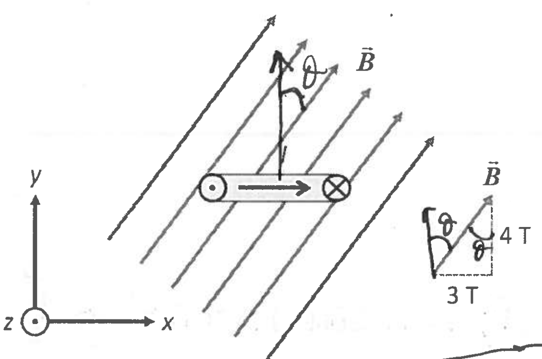
The next two questions pertain to the situation described below.

A current carrying loop of radius $r = 14\ cm$ is oriented horizontally, with its area parallel to the x-z-plane in the figure below, and a uniform magnetic field is applied that has no z-component. The x-component of the B field is $3\ T$ and its y-component is $4\ T$. The current $I = 7\ A$ is flowing into the (−z) direction at the rightmost point of the loop, as denoted in the figure that shows a side view of the loop. (The (−z)-direction points into the page).



$\sqrt{(3T)^2+(4T)^2} = 5\ T$

18) What is the **magnitude** of the torque on the current loop?

$\tau = IAB\sin\theta \cdot \left(\frac{3}{5}\right)$

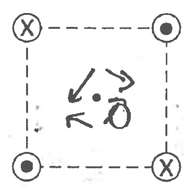
7A $\quad \pi(0.14m)^2$

a. $\tau = 1.7\ N\ m$
b. $\tau = 2500\ N\ m$
c. $\tau = 2.2\ N\ m$
d. $\tau = 1.3\ N\ m$
e. $\tau = 1800\ N\ m$

19) In which direction will the loop *start to turn* if left free?

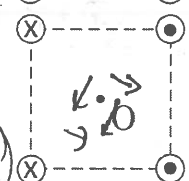
a. Clockwise about an axis parallel to the z-axis
b. Counter-clockwise about an axis parallel to the z-axis
c. Around an axis that is *not* parallel to the z axis.

20) Four long straight wires carrying currents of equal magnitude ($I_1 = I_2 = I_3 = I_4 = I$) are parallel or antiparallel to each other such that their cross sections form the corners of a square, as shown in the figures. The figures indicate the directions of the current in each wire. In which case is the magnitude of the total magnetic field at the center of the square (O) the largest?



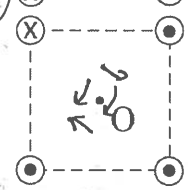
0

a.



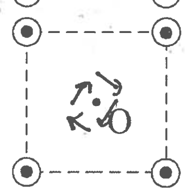
↙ + ↘ = ↓

b.



↙ + 0 = ↙

c.



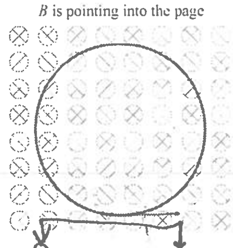
0

d.

$$R = \frac{mv}{qB}$$

21) A charged particle travels counterclockwise with speed v on a circle in the plane of the page, while a uniform magnetic field B is applied in a perpendicular direction, pointing into the page (as shown below). The period T is the amount of time the particle takes to travel around one complete circle. How would the period change if the speed of the particle was doubled?

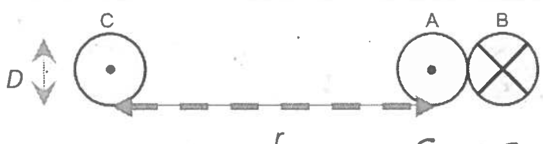
B is pointing into the page



a. T would increase by a factor of 4.
b. T would remain unchanged.
c. T would increase by a factor of 2.
d. T would decrease by a factor of 2.
e. T would decrease by a factor of 4.

$$\text{period} = \frac{2\pi R}{v} = \frac{2\pi}{\cancel{v}}\left(\frac{m\cancel{v}}{qB}\right)$$

22) Three long, parallel straight wires A, B and C carry a constant current of $I = 3\,A$ each. The direction of the current of each wire is as indicated in the figure below. The length of the wires is $L = 1\,m$ and the diameter is $D = 8\,mm$. Wires A and B are stuck to each other but electrically insulated from each other. We call the combination of wires A and B a "double wire AB". The distance from the center of C to the center of A is $r = 2\,cm$.



