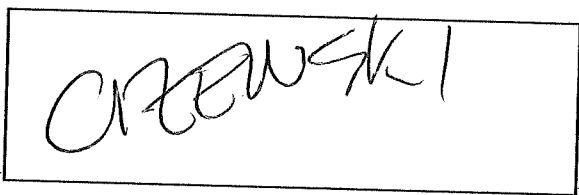


Physics 227 – Hourly Exam 2  
Thursday, November 17, 2016, 9:50 PM - 11:10 PM  
ARC 103 (Aaa-Jzz), Hill 114 (Kaa-Nzz),  
PLH (Oaa-Shz), SEC 111 (Sia-Zzz)

⇒  ⇐

Your exam code

SIGN HERE

1. Use a #2 pencil to make entries on the answer sheet. *Enter the following ID information now, before the exam starts.*
2. In the section labeled NAME (Last, First, M.I.) enter your last name, then fill in the empty circle for a blank, then enter your first name, another blank, and finally your middle initial.
3. Under STUDENT # enter your 9-digit RUID Number.
4. Under CODE enter the exam code given above.
5. Enter 227 under COURSE. You do not need to write anything else on the answer sheet for now, but you may continue to read the instructions.
6. During the exam, you are allowed one handwritten sheet of paper, 8.5 x 11 inches in size, handwritten on both sides. NO Calculators. NO Cell phones. NO smart watches.
7. The exam consists of 15 multiple-choice questions. For each multiple-choice question mark only **ONE** answer. There is no deduction of points for an incorrect answer, so even if you cannot work out the answer to a question, you should make an educated guess.
8. If you have questions or problems during the exam, you may raise your hand and a proctor will assist you. We will provide the value of physical constants that are needed. It is your responsibility to know the relevant equations.
9. You are not allowed to help any other student, ask for help from anyone but a proctor, change your seat without permission from a proctor or use any electronic device. Doing so will result in a zero score for the exam.
10. When you are done with the exam, show your student ID to a proctor, hand in only this cover sheet and your answer sheet.
11. Please sign above by the name sticker to indicate that you have read and understood these instructions.

**Possibly useful constants:**

$$\epsilon_0 = 1/\mu_0 c^2 = 8.85 \times 10^{-12} \text{ C}^2/\text{N}\cdot\text{m}^2$$

$$k = 1/4\pi\epsilon_0 = 8.99 \times 10^9 \text{ N}\cdot\text{m}^2/\text{C}^2$$

$$c = \text{speed of light} = 3.00 \times 10^8 \text{ m/s}$$

$$-q_{\text{electron}} = q_{\text{proton}} = 1.602 \times 10^{-19} \text{ C}$$

$$m_{\text{electron}} = \text{electron mass} = 9.11 \times 10^{-31} \text{ kg}$$

$$m_{\text{proton}} = \text{proton mass} = 1.67 \times 10^{-27} \text{ kg}$$

$$\mu_0 = 4\pi \times 10^{-7} \text{ T}\cdot\text{m/A} = 12.57 \times 10^{-7} \text{ T}\cdot\text{m/A}$$

$$1 \text{ eV} = 1.602 \times 10^{-19} \text{ J}$$

Circumference of a circle  $= 2\pi r$ ; area of a circle is  $\pi r^2$

Surface area of a sphere  $= 4\pi r^2$ ; Volume of a sphere  $= \frac{4}{3}\pi r^3$

Surface area of a cylinder  $= 2\pi r h + 2\pi r^2$ ; Volume of cylinder  $= \pi r^2 h$

$$\sin(0^\circ) = \cos(90^\circ) = 0$$

$$\sin(90^\circ) = \cos(0^\circ) = 1$$

$$\sin(30^\circ) = \cos(60^\circ) = 1/2$$

$$\sin(60^\circ) = \cos(30^\circ) = \sqrt{3}/2$$

$$\sin(45^\circ) = \cos(45^\circ) = \sqrt{2}/2$$

$$\frac{d}{dx} x^n = n x^{n-1}$$

$$\int x^n dx = \frac{1}{n+1} x^{n+1} \text{ except when } n = -1. \text{ For } n = -1, \int dx/x = \ln x$$

