Exam Total
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PHYS 2135 Exam III

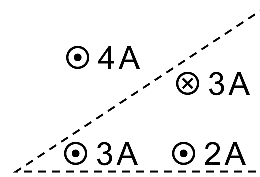
April 17, 2018

Name: ______________________________

Recitation Section: ________________

Five multiple choice questions, 8 points each. Choose the best or most nearly correct answer. For questions 6-9, solutions must begin with a correct OSE. You must show work to receive full credit for your answers. **Calculators are NOT allowed.**

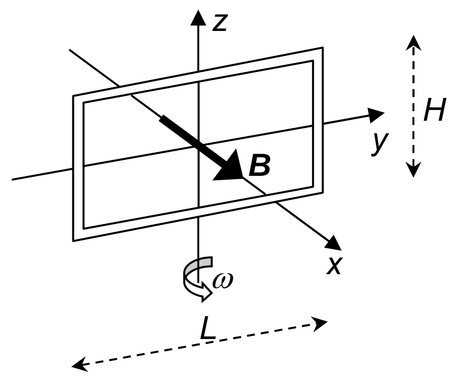
(8) __A____ **1.** The four wires carry the currents shown in the directions indicated. The line integral $\oint_L \vec{B}\bullet d\vec{s}$ is evaluated for the triangular dashed path shown in the diagram. What is the ***magnitude*** of $\oint_L \vec{B}\bullet d\vec{s}$?



[A] $8\pi\times10^{-7}$Tm [B] $16\pi\times10^{-7}$Tm

[C] $24\pi\times10^{-7}$Tm [D] $32\pi\times10^{-7}$Tm

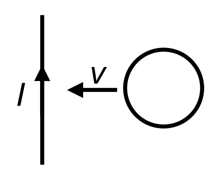
(8) __C_____ **2.** The rectangular loop in the figure is rotated with a constant angular velocity ω about the *z*-axis. The loop is in a uniform magnetic field of constant magnitude *B* directed parallel to the *x*-axis. The length and height of the loop are *L* and *H*. What is the maximum induced emf?



[A] $BLHdz/dt$ [B] $BLH\omega/2$

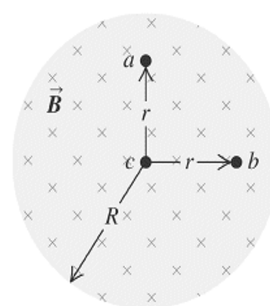
[C] $BLH\omega$ [D] $BH^2\omega$

(8) __B____ **3.** A conducting loop is moved with speed *v* towards a wire carrying a constant current *I* as shown. The direction of the net force exerted on the loop by the wire is



[A] ← [B] → [C] ⊙ [D] ⊗

(8) __D____ **4.** The drawing shows the uniform magnetic field *B* inside a long, straight solenoid. The field is directed into the plane of the drawing. The electrical current in the solenoid is increasing. What is the initial direction of motion of a positive point charge placed at rest at point a?



[A] ↑ [B] → [C] ↓ [D] ←

(8) ________ **5.** The greatest application of this material is …

[A] railguns. [B] jumping rings.

[C] floating coils. [D] slow-falling magnets.

[E] light from the sun.

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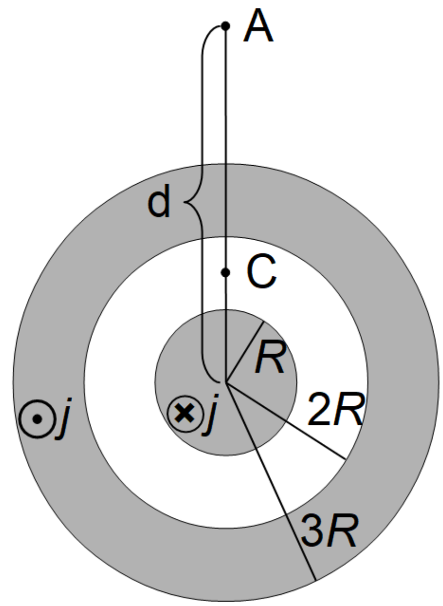
6. A long straight coaxial cable consists of a cylindrical inner conductor of radius R surrounded by a hollow cylindrical conductor with inner radius $2R$ and outer radius $3R$. A cross section of the cable is shown in the figure. The inner cylinder carries a uniform current density j directed into the page. The outer hollow cylinder carries a uniform current density of the same magnitude j, but out of the page.



(5) (a) Find the current I_{in} flowing in the inner cylinder in terms of the system parameters.

$$I_{\text{in}} = j\pi R^2$$

(10) (b) Find the current I_{out} flowing in the outer hollow cylinder in terms of the system parameters.

$$I_{\text{out}} = j[\pi(3R)^2 - \pi(2R)^2]$$
$$I_{\text{out}} = 5j\pi R^2$$

(5) (c) What is the direction of the magnetic field at point C (circle one)?

↑ ↓ ← (→) ⊗ ⊙

(20) (d) Use Ampere's law to find the magnitude of the magnetic field at point A which is a distance d from the center of the cable.

$$\oint \vec{B} \cdot d\vec{s} = \mu_0 I_{\text{enc}}$$
$$B(2\pi r) = \mu_0(5j\pi R^2 - j\pi R^2)$$
$$B = \frac{\mu_0(4j\pi R^2)}{2\pi d}$$
$$B = \frac{2\mu_0 j R^2}{d}$$

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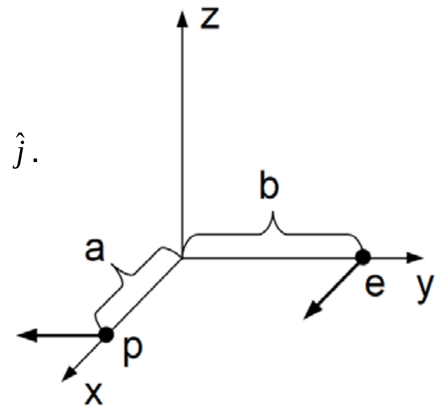
7. At a given instant of time, an electron is located at (0,b,0) and is moving with a speed $\mathbf{v}_e = v_0\,\hat{i}$. At the same time, a proton is located at (a,0,0) and is moving with a speed $\mathbf{v}_p = -v_0\,\hat{j}$. Express all answers in unit vector notation.