$$\leftarrow F_A \qquad F_B \rightarrow$$

What is the net force on the double wire AB due to wire C?

a. $F = 1.5 \times 10^{-4}\,N$
b. $F = 0\,N$
c. $F = 2.6 \times 10^{-5}\,N$

$$F_{AB} = F_A + F_B$$

$$= \frac{\mu_0 I_C I_A}{2\pi r_{AC}} - \frac{\mu_0 I_C I_B}{2\pi r_{BC}}$$

$I_C = I_A = I_B$

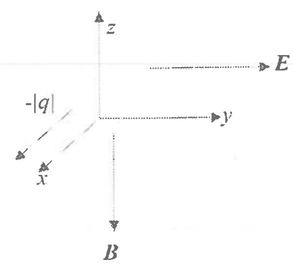
$$= \frac{\mu_0 I^2}{2\pi}\left[\frac{1}{r_{AC}} - \frac{1}{r_{BC}}\right]$$

3A

$r_{AC} = 0.02\,m$

$r_{BC} = 0.028\,m$

23) A particle of charge $-|q|$ moves in the positive x-direction with speed v. There is a uniform electric field E of magnitude $|E|$ pointing in the positive y-direction and a uniform magnetic field B pointing in the *negative z-direction*. What must be the magnitude of the magnetic field, $|E|$, such that the particle does not accelerate? (Hint: Pay careful attention to the given direction of E and B).

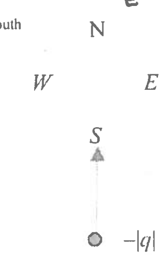


a. $|B| = |E|$
b. The charge will accelerate for any magnetic field B pointing in the negative z-direction.
c. $|B| = |E|/v$

$\vec{F}_B$ is in SAME DIRECTION as $\vec{F}_E$

24) A negatively charged particle enters a uniform magnetic field from the south and is pushed to the east.

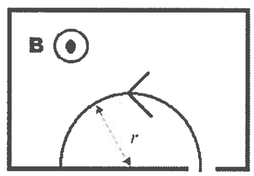
In which direction does the magnetic field point?



a. The magnetic field points into the page.
b. The magnetic field points out of the page.

The next two questions pertain to the situation described below.

A negatively charged particle with charge $q = -3e$ enters a uniform magnetic field $B = 0.3\ T$ pointing out of the page with a speed of $v = 10^6\ m/s$ and sweeps out a half circle of radius $r = 5.9\ cm$ before leaving the field.



25) What is the particle's mass?

a. More information is required to determine the mass of the particle.
b. $m = 2.8 \times 10^{-20}\ kg$
c. $m = 8.5 \times 10^{-27}\ kg$
d. $m = 8.5 \times 10^{-21}\ kg$
e. $m = 2.8 \times 10^{-26}\ kg$

$R = \frac{mv}{qB} \Rightarrow m = \frac{RqB}{v}$

$-3 \cdot 1.6 \times 10^{-19}\ C$

$0.3\ T$

$0.059\ m$

$10^6\ m/s$

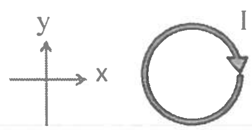
26) What is the speed v of the particle upon exiting the region with the B field?

a. $v = 10^5\ m/s$
b. $v = 10^7\ m/s$
c. $v = 10^4\ m/s$
d. $v = 0\ m/s$
e. $v = 10^6\ m/s$

Same as before

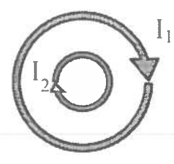
Physics 102 Hour Exam 2 – SP15

1. A
2. B
3. C
4. A
5. A
6. C
7. A
8. A
9. B
10. C
11. C
12. C
13. A
14. D
15. A
16. D
17. A
18. D
19. A
20. B
21. B
22. C
23. B
24. A
25. C
26. E



1. The picture above shows a top-down view of a solenoid. The current I in the solenoid flows clockwise. Which way does the magnetic field point at the center of the solenoid?

a. Into the page
b. Out of the page
c. Along the +y direction
d. Along the −y direction
e. Along the +x direction