$$\frac{d}{dx} \sin(ax) = a \cos(ax)$$

$$\frac{d}{dx} \cos(ax) = -a \sin(ax)$$

$$\int \sin(ax) dx = -\cos(ax)/a$$

$$\int \cos(ax) dx = \sin(ax)/a$$

Some metric prefixes:

$$\text{f} = \text{femto} = 10^{-15}$$

$$\text{p} = \text{pico} = 10^{-12}$$

$$\text{n} = \text{nano} = 10^{-9}$$

$$\mu = \text{micro} = 10^{-6}$$

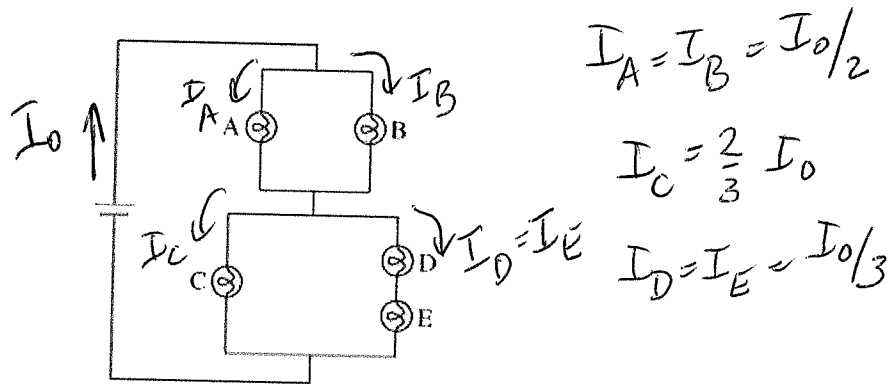
$$\text{m} = \text{milli} = 10^{-3}$$

$$\text{k} = \text{kilo} = 10^3$$

$$\text{M} = \text{mega} = 10^6$$

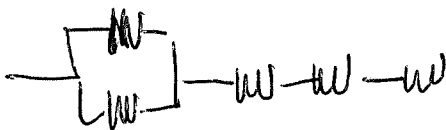
$$\text{G} = \text{giga} = 10^9$$

1. Consider a circuit containing five identical light bulbs and an ideal battery. Assume that the resistance of each light bulb remains constant. Which statement is TRUE for the brightness of the bulbs (A through E)?



Brightness = Power =  $I^2 R \Rightarrow$  Power C is greatest

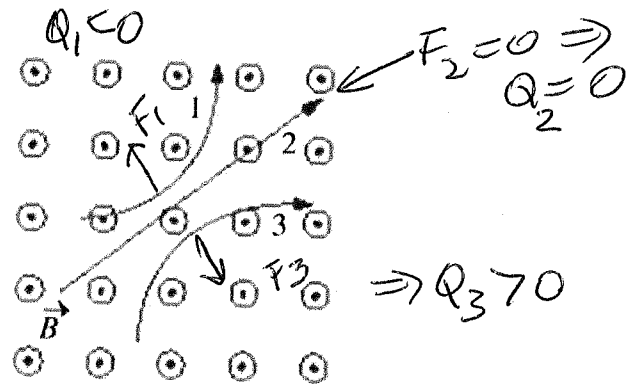
- a) Bulb A is brighter than bulb B is brighter than bulb C is brighter than bulb D is brighter than bulb E.
  - b) Bulb A and bulb B are equally bright and brighter than bulb C.
  - c) Bulb D and bulb E are equally bright and brighter than bulb C.
  - ☒ d) Bulb C is the brightest.
  - e) All of the bulbs are equally bright.
2. You are working late in your electronics lab and find that you need various resistors for a project. However, you only have a big box of  $10.0 \Omega$  resistors. How can you put together these resistors to have  $R_{eq} = 35 \Omega$  equivalent resistance?
- a) A parallel combination of three resistors then connected in series with three others will have  $R_{eq} = 35 \Omega$ .
  - ☒ b) A parallel combination of two resistors then connected in series with three others will have  $R_{eq} = 35 \Omega$ .
  - c) A parallel combination of three resistors then connected in series with two others will have  $R_{eq} = 35 \Omega$ .
  - d) It is not possible to put together only  $10 \Omega$  resistors to get  $R_{eq} = 35 \Omega$ .
  - e) A parallel combination of two resistors then connected in series with two others will have  $R_{eq} = 35 \Omega$ .



$$R_{eq} = \frac{R}{2} + 3R = 35 \Omega$$

3. Three particles travel through a region of space where the magnetic field  $\vec{B}$  is out of the page, as shown in the figure. What is the electric charge  $Q$  of each of the three particles?