(15) (a) What is the magnetic field at the origin produced by the electron?

$$\vec{B}_e = \frac{\mu_0}{4\pi}\frac{q\vec{v}\times\hat{r}}{r^2}$$

$$\vec{B}_e = \frac{\mu_0}{4\pi}\frac{(-e)v_0\hat{i}\times(-\hat{j})}{b^2}$$

$$\vec{B}_e = \frac{\mu_0 e v_0}{4\pi b^2}\hat{k}$$

(15) (b) What is the magnetic field at the origin produced by the proton?

$$\vec{B}_p = \frac{\mu_0}{4\pi}\frac{q\vec{v}\times\hat{r}}{r^2}$$

$$\vec{B}_p = \frac{\mu_0}{4\pi}\frac{e(-v_0)\hat{j}\times(-\hat{i})}{a^2}$$

$$\vec{B}_p = \frac{-\mu_0 e v_0}{4\pi a^2}\hat{k}$$

(10) (c) What is the total magnetic field at the origin?

$$\vec{B} = \vec{B}_e + \vec{B}_p$$

$$\vec{B} = \frac{\mu_0 e v_0}{4\pi}\left(\frac{1}{b^2} - \frac{1}{a^2}\right)\hat{k}$$

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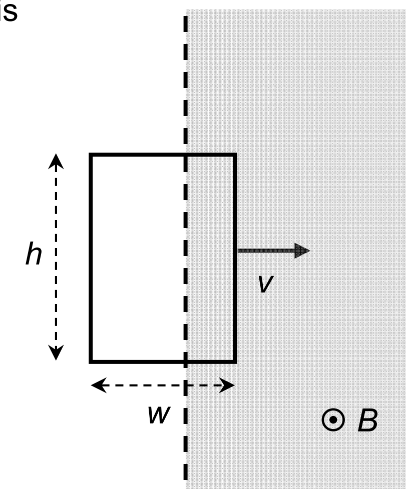
8. A rectangular loop of wire of height *h*, width *w,* and total resistance *R* is pulled with constant speed *v* into a region of uniform magnetic field *B* directed out of the page, perpendicular to the plane containing the rectangular loop.The figure shows the loop a short time after the right edge of the rectangular loop enters the magnetic field.



(10) (a) In what direction is the current induced in the loop at the moment shown? (circle one.)

(15) (b) Find the magnitude of the current *I* induced in the loop at the moment shown. [Express the answer in terms of the given parameters and fundamental constants.]

$$\mathcal{E} = \left|\frac{d\Phi}{dt}\right|$$
$$\mathcal{E} = \left|\frac{d}{dt}(B\,h\,x)\right|$$
$$\mathcal{E} = |B\,h\,v|$$

$$\mathcal{E} = IR$$
$$\frac{\mathcal{E}}{R} = I$$
$$\frac{Bhv}{R} = I$$

(15) (d) Find the magnitude of the external force F_{ext} required, at the moment shown, to keep the loop moving to the right with constant speed *v*. [Express the answer in terms of the given parameters and fundamental constants.]

$$F_{ext} = F_B$$
$$F_{ext} = |I\,\vec{h} \times \vec{B}|$$
$$F_{ext} = IhB$$
$$F_{ext} = \left(\frac{Bhv}{R}\right) hB$$
$$F_{ext} = \frac{B^2 h^2 v}{R}$$

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9. The Hubble Space Telescope has two solar panels, each with an area of *A*, to collect energy from the sun. The telescope is a distance *R* from the sun, and the total power output of the sun is P_{sun}. [All answers must be expressed in terms of *A*, *R*, P_{sun}, Δt and fundamental constants.]

(15) (a) Assuming the solar panels are oriented perpendicular to the solar radiation, how much solar energy strikes the solar panels in time, Δt?

$$\frac{P_p}{2A} = \frac{P_{sun}}{4\pi R^2} \qquad \frac{\Delta E}{\Delta t} = \frac{P_{sun} A}{2\pi R^2}$$

$$P_p = \frac{P_{sun} A}{2\pi R^2} \qquad \Delta E = \frac{P_{sun} A \Delta T}{2\pi R^2}$$

(15) (b) If we further assume the panels are perfect absorbers, how much force is exerted on the telescope by solar radiation hitting its solar panels?

$$\frac{I}{c} = \langle P_{rad} \rangle = \frac{F}{2A}$$

$$\frac{P_{sun}}{4\pi R^2 c} = \frac{F}{2A}$$

$$\frac{P_{sun} A}{2\pi R^2 c} = F$$

(10) (c) What is the electric field amplitude at the panel surfaces?

$$\frac{P_{sun}}{4\pi R^2} = I = c\langle u \rangle = \frac{1}{2} c \epsilon_0 E_{max}^2$$

$$\frac{2 P_{sun}}{4\pi R^2 c \epsilon_0} = E_{max}^2$$

$$\frac{1}{R}\sqrt{\frac{P_{sun}}{2\pi c \epsilon_0}} = E_{max}$$

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