3. Suppose a smaller diameter solenoid is placed inside a larger diameter solenoid, as shown in the top-down view above. The first has current I_1 and turns per unit length n_1. The second has current I_2 and turns per unit length n_2. Both currents are in the clockwise direction. What is the magnitude of the magnetic field at the center of the solenoids?

a. $B=0$
b. $B=\mu_0|I_1n_1+I_2n_2|$
c. $B=\mu_0|I_1n_1-I_2n_2|$
d. $B=\mu_0|I_1n_2+I_2n_1|$
e. $B=\mu_0|I_1n_2-I_2n_1|$

4. If you have a solenoid 13m long that consists of 169 turns, what current must you put through it to produce a 50μT magnetic field at the center?

a. 0.2A
b. 3.1A
c. 39.8A
d. 235A
e. 3060A

$$B = \mu_0 I n = \mu_0 I \frac{N_{turns}}{L}$$

$$I = \frac{B}{\mu_0} \frac{L}{N_{turns}}$$

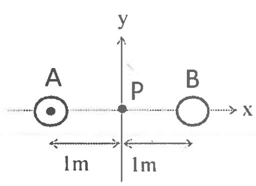
50×10^{-6} T

13 m

169

The next two questions refer to the following situation:

As shown in the picture below, two long, straight wires are separated by 2m. The point P lies at the midpoint of the line connecting the two wires.



5. If the current through wire A is 1 A and no current flows through wire B, what is the magnitude of the magnetic field at point P?

a. 1×10^{-7} T
b. 2×10^{-7} T
c. 4×10^{-7} T
d. 3.14×10^{-7} T
e. 0.318×10^{-7} T

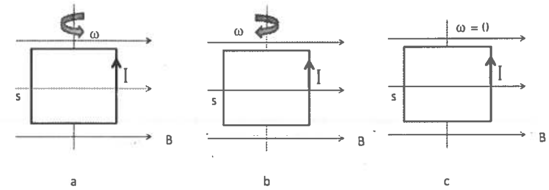
$B = \mu_0 \frac{I}{2\pi r}$ 1 A 1 m

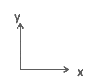
6. What is the direction of the magnetic field at point P if 1A flows through wire B into the page?

a. Into the page
b. Out of the page
c. +y direction
d. –y direction
e. The magnetic field would be zero

The next two questions pertain to the same situation.

10. A square loop (connected to a battery not shown in the picture) has a current I flowing in the loop as indicated below and lies in the x-y plane. The loop is in an external uniform magnetic field B which points in the x direction. The left side of the loop is labeled s. In which direction does the loop rotate?





a. side s rotates out of the page
b. side s rotates into the page
c. the loop does not rotate

11. The current in the loop is I = 2.2 A, the side is 10 cm, the magnetic field B = 2 T and the number of turns in the loop N = 3. What is the magnitude of the torque on the loop?

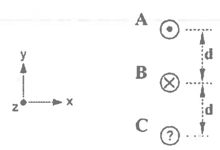
a. $\tau = 0.023$ N-m
b. $\tau = 0.974$ N-m
c. $\tau = 0.132$ N-m

$\tau = N I A B \underbrace{\sin\theta}_{=1}$

3 2.2 A $(0.1\,m)^2$ 2T

The next two questions pertain to the following situation:

The picture below shows three wires oriented vertically, each spaced a distance d = 10 cm apart. Wire A has current $I_A = 5$ A pointing out of the page (+z direction) and Wire B has current $I_B = 5$ A pointing into of the page (-z direction). Wire C has unknown current and direction. Each wire is 10 m long.



12. If we want current B to have a net force of zero on it, then in what direction should current C point?

a. out of the page
b. into the page
c. no current is necessary

13. Assume the direction and magnitude of the current in wire C is such that the net force on wire B is zero. In which direction could an external magnetic field B_{ext} be applied so that there continues to be no net force on wire B?

a. +x
b. +y
c. +z

The next two questions pertain to the following situation:

A charge with m= 1 kg and Q= +1.0 C enters into a parallel plate capacitor with E=100.0 V/m. An external magnetic field with magnitude of 2.0 T is applied in some direction. Ignore the force of gravity.