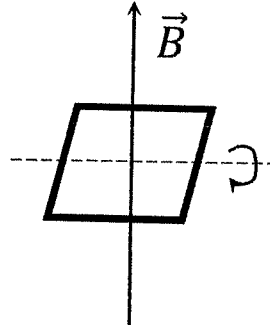
- a)  $Q_1$  is negative,  $Q_2$  is neutral, and  $Q_3$  is positive.  
 b)  $Q_1$  is positive,  $Q_2$  is negative, and  $Q_3$  is neutral.  
 c)  $Q_1$  is neutral,  $Q_2$  is positive, and  $Q_3$  is negative.  
 d)  $Q_1$  is neutral,  $Q_2$  is negative, and  $Q_3$  is positive.  
 e)  $Q_1$  is positive,  $Q_2$  is neutral, and  $Q_3$  is negative.



$$\vec{F} = q \vec{v} \times \vec{B}$$

4. A flat, square coil with sides of length  $L$  and with  $N$  turns rotates in a magnetic field of magnitude  $B$ . The coil rotates on an axis through its center that is perpendicular to  $B$  as shown in the figure. What is the angular speed  $\omega$  of the coil if the maximum emf produced is  $\mathcal{E}$ ?

- a)  $\omega = \mathcal{E}/NBL^2$  rad/s  
 b)  $\omega = \mathcal{E}NBL^2$  rad/s  
 c)  $\omega = 2\pi\mathcal{E}/NBL^2$  rad/s  
 d)  $\omega = 2\pi\mathcal{E}/BL^2$  rad/s  
 e)  $\omega = \mathcal{E}BL^2$  rad/s



$$\mathcal{E} = -\frac{d\Phi_B}{dt} = -\frac{d}{dt} (NBL^2 \sin(\omega t))$$

$$= -\omega NBL^2 \cos \omega t$$

$$\mathcal{E}_{\max} = \omega NBL^2 \Rightarrow \omega = \frac{\mathcal{E}}{NBL^2}$$

5. A 60-W light bulb (bulb A), a 120-W light bulb (bulb B) and a 240-W light bulb (bulb C) are connected in series as shown in the figure. Rank the voltage drops  $V$  across the light bulbs.

$$P = V^2/R \quad R_A = \frac{(120)(120)}{60} = 2(120)$$

$$R_B = \frac{(120)(120)}{120} = 1(120)$$

$$R_C = \frac{(120)(120)}{2(120)} = \frac{120}{2}$$

$$\Rightarrow R_A > R_B > R_C$$

$$I_A = I_B = I_C$$

$$V_A \propto I_A$$

$$V_B \propto I/2$$

$$V_C \propto I/4$$

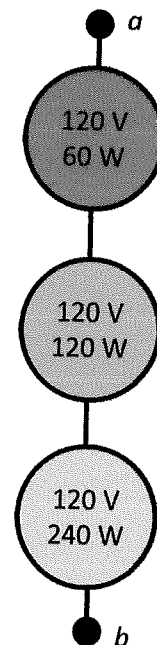
a)  $V_A = V_B = V_C$

b)  $V_C > V_B > V_A$

c)  $V_B > V_A > V_C$

d)  $V_B > V_C = V_A$

e)  $V_A > V_B > V_C$



6. A 100-V battery with an internal resistance  $r = 50 \Omega$ , a resistor with a resistance of  $R = 50 \Omega$ , and a capacitor with a capacitance of  $C = 2 \mu\text{F}$  are connected in series. What is the time constant  $\tau$  of this circuit?

