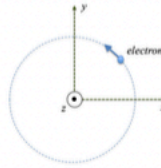


1)

[10 pts.] An electron (charge $-e$, mass m) moves at constant speed on a circular orbit in the x - y -plane, counter-clockwise with a period T , in a uniform magnetic field (see figure). The magnetic field is (hint: the centripetal force is $F=mv^2/r$)



$$\vec{B} = + \frac{m}{eT} \hat{z}$$

$$\vec{B} = - \frac{m}{eT} \hat{z}$$

$$\vec{B} = + \frac{mT}{2\pi e} \hat{z}$$

$$\vec{B} = - \frac{mT}{2\pi e} \hat{z}$$

$$\vec{B} = + \frac{2\pi m}{eT} \hat{z}$$

$$\vec{B} = - \frac{2\pi m}{eT} \hat{z}$$

$$\vec{B} = + \frac{mT}{e} \hat{z}$$

$$\vec{B} = - \frac{mT}{e} \hat{z}$$

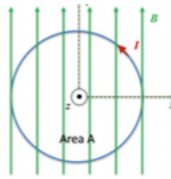
$$\vec{B} = + \frac{m}{2\pi eT} \hat{z}$$

$$\vec{B} = - \frac{m}{2\pi eT} \hat{z}$$

None of the above

2)

2) [10 pts.] A current loop of area 0.1m^2 , carrying a counter-clockwise current of 0.5 A , is lying in the x - y plane (see figure). A uniform magnetic field of magnitude $B = 0.25\text{ T}$ is pointing in the positive y -direction. Using the magnetic moment of the loop, compute the torque on the current loop.



$= + 0.25\text{ N}\cdot\text{m}\hat{x}$

$= - 0.25\text{ N}\cdot\text{m}\hat{x}$

$= + 0.13\text{ N}\cdot\text{m}\hat{y}$

$= - 0.13\text{ N}\cdot\text{m}\hat{y}$

$= - 0.013\text{ N}\cdot\text{m}\hat{x}$

$= + 0.26\text{ N}\cdot\text{m}\hat{y}$

$= - 0.013\text{ N}\cdot\text{m}\hat{y}$

$= + 0.05\text{ N}\cdot\text{m}\hat{x}$

$= - 0.05\text{ N}\cdot\text{m}\hat{x}$

None of the above

3)

1) [6 pts.] The work done by the Lorentz force acting on an electron moving in a uniform magnetic field (no electric field)

depends on the direction of motion of the electron

is positive, keeping it on a helical (or circular) path

is negative, keeping it on a helical (or circular) path

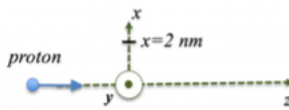
keeps changing sign during the electron's motion

is zero

None of the above

4)

4) [10 pts.] A proton (charge $+e$) is moving along the z -axis in positive direction. When it passes through $z=0$, it produces a magnetic field of 0.5 T at $x = 2 \text{ nm}$. What is the direction of the magnetic field and the speed of the proton?



B in positive z -direction, speed $3.25 \cdot 10^8 \text{ m/s}$

B in negative z -direction, speed $3.25 \cdot 10^8 \text{ m/s}$

B in positive y -direction, speed $1.25 \cdot 10^8 \text{ m/s}$

B in negative y -direction, speed $1.25 \cdot 10^8 \text{ m/s}$

B in positive y -direction, speed $0.25 \cdot 10^8 \text{ m/s}$

B in negative y -direction, speed $0.25 \cdot 10^8 \text{ m/s}$

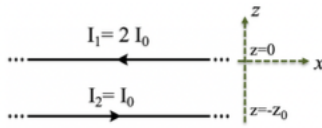
B in positive x -direction, speed $0.025 \cdot 10^8 \text{ m/s}$

B in negative x -direction, speed $0.025 \cdot 10^8 \text{ m/s}$

None of the above

5)

[8 pts.] Two straight long parallel wires in x-direction are placed in the x-z-plane carrying current $I_1 = 2 I_0$ and $I_2 = I_0$, see the figure below. Wire-1 is located at $z=0$ and wire-2 is at $z=-z_0$ ($z_0 > 0$). The total magnetic field is zero at :



$z = -4 z_0$

$z = -2 z_0$

$z = -\frac{2}{3} z_0$

$z = -z_0/2$

$z = z_0$

$z = 2 z_0$

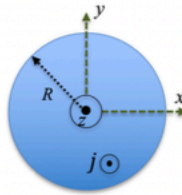
$z = 4 z_0$

nowhere

None of the above

6)

[10 pts.] A long uniform cylindrical wire of radius R is aligned with and centered on the z -axis as shown in the figure. It carries a uniform current density j in the direction out of the page. Apply Ampère's law to compute the direction and magnitude of the magnetic field at any location which is a distance $r > R$ from the wire.