15. Which direction should the magnetic field point to make it possible for the particle to travel in a straight line?

a. Into the page
b. Out of the page
c. +y
d. −y
e. +x

16. What is the initial speed of this charge if it travels in a straight line?

a. 40 m/s
b. 50 m/s
c. 100 m/s
d. 0.02 m/s
e. 65 m/s

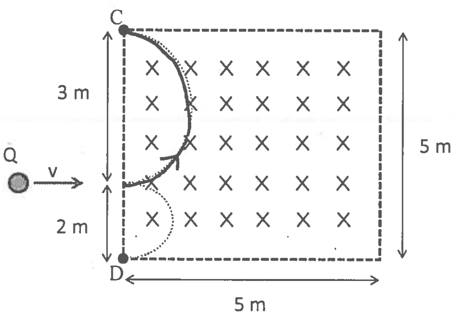
$\cancel{q}vB = \cancel{q}E$

$v = \frac{E}{B}$ ← 100 V/m

2T

The next question pertains to the following situation:

A charged particle with charge Q= 1C is travelling at v = 1 m/s in the +x direction toward a square with side length 5m containing magnetic field B= 3 Tesla, directed into the page. The particle enters the field at y=2 meters above the bottom of the square. There is no magnetic field anywhere outside the square.



17. The particle travels in a complete semi-circle. Given the direction of the magnetic field, this means that the particle exits at either point C or D, which you must determine. What is the mass of the particle?

a. 0.3 kg
b. 1 kg
c. 3 kg
d. 4.5 kg
e. 7.5 kg

$r = \frac{mv}{qB} \Rightarrow m = \frac{r\,q\,B}{v}$

3 T

1 m/s

1.5 m

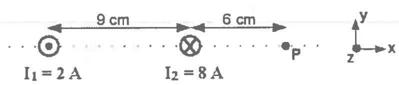
1C

KEY
Fall 2011 – Exam 2

1. a
2. b
3. b
4. b
5. b
6. c
7. a
8. b
9. b
10. a
11. c
12. a
13. c
14. d
15. a
16. b
17. d
18. c
19. d
20. c
21. a
22. a
23. d
24. b
25. b
26. d

The next two questions pertain to the following situation:

Two long straight wires are placed parallel to one another 9 cm apart, as shown in the figure. The current in wire 1 is oriented out of the page, and the current in wire 2 is oriented into the page. A point P is located 6 cm to the right of wire 2.



18. Calculate the net magnetic field in the y direction at the point P.

a. $B_{net} = +1.04 \times 10^{-5}$ T
b. $B_{net} = +3.99 \times 10^{-5}$ T
c. $B_{net} = +6.72 \times 10^{-5}$ T
d. $B_{net} = -5.34 \times 10^{-5}$ T
e. $B_{net} = -2.40 \times 10^{-5}$ T

$$\vec{B} = \vec{B}_1 + \vec{B}_2 = |\vec{B}_1|(+\hat{y}) + |\vec{B}_2|(-\hat{y})$$

$$B_y = \frac{\mu_0}{2\pi}\left[\frac{I_1}{r_1} - \frac{I_2}{r_2}\right]$$

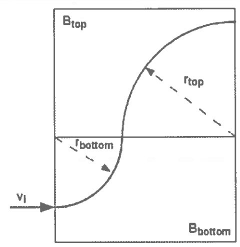
2 A   0.15 m   8 A   0.06 m

19. The net magnetic field due to the two wires equals zero at a point in the region between the two wires.

a. True
b. False

The next three questions pertain to the following situation:

A particle of mass 5×10^{-8} kg and speed $v_i = 3000$ m/s enters a region with magnetic field B_{bottom}, which is perpendicular to the plane of the paper. The magnitude of B_{bottom} is not known. The particle follows a quarter-circle trajectory and enters another region with a different magnetic field B_{top}, which is also perpendicular to the plane of the paper. It again follows a quarter-circle trajectory. The magnitude of B_{top} is also not known. The radius of curvature for the motion in the top region is larger than that in the bottom region ($r_{top} > r_{bottom}$).



