Assignment 6

1. Take a thin tube of inner radius a and outer radius b. It is made of a non-magnetic conducting material of conductivity σ which is the inverse of the resistivity. As soon as a magnet of magnetic moment M and mass m is dropped through the tube, it attains a terminal velocity $v_T = \frac{mg}{k}$. If $k \propto \frac{\mu_0^\alpha \sigma^\beta M^\gamma (b-a)^\delta}{a^4}$ then the values of $\alpha, \beta, \gamma, \delta$ are respectively:

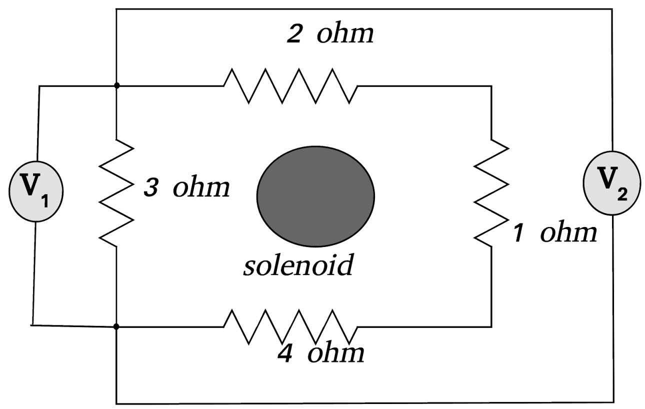
   A. $2, 1, 2, 1$

   B. $1, 2, 2, 1$

   C. $1, 1, 2, 2$

   D. $2, 1, 1, 2$

2. Shown in the circuit is a square loop made of 4 resisters around a solenoid shown by circular shaded region.



   The current in the solenoid changes with time so that the EMF developed is $20\,V$. When a voltmeter is connected across the $3\,\Omega$ resister in two different ways giving the voltage V_1 and V_2 respectively. Then

   A. $V_1 = V_2 = 6\,V$

   B. $V_1 = 14\,V \text{and}\, V_2 = 6\,V$

   C. $V_1 = 6\,V \text{and}\, V_2 = 14\,V$

   D. $V_1 = V_2 = 14\,V$

3. A charged particle of charge q is moving along the positive $z-$axis with constant speed v. It passes the origin at time $t = 0$. At a later time t, the displacement current density at the origin is: $(v << c)$

   A. $\frac{1}{4\pi\epsilon_0} \frac{q}{v^2 t^2} \hat{z}$

   B. $\frac{-1}{2\pi\epsilon_0} \frac{q}{v^2 t^2} \hat{z}$

   C. $\frac{1}{2\pi} \frac{q}{v^2 t^3} \hat{z}$

   D. $\frac{-1}{4\pi} \frac{q}{v^2 t^3} \hat{z}$

4. If the charged particle of problem 3 produces a magnetic field $\vec{B}(t)$ at a distance R from the origin in the xy-plane, then $\vec{B}(t)$ is: (polar coordinates are used)

   A. 0

   B. $\frac{1}{c^2} \frac{qv^2 t}{(R^2+v^2t^2)^{\frac{3}{2}}} \hat{\phi}$

   C. $\frac{1}{4\pi\epsilon_0} \frac{qvR}{(R^2+v^2t^2)^{\frac{3}{2}}} \hat{\phi}$

   D. $\frac{\mu_0}{4\pi} \frac{qvR}{(R^2+v^2t^2)^{\frac{3}{2}}} \hat{\phi}$

5. A sphere carries surface charge density σ. Its centre is at the origin and it is rotating about the $z-$axis with angular speed $\vec{\omega} = \omega\hat{z}$. The Poynting vector $\vec{S}(\theta)$ just outside its surface is given as:

