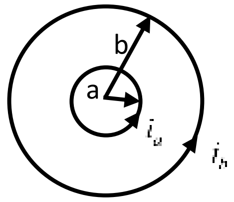
Inductance and Eddy Current

2021-22

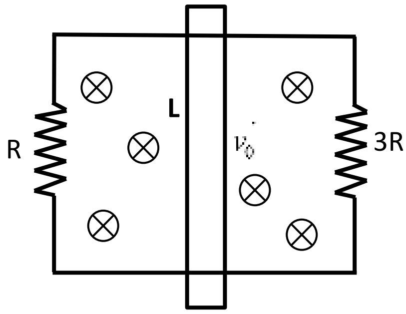
Each question carries 10 marks.
Test Time: 30 minutes

1. A circular loop of radius a is placed inside another circular loop of radius 'b' as shown. The inner loop carries a current 'i_a'. Find the expression for the current in the outer loop due to the inner loop. $(a << b)$ (Assume the outer loop resistance is R)



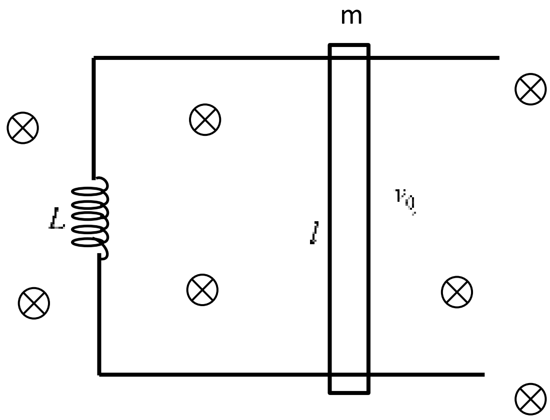
(A) $\frac{\mu_0 \pi a^2}{bR}\frac{di_a}{dt}$ (B) $\frac{\mu_0 \pi b^2}{ba}\frac{di_b}{dt}$ (C) $\frac{\mu_0 \pi a^2}{2bR}\frac{di_a}{dt}$ (D) $\frac{\mu_0 \pi b^2}{2ba}\frac{di_b}{dt}$

2. Two parallel, perfectly conducting rails are connected by resistances R and $3R$ as shown. A rod of length L and resistance $2R$ slides over the rails as shown. The whole set up is oriented horizontally. A uniform magnetic field pointing vertically downward fills the entire space. Assume that there is no friction between the rod and the rails. The rod has an initial velocity v_0 in the direction shown. Find the magnitude current passing through the rod at the instant the rod has an initial velocity v_0.



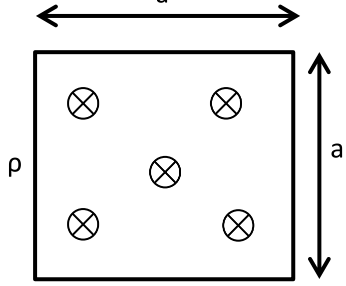
(A) $\frac{4BLv_0}{3R}$ (B) $\frac{4BLv_0}{2R}$ (C) $\frac{4BLv_0}{11R}$ (D) $\frac{3BLv_0}{11R}$

3. Two parallel, perfectly conducting rails are connected by an inductor L at one end as shown. A rod of mass m and length l slides over the rails. The whole set up is oriented horizontally. A uniform magnetic field pointing vertically downward, fills the entire space. Assume that there is no friction between the rod and the rails. The rod has an initial velocity v_0 in the direction shown. Find the maximum displacement of the rod from its central position.