20. Given that the particle has charge $q = +6$ μC, in which direction does B_{top} point?

a. into the page
b. out of the page

21. Which is true regarding the relationship between B_{top} and B_{bottom}?

a. $B_{top} < B_{bottom}$
b. $B_{top} = B_{bottom}$
c. $B_{top} > B_{bottom}$

22. Calculate B_{top} if r_{top} is 1.35 meters.

a. $B_{top} = 4.9$ T
b. $B_{top} = 18.5$ T
c. $B_{top} = 68.4$ T
d. $B_{top} = 173$ T
e. $B_{top} = 557$ T

$$r = \frac{mv}{qB}$$

$$B = \frac{mv}{qr}$$

3000 m/s

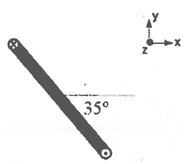
5×10^{-8} kg

6×10^{-6} C

1.35 m

The next two questions pertain to the following situation:

A square loop with sides of unknown length L is carrying a current I = 3 A. The loop is oriented in space at a 35° angle with respect to the horizontal. The current flows into the page at the top of the loop and out of the page at the bottom of the loop, as shown in the picture below. A magnetic field of magnitude B = 2.8 mT is applied in an unknown direction.



23. In which direction could the magnetic field be oriented for the torque due to the magnetic field to cause the loop to rotate in the counter-clockwise (CCW) direction as viewed in the picture above?

a. +x
b. +y
c. +z

24. Presume the magnetic field is now directed downward, in the −y direction. The torque on the loop is measured to be $\tau = 6.4 \times 10^{-6}$ N m. Calculate the length L of the sides of the square.

a. L = 0.381 m
b. L = 0.192 m
c. L = 0.633 m
d. L = 0.085 m
e. L = 0.037 m

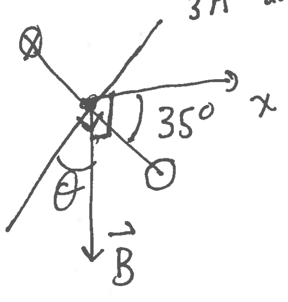
$$\tau = I A B \sin\theta$$

$$\tau = I L^2 B \sin\theta$$

$$L = \sqrt{\frac{\tau}{I B \sin\theta}}$$

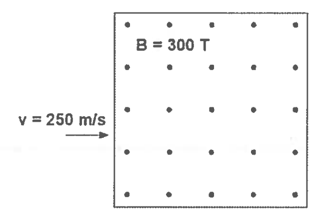
6.4×10^{-6} Nm

3 A 2.8×10^{-3} T   35°



The next two questions pertain to the following situation:

A positively charged particle moving with speed v = 250 m/s enters a region of magnetic field of magnitude B = 300 T oriented out of the page, as shown in the figure. The magnetic force on the particle is measured to be 15×10^{-9} N.



15×10^{-9} N

25. Calculate the charge Q of the particle.

a. $Q = 1 \times 10^{-13}$ C
b. $Q = 2 \times 10^{-13}$ C
c. $Q = 3 \times 10^{-13}$ C
d. $Q = 4 \times 10^{-13}$ C
e. $Q = 5 \times 10^{-13}$ C

$$F = q v B \Rightarrow q = \frac{F}{vB}$$

250 m/s   300 T

26. An electric field is now applied in the same region as the magnetic field. In which direction must the electric field be oriented so that the charge travels a straight-line trajectory through the region of the two fields?

a. up
b. down
c. into the page
d. out of the page
e. right

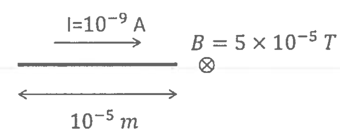
Check to make sure you bubbled in all your answers.
Did you bubble in your name, exam version and network-ID?

KEY
Spring 2012 – Exam 2

1. c
2. c
3. a
4. c
5. a
6. b
7. a
8. b
9. c
10. c
11. c
12. a
13. d
14. c
15. a
16. c
17. c
18. c
19. b
20. b
21. a
22. b
23. a
24. c
25. b
26. a

8. A 10^{-5} m long carbon nanotube with a mass of 2×10^{-20} kg is used as a wire. As shown, the nanotube carries 10^{-9} A of current to the right. If the Earth's magnetic field is 5×10^{-5} T and points into the page, what is the acceleration of the nanotube?