$$B = \frac{\mu_0}{2} \left(\frac{j}{r R^2} \right) \text{ in the y-direction}$$

$$B = \frac{\mu_0}{2} \left(\frac{j}{r R^2} \right) \text{ in the tangential direction}$$

$$B = \frac{\mu_0}{2} \left(\frac{j}{r R^2} \right) \text{ in the radial direction}$$

$$B = \frac{\mu_0}{2} \left(\frac{j R^2}{r} \right) \text{ in the x-direction}$$

$$B = \frac{\mu_0}{2} \left(\frac{j R^2}{r} \right) \text{ in the tangential direction}$$

$$B = \frac{\mu_0}{2} \left(\frac{j R^2}{r} \right) \text{ in the radial direction}$$

$$B = \frac{\mu_0}{2} \left(\frac{j R}{r^2} \right) \text{ in the z-direction}$$

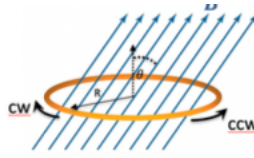
$$B = \frac{\mu_0}{2} \left(\frac{j R}{r^2} \right) \text{ in the tangential direction}$$

$$B = \frac{\mu_0}{2} \left(\frac{j R}{r^2} \right) \text{ in the radial direction}$$

None of the above

7)

7) [8 pts.] A current loop of radius R is located in the x - y -plane and immersed in a uniform magnetic field that makes an angle θ with the normal vector of the loop, see figure. The magnetic field strength increases at a rate $\frac{dB}{dt}$. What is the magnitude and direction (as viewed from above) of the electric field induced along the current loop? (cw=clockwise, ccw=counter-clockwise)



$$E = \frac{R}{2} \frac{dB}{dt} \cos(\theta), \text{ ccw}$$

$$E = \frac{R}{2} \frac{dB}{dt} \cos(\theta), \text{ cw}$$

$$E = R^2 \frac{dB}{dt} \sin(\theta), \text{ ccw}$$

$$E = \frac{1}{2R} \frac{dB}{dt} \cos(\theta), \text{ cw}$$

$$E = \frac{1}{2R} \frac{dB}{dt} \tan(\theta), \text{ cw}$$

$$E = \pi R^2 \frac{dB}{dt} \sin(\theta), \text{ cw}$$

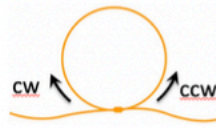
$$E = \frac{R}{2} \frac{dB}{dt} \tan(\theta), \text{ ccw}$$

$$E = \pi R^2 \frac{dB}{dt} \cos(\theta), \text{ cw}$$

None of the above

8)

[8 pts.] A circular current loop (initial radius r_0) is made of a movable cable that can be pulled to contract the loop, as shown on the figure. The loop is immersed in a uniform magnetic field pointing out of the page (parallel to the normal vector of the loop). A student starts to pull on both ends of the cable, reducing the radius as $r(t)=r_0-vt$. Calculate the EMF induced in the loop.



$B \ 2 \ \pi v \ (r_0 - vt)$, inducing a clockwise current

$B \ 2 \ \pi v \ (r_0 - vt)$, inducing a counter-clockwise current

$B \ \pi v \ (r_0 - vt)$, inducing a clockwise current

$B \ \pi v \ (r_0 - vt)$, inducing a counter-clockwise current

$B \ \pi \ (r_0 - vt)^2$, inducing a clockwise current

$B \ \pi \ (r_0 - vt)^2$, inducing a counter-clockwise current

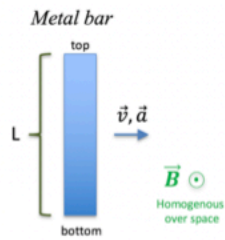
$B \ 2 \ \pi \ v \ r_0$, inducing a clockwise current

$B \ 2 \ \pi \ v \ r_0$, inducing a counter-clockwise current

None of the above

9)

[6 pts.] A metal bar of height L is moving and accelerating towards the right through a uniform magnetic field B pointing out of the page as shown in the picture. The voltage difference between the top and bottom ends of the bar, $\Delta V = V_{\text{top}} - V_{\text{bottom}}$, is :



positive and constant

negative and constant

zero

positive and increasing

negative and decreasing

oscillating between positive and negative

None of the above

10)

[6 pts.] The current inside a coil is ramped up steadily from 0 to 5 A during a 0.5 s time interval. It is found to induce an EMF of 2 V. What is the inductance of the coil?

20 H

5 H

2 H

0.5 H

0.2 H

0.05 H

None of the above

11)

11) [8 pts.] What current is needed in a long solenoid coil (2000 windings, 1.5 m long) to produce an energy density of 20J/m^3 inside it?

32 A

17.6 A

4.2 A

3.4 A

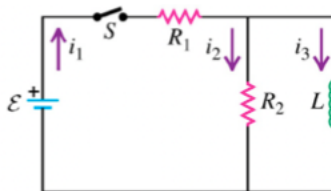
3.0 A

0.88 A

None of the above

12)

12) [10 pts.] In the circuit shown the switch is closed at time $t=0$. Find the current i_1 immediately after the switch has been closed, $i_1(t \rightarrow 0)$, and in the long-time limit, $i_1(t \rightarrow \infty)$.



$\frac{\mathcal{E}}{R_1 + R_2}$ and 0

0 and 0

0 and $\frac{\mathcal{E}}{R_1}$

0 and $\frac{\mathcal{E}}{R_2}$

$\frac{\mathcal{E}}{R_1 + R_2}$ and $\frac{\mathcal{E}}{R_1}$

$\frac{\mathcal{E}}{R_1}$ and $\frac{\mathcal{E}}{R_1 + R_2}$ and

None of the above