a)  $\tau = 2 \text{ s}$

b)  $\tau = 2 \times 10^{-6} \text{ s}$

c)  $\tau = 2 \times 10^{-4} \text{ s}$

d)  $\tau = 1 \times 10^{-4} \text{ s}$

e)  $\tau = 1 \times 10^{-6} \text{ s}$

$$\tau = (r + R)C = (50 \Omega + 50 \Omega)(2 \times 10^{-6} \text{ F})$$

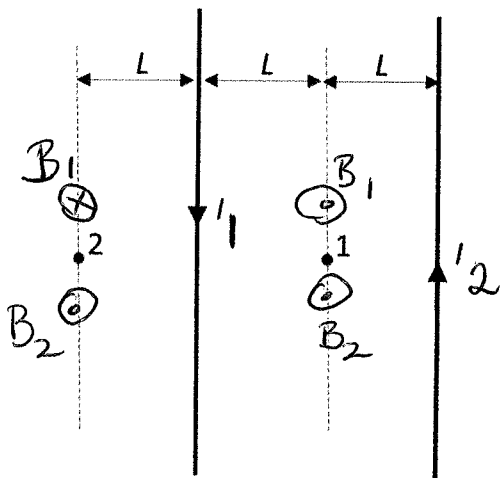
$$= 2 \times 10^{-4} \text{ s}$$

7. Two infinitely long straight wires carry equal currents  $I$  in opposite directions. All distances are shown in the figure. What is the magnitude of the magnetic field at point 2,  $B_2$ , in terms of the magnitude of the magnetic field at point one,  $B_1$ ?

$$B_1 = 2 \left( \frac{\mu_0 I}{2\pi L} \right) = 2 B_0$$

$$B_2 = -\frac{\mu_0 I}{2\pi L} + \frac{\mu_0 I}{2\pi L}$$

- a)  $B_2 = B_1$   
 b)  $B_2 = 3B_1/2$   
 c)  $B_2 = 2B_1/3$   
 (d)  $B_2 = B_1/3$   
 e)  $B_2 = 2B_1$

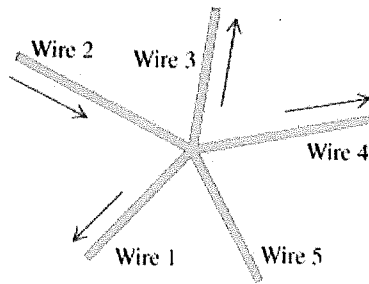


$$B_2 = B_0 - \frac{1}{3} B_0 = \frac{2}{3} B_0 = \frac{2}{3} \left( \frac{B_1}{2} \right) = \frac{1}{3} B_1$$

8. A capacitor is charging in a simple RC circuit with a dc battery. Which one of the following statements about this capacitor is TRUE?
- a) There is no magnetic field between the capacitor plates because no charge travels between the plates. **F**
- (b) There is a magnetic field between the capacitor plates, even though no charge travels between them, because the electric flux between the plates is changing. **T**
- c) There is a magnetic field between the capacitor plates, even though no charge travels between them, because the magnetic flux between the plates is changing. **F**
- d) The magnetic field between the capacitor plates is increasing with time because the charge on the plates is increasing. **F**
- e) There is a magnetic field between the capacitor plates because charge travels between the plates by jumping from one plate to the other. **F**

charging  $\Rightarrow \frac{d\Phi_E}{dt} \neq 0 \Rightarrow$  induce  $\vec{B}$   
 from displacement current.

9. A junction of five wires is shown in the figure.



Current density  

$$\vec{I} = \vec{j} A$$

Wire	Current density (A/mm <sup>2</sup> )	Area (mm <sup>2</sup> )	Current (A)
Wire 1	2.0	2.0	???
Wire 2	???	3.0	2.0
Wire 3	2.0	1.0	???
Wire 4	1.0	???	4.0

$$I_1 = (2)(2) = 4A$$

$$I_3 = (2)(1) = 2A$$

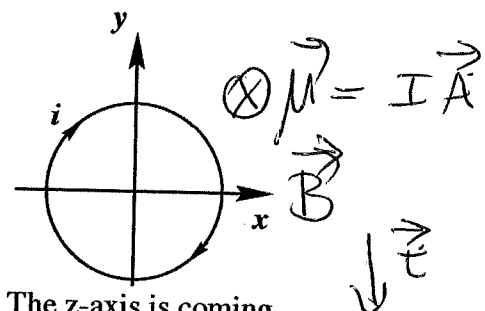
The arrows indicate the direction of current flow. Information about the magnitudes of the current density and the cross sectional areas for wires 1, 2, 3, and 4 is given in the table. Some of the values are unknown. What is the current  $I_5$  in wire 5? The current out of the junction is defined as positive and the current into the junction as negative.