a. 9.8 m/s^2
b. 25 m/s^2
c. 5×10^{-9} m/s^2
d. 0.04 m/s^2
e. 2.5×10^{-19} m/s^2



$$F = ILB\underbrace{\sin\theta}_{=1}$$

$$a = \frac{F}{m} = \frac{ILB}{m}$$

5×10^{-5} T

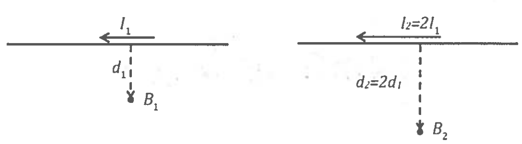
2×10^{-20} kg

10^{-9} A

10^{-5} m

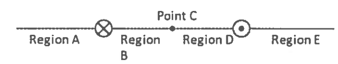
19. A long straight wire carries current, I_1. It produces a magnetic field, B_1, at a distance, d_1, from the wire. Now, both the current and the distance are doubled. Compare the new magnetic field, B_2, to the original field, B_1.

a. $B_2 < B_1$
b. $B_2 = B_1$
c. $B_2 > B_1$



$$B = \frac{\mu_0 I}{2\pi r} \quad \begin{matrix} \leftarrow \times 2 \\ \leftarrow \times 2 \end{matrix}$$

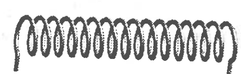
20. Two wires carry current perpendicular to the page. The magnitudes of the two currents are equal, but one is into and one is out of the page, as shown. Where on the line is the magnetic field zero?



a. Somewhere in region A
b. Somewhere in region B
c. At point C
d. Somewhere in region D
e. The magnetic field is not zero anywhere on the line.

Because currents are equal

21. The coil of an MRI solenoid is 8 cm long and has a 0.025 m radius. There are 500 turns of wire. How much current is needed to produce a 3 T magnetic field inside the solenoid? (Note: This device images mice, not humans!)



a. $I = 6.0\times10^{-10}$ A
b. $I = 382$ A
c. $I = 4774$ A
d. $I = 1.91\times10^{5}$ A
e. $I = 1.49\times10^{10}$ A

$$B = \mu_0 n I$$

$$= \mu_0 \frac{N_{turns}}{L} I$$

$$I = \frac{BL}{\mu_0 N_{turns}}$$

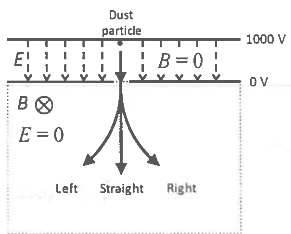
3 T

0.08 m

500

The next two questions pertain to this situation:

A charged dust particle ($m = 3\times10^{-21}$ kg, $q = +1.6\times10^{-16}$ C) is accelerated from rest by an electric field through a 10^3 V potential difference. The magnetic field is zero in the electric field region. It then enters a region that contains a uniform 1.5 T magnetic field that points into the page. $E = 0$ in the magnetic field region.



22. Which of the three paths shown in the figure does the dust particle follow?

a. Left
b. Straight
c. Right

23. What is the radius of curvature of the particle's motion in the magnetic field region?

a. $R = 0.022$ m
b. $R = 0.129$ m
c. $R = 1.53$ m
d. $R = 15.3$ m
e. $R = 1096$ m

3×10^{-21} kg

$r = \frac{mv}{qB}$

1.6×10^{-16} C

1.5 T

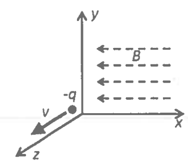
First must get v:

$\frac{1}{2}mv^2 = qV$

$\Rightarrow v = \sqrt{\frac{2qV}{m}} = 10.3\times10^3$ m/s

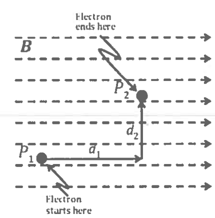
$r = \frac{mv}{qB}$

24. A negatively charged particle, $-q$, is moving in the $+z$ direction in a region that contains a uniform magnetic field along the $-x$ direction. In what direction must an electric field point so that there is no net force on the particle?



a. Along $+x$
b. Along $-x$
c. Along $+y$
d. Along $-y$
e. Along $-z$

25. An electron (mass $m = 9.11\times10^{-31}$ kg, and charge $q = -1.60\times10^{-19}$ C) is initially at point P_1 with speed $v_1 = 3.1\times10^4$ m/s. It is moving in a uniform magnetic field of strength $B = 0.15$ T. How fast (v_2) is the electron moving when it reaches point P_2, which is $d_1 = 2.5\times10^{-7}$ m along B and $d_2 = 1.5\times10^{-7}$ m perpendicular to B with respect to P_1?

