outer surface of conductor. Therefore inside a hollow conductor there is no charge and hence charge density is zero.

34. **(a)** Potential gradient of wire $= \frac{V}{\ell} = \left(\frac{\rho}{A}\right) \times I$
where ℓ & A are the length and cross-section of wire
so $\frac{V}{\ell} = \frac{4 \times 10^{-7}}{8 \times 10^{-6}} \times 0.5 = 25 \text{mV / meter}$

35. **(a)**

36. **(c)** Equating magnetic force to centripetal force,
$$\frac{mv^2}{r} = qvB \sin 90^\circ$$
Time to complete one revolution, $T = \frac{2\pi r}{v} = \frac{2\pi m}{qB}$

37. **(b)** As $R \propto V^2/P$ or $R \propto 1/P$, so resistance of heater is less than that of fan.

38. **(b)**

39. **(b)** Magnetic field at a point on one end of a solenoid
$$B = \frac{1}{2}\mu_0 ni$$

40. **(b)** Magnetic meridian of a place is defined as the vertical plane which passes through the imaginary line joining the magnetic North and South-poles. This pane would intersect the surface of the Earth in a longitude like circle.

41. **(a)** $L = \frac{\varepsilon}{dI/dt} = \frac{10 \times 10^{-3}}{2} = 5 \times 10^{-3}$ Henry

42. **(c)** Impedance at resonant frequency is minimum in series LCR circuit.
So, $Z = \sqrt{R^2 + \left(2\pi fL - \frac{1}{2\pi fC}\right)^2}$

43. **(d)** Relative motion between the magnet and the coil that is responsible for induction in the coil.

44. **(a)** Force between two long conductor carrying current,
$$F = \frac{\mu_0}{4\pi}\frac{2I_1I_2}{d} \times \ell\,;\; F' = -\frac{\mu_0}{4\pi}\frac{2(2I_1)I_2}{3d}\ell$$
$$\therefore \frac{F'}{F} = \frac{-2}{3}$$

45. **(c)**

46. **(c)** Sensitivity of galvanometer, $s = \frac{\theta}{i} \approx \frac{\tan\theta}{i} = \frac{\mu_0 N}{2RB_H}$.
If a magnetic material is placed inside coil of galvanometer, then
$$s' = \frac{\mu_r \mu_0 N}{2RB_H}.$$

47. **(a)** In the battery connected capacitor V remains constant while C increases with the introduction of dielectric.

48. **(b)** $E = -\frac{dv}{dx}$

49. **(c)** Due to electric field, the force is $\vec{F} = q\vec{E}$ in the direction of $\vec{E}$. Since $\vec{E}$ is parallel to $\vec{B}$, the particle velocity $\vec{v}$ (acquired due to force $\vec{F}$) is parallel to $\vec{B}$. Hence $\vec{B}$ will not exert any force since $\vec{v} \times \vec{B} = 0$ and the motion of the particle is not affected by $\vec{B}$.

50. **(c)** Potential energy of a dipole in external field U is
$U = -\vec{P} \cdot \vec{E}$
for stable equilibrium $\theta = 0°$
$U = -pE\cos 0° = -pE$
$\therefore U = -qLE$

51. **(c)**

52. **(b)** In series RLC circuit,
Voltage, $V = \sqrt{V_R^2 + (V_L - V_C)^2}$
And, at resonance, $V_L = V_C$
Hence, $V = V_R$

53. **(a)**

54. **(d)** In LCR series circuit, resonance frequency f_0 is given by
$$L\omega = \frac{1}{C\omega} \Rightarrow \omega^2 = \frac{1}{LC} \quad \therefore \omega = \sqrt{\frac{1}{LC}} = 2\pi f_0$$
$$\therefore f_0 = \frac{1}{2\pi\sqrt{LC}} \quad \text{or} \quad f_0 \alpha \frac{1}{\sqrt{C}}$$
When the capacitance of the circuit is made 4 times, its resonant frequency become f_0'
$$\therefore \frac{f_0'}{f_0} = \frac{\sqrt{C}}{\sqrt{4C}} \quad \text{or} \quad f_0' = \frac{f_0}{2}$$

55. **(c)** $Z = \sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}$
Here R = 100 W, L = 0.5 henry, C = 10 × 10^6 farad
$\omega = 2 p \pi = 100\pi$.