- a)  $I_5 = +8.0$  A       $-I_1 + I_2 - I_3 + I_4 + I_5 = 0$   
 b)  $I_5 = +4.0$  A  
 c)  $I_5 = -8.0$  A       $I_5 = I_2 - (I_1 + I_3 + I_4) = 2 - (10) = -8A$   
 d)  $I_5 = -4.0$  A  
 e) Not enough information is given to determine  $I_5$ .

10. A circular coil of radius  $R$  with  $N$  turns lies in the  $x-y$  plane in a uniform magnetic field of magnitude  $B$  in the  $+x$  direction. The current in the loop is  $i$  (in the direction shown in the figure). What are the magnitude  $\tau$  and direction of the torque vector acting on the coil?

$$\vec{\tau} = \vec{\mu} \times \vec{B} = (N\vec{A} \times \pi R^2) \times (B)$$

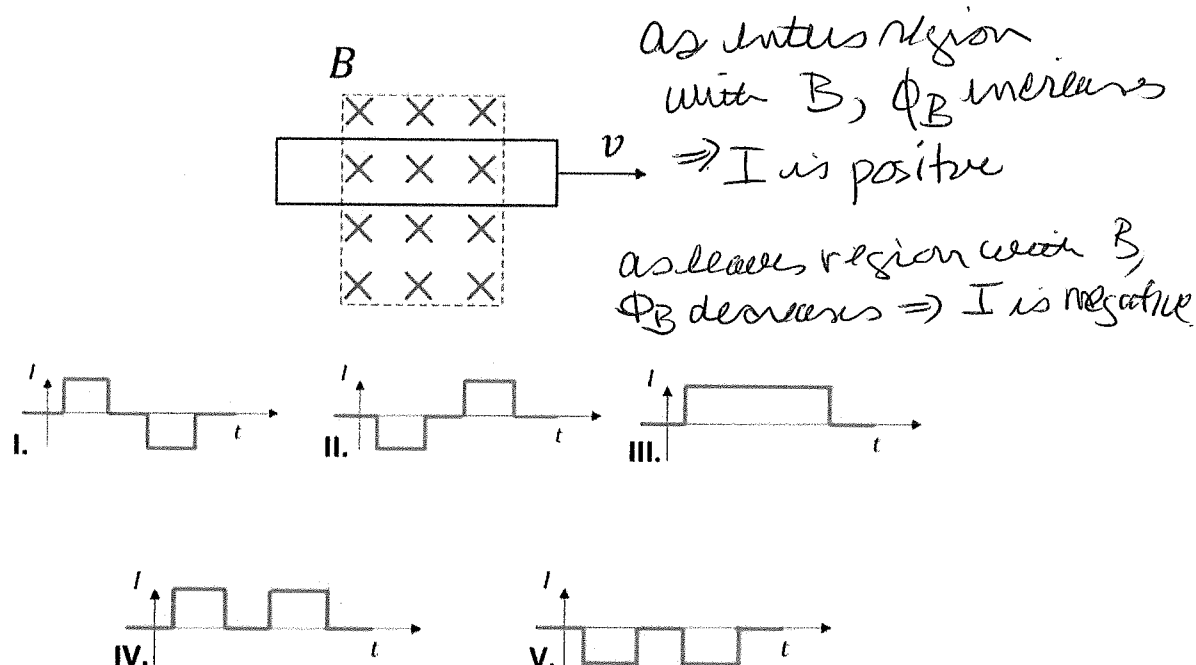
$$= \hat{x} \pi R^2 N B$$



The z-axis is coming out of the page.

- a)  $\tau = i\pi R^2 B$  in the  $+z$  direction.  
 b)  $\tau = i\pi R^2 N B$  in the  $-z$  direction.  
 c)  $\tau = i\pi R^2 N B$  in the  $+y$  direction.  
 d)  $\tau = i\pi R^2 B$  in the  $-y$  direction.  
 e)  $\tau = i\pi R^2 N B$  in the  $-y$  direction.