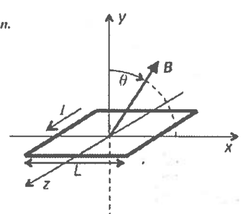


a. $v_2 = 1.1\times10^4$ m/s
b. $v_2 = 3.1\times10^4$ m/s
c. $v_2 = 5.1\times10^4$ m/s
d. $v_2 = 6.7\times10^4$ m/s
e. The electron does not have enough energy to reach point P_2.

SAME as before

The next two questions pertain to this situation.

A square loop with sides, $L = 0.1$ m, lies in the x-z plane and carries electric current, $I = 3.7$ A, in the direction shown. The magnetic field, $B = 0.22$ T, lies in the x-y plane, rotated away from the $+y$ direction by an angle θ, as shown.



26. What value of θ would make the torque on the loop equal to zero?

a. $\theta = 0°$
b. $\theta = 45°$
c. $\theta = 90°$
d. $\theta = -90°$
e. The torque is never equal to zero.

27. For $\theta = 37°$, how much torque, τ, is exerted on the loop?

a. $\tau = 4.90\times10^{-3}$ N m
b. $\tau = 6.50\times10^{-3}$ N m
c. $\tau = 8.14\times10^{-3}$ N m
d. $\tau = 2.23\times10^{-2}$ N m
e. $\tau = 8.14\times10^{-2}$ N m

0.22 T

$\tau = IAB \sin\theta$

37°

3.7 A

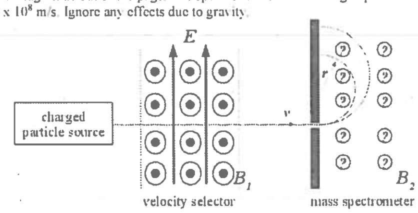
$(0.1 m)^2$

KEY
Exam 2 – Fall 2012

1. c
2. a
3. b
4. a
5. c
6. b
7. c
8. b
9. d
10. c
11. b
12. a
13. c
14. b
15. b
16. c
17. b
18. c
19. b
20. c
21. b
22. c
23. b
24. c
25. b
26. a
27. a

The next three questions pertain to the following situation:

A beam of particles is sent through a velocity selector in order to isolate charges of a particular speed to enter into a mass spectrometer (see below). In the region of the velocity selector, the electric field $E = 2500$ N/C upward and the magnetic field B_1 is of unknown magnitude out of the page. The speed of the selected charged particles is $v = 2.2 \times 10^8$ m/s. Ignore any effects due to gravity.



1. The velocity selector is set up to select positive charges *only*.

a. T
b. F

2. What is the magnitude of the magnetic field B_1 in the region of the velocity selector?

a. $B_1 = 0.13$ µT
b. $B_1 = 11$ µT
c. $B_1 = 56$ µT
d. $B_1 = 84$ µT
e. $B_1 = 166$ µT

$$qvB = qE \quad \leftarrow 2500 \text{ N/C}$$

$$\Rightarrow B = \frac{E}{v} \leftarrow 2.2\times10^{8} \text{ m/s}$$

3. The selected charged particles are then sent into a mass spectrometer to identify the composition of the stream from the source. The magnetic field $B_2 = 5.5$ µT in this region is oriented such that the charged particles deflect in semicircles as shown. For a certain particle in the beam, the mass is measured to be $m = 1.56 \times 10^{-24}$ kg for following a path of radius $r = 7.5$ mm. What is the charge q of the particle?

a. $q = 41.8$ nC
b. $q = 96.2$ nC
c. $q = 8.3$ nC
d. $q = 0.368$ nC
e. $q = 25.0$ nC

$$r = \frac{mv}{qB}$$

$$\Rightarrow q = \frac{mv}{rB}$$

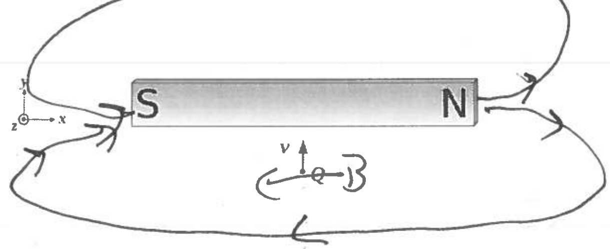
v: 2.2×10^{8} m/s

B: 5.5×10^{-6} T

m: 1.56×10^{-24} kg

r: 7.5×10^{-3} m

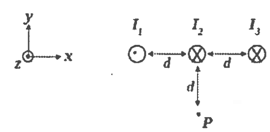
7. A proton is moving toward a bar magnet. What is the direction of the magnetic force on the proton if it travels in the $+y$ direction at the point designated Q in the figure? (The point Q is directly below the center of the bar magnet.)