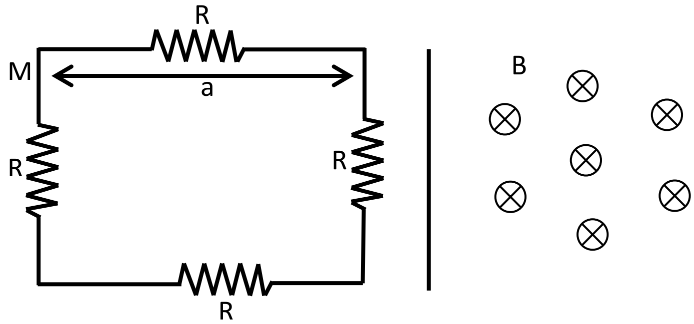
(A) $\frac{v_0 mL}{Bl}$ (B) $\frac{v_0 mL}{\sqrt{Bl}}$ (C) $v_0\sqrt{\frac{mL}{Bl}}$ (D) $\frac{v_0\sqrt{mL}}{Bl}$

4. A thin square frame of length 'a' and resistivity 'ρ' is placed in a region of uniform but time varying magnetic field B, perpendicular to the plane of the ring. The initial magnetic field is B_0 and it decreases to zero in time T. Find the current through the frame wire as a function of time.
(The cross sectional area of the wire is A)



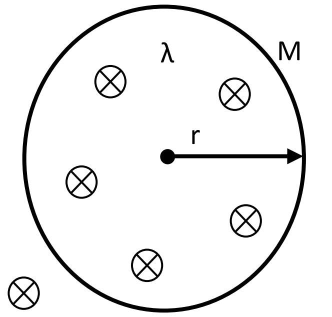
(A) $\frac{aB_0A}{4T\rho}$ (B) $\frac{aB_0A}{4\rho}$ (C) $\frac{aB_0}{4\rho}$ (D) $\frac{aB_0A}{4T}$

5. A square frame of side length a and mass M has a resistance R in each of its arms. A force F is applied on the frame and it moves with constant velocity v into the region having magnetic field B until the frame fully enters the filed. Find the applied force F.



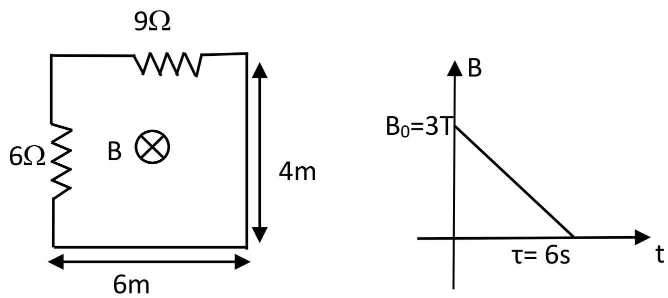
(A) $\frac{B^2a^2v^2}{2R}$ (B) $\frac{B^2a^2v}{2R}$ (C) $\frac{B^2a^2v}{4R}$ (D) $\frac{B^2a^2v^2}{4R}$

6. A non-conducting ring of mass M and radius $'r'$ with uniform linear charge density λ encloses a region of a uniform (in space) but time varying magnetic field B, perpendicular to the plane of the ring (pointing into the diagram). The initial magnetic field is B_0. The magnetic field is then switched off and decreases to zero. Find the angular velocity of the ring when the magnetic field becomes zero.

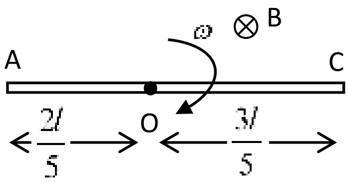


(A) $\frac{B_0\pi r^2\lambda}{2M}$ (B) $\frac{B_0\pi r\lambda}{M}$ (C) $\frac{B_0\pi r^2\lambda^2}{M}$ (D) $\frac{B_0\pi r\lambda}{2M}$

7. A rectangular wire frame with resistances 6Ω and 9Ω on two of its arms is kept in a region of uniform (in space) but time varying magnetic field B, perpendicular to the plane of the frame (pointing into the diagram). The change in the magnetic field with respect to time is as shown in the graph. Find the total charge that passes through the 6Ω resistor from $t = 0$ to $t = T$.



8. A thin uniform rod of length l is rotating in the horizontal plane with angular velocity ω in a region of uniform magnetic field B, acting vertically downward. Find the potential drop from C to A, V_{CA}.



(A) $\frac{-\omega Bl^2}{10}$ (B) $\frac{\omega Bl^2}{5}$ (C) $\frac{\omega Bl^2}{10}$ (D) $\frac{-\omega Bl^2}{5}$