11. In the top figure below, a rectangular wire loop moves with a constant speed  $v$ . There is a magnetic field  $\vec{B}$  in a region of space within the dashed-line boundary. The loop starts completely to the left of the shaded region and ends up completely to the right of the shaded region.



Which of the graphs of the time dependence of current in the loop,  $I(t)$ , corresponds to this process? The clock-wise current is defined as positive.

- a) Graph (V) best represents  $I(t)$ .
  - b) Graph (III) best represents  $I(t)$ .
  - ☒ c) Graph (II) best represents  $I(t)$ .
  - d) Graph (IV) best represents  $I(t)$ .
  - e) Graph (I) best represents  $I(t)$ .
12. Two long, parallel wires are separated by a distance  $x$ . The force per unit length that each wire exerts on the other is  $F$ . The wires repel each other. If the current in one wire is  $I_1$ , what is the current  $I_2$  in the other wire?
- a)  $I_2 = (2\pi x F)/(\mu_0 I_1)$ , in the same direction.
  - ☒ b)  $I_2 = (2\pi x F)/(\mu_0 I_1)$ , in the opposite direction.
  - c)  $I_2 = (x F)/(2\pi \mu_0 I_1)$ , in the same direction.
  - d)  $I_2 = (\pi x F)/(2\mu_0 I_1)$ , in the opposite direction.
  - e)  $I_2 = (\pi x F)/(\mu_0 I_1)$ , in the opposite direction.

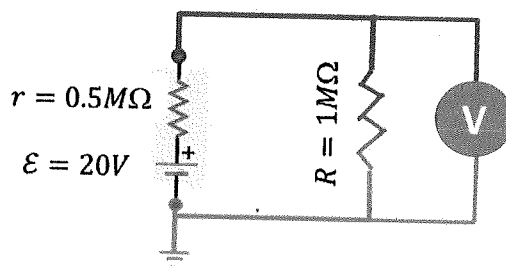
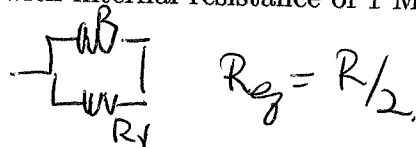
$$\frac{F}{L} = \frac{\mu_0 I_1 I_2}{2\pi x} \Rightarrow I_2 = \frac{F(2\pi x)}{\mu_0 I_1}$$

repel  $\Rightarrow$  opposite direction



13. A circuit is shown in the figure. You measure the voltage difference across a  $R = 1\text{ M}\Omega$  resistor using the voltmeter with internal resistance of  $1\text{ M}\Omega$ . What is the reading  $V_V$  of the voltmeter?

$$R_{eq} = r + R + R_V = 0.5\text{ M}\Omega + 0.5\text{ M}\Omega = 1\text{ M}\Omega$$



- a)  $V_V = 0\text{ V}$   
 b)  $V_V = 15\text{ V}$   
 c)  $V_V = 10\text{ V}$   
 d)  $V_V = 5.0\text{ V}$   
 e)  $V_V = 20\text{ V}$

$$I = \frac{\mathcal{E}}{R_{eq}} = \frac{20\text{ V}}{1\text{ k}\Omega} = 20 \times 10^{-6}\text{ A}$$

$$V_R = V_V = \frac{I}{2} R = \frac{(10 \times 10^{-6}\text{ A})}{2} (1 \times 10^6\Omega) = 10\text{ V}$$

14. A particle with charge  $q = -1\text{ C}$  is moving in the positive  $+y$  direction with  $v = 1\text{ m/s}$ . The magnetic field at its position is  $\vec{B} = (1\hat{i} + 2\hat{j} + 3\hat{k})\text{ T}$ . What is the magnetic force  $\vec{F}$  on the particle?

