Exam-3 Phys-207 spring2021

1) *[10 pts.]* Charged particle Lorentz force; A particle of charge +12 mC is moving at a speed of 130 m/s in the positive x-direction through a uniform magnetic field. The particle is experiencing a Lorentz force in negative y-direction of magnitude 3 N. The magnetic field is

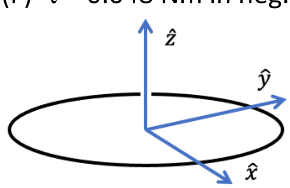
(A) B= 0.1 T in pos. z-direction
(B) B=0.1 T in neg. z-direction
(C) B=0.4 T in pos. z-direction
(D) B=0.4 T in neg. z-direction
(E) B= 0.8 T in pos. z-direction
(F) B=0.8 T in neg. z-direction
(G) B=1.9 T in pos. z-direction <<<correct
(H) B=1.9 T in neg. z-direction

2) *[8 pts.]* Proton in a Magnetic Field ; A proton (charge +e, mass $1.67*10^{-27}$ kg) is moving in the x-y-plane at an unknown speed. A uniform magnetic field of strength 2.8 T, directed in positive z-direction, is causing the proton to be in a uniform circular motion. Calculate the frequency (revolutions per second) of the proton's periodic motion.
(The centripetal force is $F=mv^2/r$)

(A) 520 Hz
(B) 13000 Hz
(C) $4.3 \cdot 10^7$ Hz <<<correct
(D) $2.7 \cdot 10^8$ Hz
(E) $5.6 \cdot 10^{17}$ Hz
(F) $9.8 \cdot 10^{18}$ Hz

3) *[10 pts.] Circular loop torque;* A circular wire loop of radius 0.15 m is lying in the x-y plane as illustrated, carrying a current of 1.8 A resulting in a magnetic moment pointing in the positive z-direction. A uniform magnetic field of magnitude B = 0.4 T is pointing in the positive x-direction. Determine the torque acting on it.

(A) τ = 0.48 Nm in pos. x-dir.
(B) τ = 0.51 Nm in neg. x-dir.
(C) τ = 0.21 Nm in neg. y-dir.
(D) τ = 0.051 Nm in pos. y-dir. <<<correct
(E) τ =0.021 Nm in pos. y-dir.
(F) τ = 0.048 Nm in neg. x-dir.



4) [*6 pts.*] Lorentz Force work; The work done by the Lorentz force acting on and electron moving in a uniform magnetic field (no electric field)

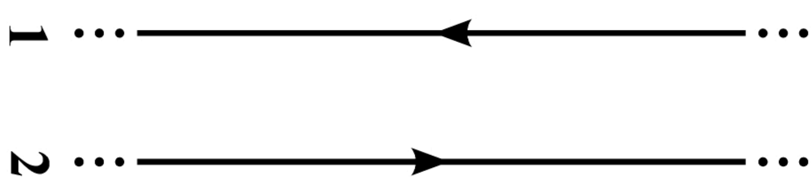
(A) depends on the angle between the electron's velocity and the B-field
(B) is positive, keeping the electron on a circular path
(C) is negative, keeping the electron on a circular path
(D) keeps changing sign during the electron's motion
(E) is zero <<<correct
(F) none of above.

5) [*10 pts.*] Thick wire magnetic field; A thick wire with circular cross-sectional area of radius R carries a uniform current density j. The magnetic field inside the wire, at a radius r < R from its center, is

(A) $B = \frac{1}{2} \mu_0 j r$ <<<correct
(B) $B = \mu_0 j / r$
(C) $B = 2 \mu_0 / (j r)$
(D) $B = 2\pi \mu_0 j r^2$
(E) $B = \mu_0 j / r^2$
(F) $B = 2\pi \mu_0 j r^3$

6) *[10 pts.]* Long wire forces; An infinitely long wire-1 carries a current $I_1 = 2 I_0$. A second straight wire-2 of finite length L runs parallel to wire-1 at a distance d and carries a current $I_2 = I_0$ in opposite direction. The Lorentz force on wire-2 is

(A) $F_{12} = (\mu_0/\pi)\, d\, I_0^2 / L$ attractive
(B) $F_{12} = (\mu_0/\pi)\, L\, I_0^2 / d$ attractive
(C) $F_{12} = (\mu_0/\pi)\, L^2 I_0^2 / d$ attractive
(D) $F_{12} = (\mu_0/\pi)\, L\, I_0^2 / d$ repulsive <<<correct
(E) $F_{12} = (\mu_0/\pi)\, L^2 I_0^2 / d^2$ attractive
(F) $F_{12} = (\mu_0/\pi)\, L^2 I_0^2 / d$ repulsive
(G) $F_{12} = (\mu_0/\pi)\, 2L\, I_0^2 / d$ repulsive