   A. $\frac{\sigma^2 R\omega}{\epsilon_0}\hat{\phi}$

   B. $\frac{\sigma^2 R\omega}{3\epsilon_0}\sin\theta\hat{\phi}$

   C. $\frac{\sigma^2 R\omega}{2\epsilon_0}\cos\theta\hat{\phi}$

   D. $\frac{\sigma^2 R\omega}{3\epsilon_0}\cos\theta\hat{\phi}$

6. A long solenoid with radius R has n turns per unit length and is carrying a current I_0 at time $t = 0$. If the current for $t > 0$ changes as $I = I_0 + \alpha t$, then Poynting vector just inside the cylindrical surface of the solenoid will be: (use cylindrical coordinates)

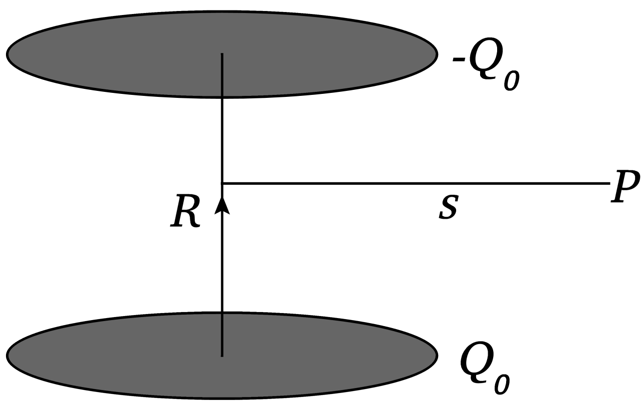
   A. $\frac{n^2 R^2 \alpha^2 t}{2}\hat{s}$

   B. $\frac{-\mu^2 n^2 R^2 \alpha(I_0+\alpha t)}{4}\hat{s}$

   C. $\frac{-\mu n^2 R^2 \alpha(I_0+\alpha t)}{4}\hat{s}$

   D. $\frac{-\mu n^2 R\alpha(I_0+\alpha t)}{2}\hat{s}$

7. Consider two large circular plates of radius a forming a capacitor with the distance between the plates being d. They carry an initial charge $\pm Q$ as shown.



   If they are connected by a thin wire passing through their centre, a current starts flowing through the wire. If the resistance of the wire is R, what will be the magnetic field at a distance s from the wire at point P: (assume wire to be long wire and use the cylindrical coordinates)

   A. $\frac{\mu_0}{4\pi}\frac{Q_0}{RC}e^{-\frac{t}{RC}}(\frac{a}{s^2} - \frac{1}{s})\hat{\phi}$

   B. $\frac{\mu_0}{4\pi}\frac{Q_0}{RC}e^{-\frac{t}{RC}}(\frac{a}{s^2} + \frac{1}{s})\hat{\phi}$

   C. $\frac{\mu_0}{4\pi}\frac{Q_0}{RC}e^{-\frac{t}{RC}}(\frac{1}{s} - \frac{s}{a^2})\hat{\phi}$

   D. $\frac{\mu_0}{4\pi}\frac{Q_0}{RC}e^{-\frac{t}{RC}}(\frac{a}{s^2} - \frac{s}{a^2})\hat{\phi}$

8. The Poynting vector in problem 7 at a distance s from the wire at point P (using cylindrical coordinates) is:

   A. $\frac{-Q_0^2}{2\pi a^2\epsilon_0 RC}e^{-\frac{2t}{RC}}(\frac{1}{s} - \frac{s}{a^2})\hat{s}$

   B. $\frac{Q_0^2}{2\pi a^2\epsilon_0 RC}e^{-\frac{2t}{RC}}(\frac{1}{s} + \frac{s}{a^2})\hat{s}$

   C. $\frac{-Q_0^2}{2\pi a^2\epsilon_0 RC}e^{-\frac{2t}{RC}}(\frac{a}{s^2} - \frac{s}{a^2})\hat{s}$

   D. $\frac{Q_0^2}{2\pi a^2\epsilon_0 RC}e^{-\frac{2t}{RC}}(\frac{1}{s} - \frac{s}{a^2})\hat{s}$