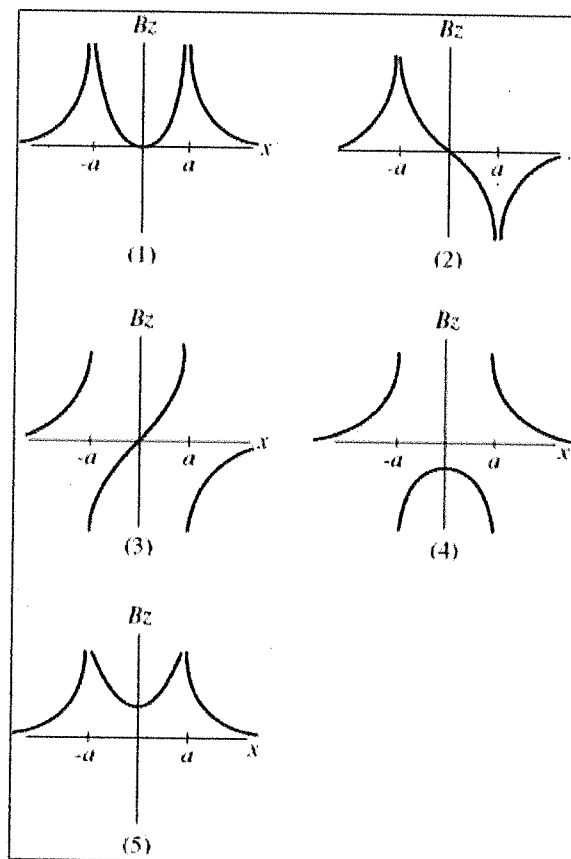
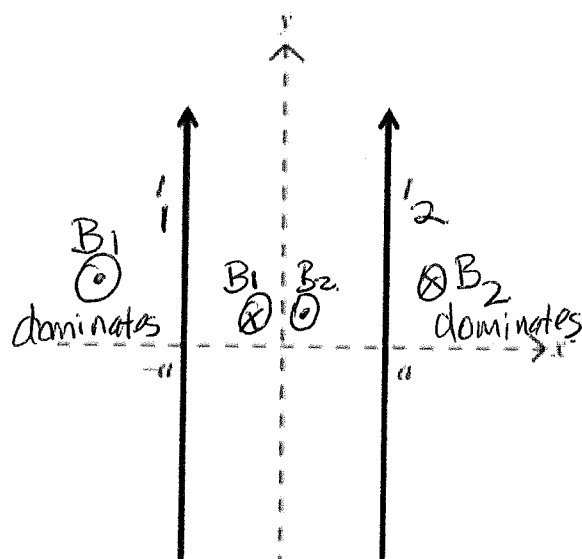
- a)  $\vec{F} = -1\hat{i} - 2\hat{j} - 3\hat{k}\text{ N}$   
 b)  $\vec{F} = -3\hat{i} + 1\hat{k}\text{ N}$   
 c)  $\vec{F} = -3\hat{i} - 1\hat{k}\text{ N}$   
 d)  $\vec{F} = -1\hat{i} + 2\hat{k}\text{ N}$   
 e)  $\vec{F} = +1\hat{i} - 2\hat{k}\text{ N}$

$$F_x = q v_y B_z = (-1)(1)(3) \Rightarrow -3\hat{i}$$

$$F_y = 0$$

$$F_z = -q v_y B_x = -(-1)(1)(1) \Rightarrow +1\hat{k}$$

15. Two very long parallel wires in the  $xy$ -plane, a distance  $2a$  apart, are parallel to the  $y$ -axis and carry equal currents  $I$ , as shown in the left figure. The  $+z$  direction points perpendicular to the  $xy$ -plane in a right-handed coordinate system. If both currents flow in the  $+y$  direction, which one of the graphs, one through five, best represents the  $z$  component of the net magnetic field  $B_z(x)$ , in the  $xy$ -plane, as a function of  $x$ ? Note: these graphs are *not* magnetic field lines.



- a) Graph (2) best represents  $B_z(x)$ .
- b) Graph (4) best represents  $B_z(x)$ .
- c) Graph (5) best represents  $B_z(x)$ .
- ☒ d) Graph (3) best represents  $B_z(x)$ .
- e) Graph (1) best represents  $B_z(x)$ .

$$B_z(x=0) = 0 \text{ for all } z$$

$$B_z(x < -a) > 0$$

$$B_z(x > +a) < 0$$

Only graph (3) satisfies all.