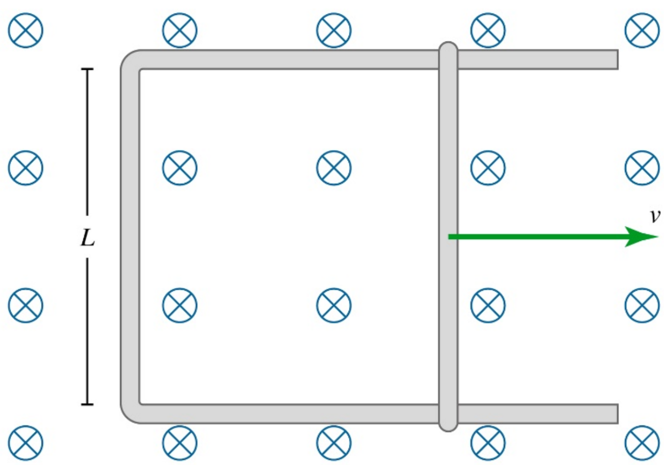
7) *[8 pts.]* Current loop in changing B field; A current loop of radius R is located in the x-y-plane and immersed in a uniform magnetic field pointing in the positive z-direction. The magnetic field strength increases at a given rate dB/dt. What is the magnitude and direction (as viewed from

the pos. z-direction) of the EMF induced in the current loop? (cw=clockwise, ccw=counter-clockwise)

(A) $\varepsilon = 2\,\pi\,R^2$ dB/dt ccw
(B) $\varepsilon = 4\,\pi\,R$ dB/dt ccw
(C) $\varepsilon = 2\,\pi\,R$ dB/dt ccw
(D) $\varepsilon = 4\,\pi\,R^2$ dB/dt cw
(E) $\varepsilon = 2\,\pi\,R$ dB/dt cw
(F) $\varepsilon = \pi\,R^2$ dB/dt cw <<<correct

8) *[8 pts.] Movable wire;* A movable wire of length L is part of a current loop that is immersed in a uniform constant magnetic field of strength B pointing into the plane, and parallel to the normal vector of the loop, as shown below. The wire is pulled to the right with a speed of v. Calculate the magnitude of the EMF and the direction of the current induced in the loop.

(A) BLv ccw <<<correct
(B) BL/v cw
(C) Bv/L ccw
(D) B/Lv cw
(E) BL^2/v ccw
(F) 0 cw



9) *[6 pts.]* Moving metal bar; Consider a metal bar (length 1.2 m) on the front grill of a car moving at 30 m/s on a highway. Assume the bar to be perpendicular to the Earth's magnetic field (directed vertically up), with a field strength of 0.5 Gauss (1 T =10^4 Gauss). Calculate the induced voltage ΔV between the ends of the bar.

(A) $2.4 * 10^{-6}$ V
(B) $2.4 * 10^{-5}$ V
(C) $6.3 * 10^{-4}$ V
(D) $3.6 * 10^{-4}$ V
(E) $1.8 * 10^{-3}$ V <<<correct
(F) 0.08 V

10) *[6 pts.]* Changing current in coil; The current through a coil is ramped up steadily from 0 to 2 A during a 0.1 s time interval. It is found to induce an EMF of 1.4 V in the coil. What is the inductance of the coil?

(A) 2.8 H
(B) 0.70 H
(C) 0.36 H
(D) 0.28 H
(E) 0.070 H <<<correct
(F) 0.036 H

11) *[8 pts.]* solenoid energy; What is the magnetic energy density in a long solenoid coil (800 windings, 0.5 m long, and area 0.3 m^2) when a current of 5 A is run through it?

(A) 0.2 J/m^3
(B) 3.4 J/m^3
(C) 10 J/m^3
(D) 40 J/m^3 <<<correct
(E) 505 J/m^3
(F) 2000 J/m^3

12) *[10 pts.] LR circuit;* In a simple LR circuit as shown below, a battery providing a voltage ε (ignore its internal resistance) is connected in series to a resistor (R) and an inductor (L). The switch is closed at time t=0, and the current starts to ramp up. Find the initial voltage across the inductor immediately after the switch has been closed, $V_L(t\rightarrow 0)$, and the long-time limit of the current in the loop, $I(t\rightarrow\infty)$.

(A) ε and ε/L
(B) ε and ε/R <<<correct
(C) ε and ε/LR
(D) ε and εL/R
(E) 0 and ε/R
(F) 0 and ε/L
(G) 0 and ε/LR
(H) 0 and εL/R