a. left
b. right
c. into the page
d. out of the page
e. There is no magnetic force on the proton.

The next three questions pertain to the following situation:

Three infinitely long current-carrying wires are placed in a horizontal line, with a distance d between each. The magnitudes of the currents in each of the wires are $I_1 = I_2 = I_3 = I$. Point P is located a distance d directly under wire 2.



10. What is the general direction of the net magnetic field at point P due to the three wires?

11. What is the y-component of the magnetic field at point P?

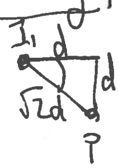
a. $B_y = +\frac{2\mu_0 I}{\pi d}$
b. $B_y = 0$
c. $B_y = +\frac{\mu_0 I}{2\pi d}$
d. $B_y = -\frac{2\mu_0 I}{\pi d}$
e. $B_y = +\frac{\mu_0 I}{\sqrt{2}\pi d}$

y comes from I_1, I_3

$B_{1y} = B_{2y} \Rightarrow \boxed{B_y = 2 \cdot B_{1y}}$

$B_{1y} = B_1 \cdot \frac{d}{\sqrt{2}d}$

$= \frac{\mu_0 I}{2\pi(\sqrt{2}d)} \cdot \frac{1}{\sqrt{2}}$



12. What is the magnitude of the net force on a length L of wire 2 due to the other two wires?

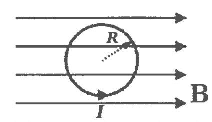
a. $F_{2,net} = \frac{\mu_0 I^2 L}{\pi d}$
b. $F_{2,net} = \frac{2\mu_0 I^3 L}{\pi d}$
c. $F_{2,net} = \frac{3\mu_0 I^2 L}{2\pi d}$

forces ADD

$F_1 = F_3 = \frac{\mu_0 I^2 L}{2\pi d}$

The next two questions pertain to the following situation:

A single wire loop is placed in a uniform magnetic field as shown in the diagram. The loop has radius $R = 15$ cm. The current in the loop is measured to be $I = 3.33$ A in the counterclockwise direction, as indicated in the figure. The net torque this loop experiences is measured to be $\tau = 5.25 \times 10^{-3}$ N·m.



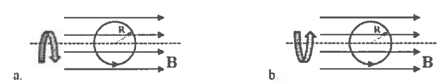
13. What is the magnitude of the magnetic field?

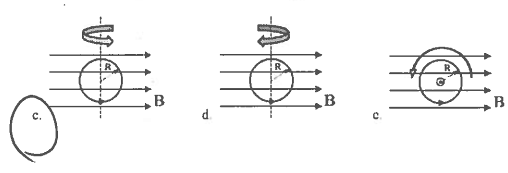
a. $B = 66.7$ mT
b. $B = 22.3$ mT
c. $B = 97.2$ mT
d. $B = 343$ mT
e. $B = 5.6$ mT

$\tau = IAB \underbrace{\sin\theta}_{=1}$

$B = \frac{\tau}{IA}$ ← 5.25×10^{-3} Nm ← $(0.15\text{ m})^2$ ← 3.33 A

14. Which picture below shows the direction of rotation at the moment the loop is allowed to rotate freely?



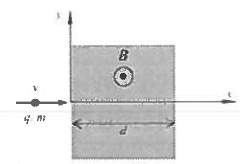


KEY
Exam 2 – Spring 2013

1. b
2. b
3. c
4. b
5. bc
6. a
7. d
8. b
9. b
10. a
11. c
12. a
13. b
14. c
15. a
16. c
17. c
18. a
19. b
20. b
21. b
22. c
23. c
24. b
25. a
26. a

The next three questions pertain to the situation described below.

A negatively-charged particle, moving at a speed v = 165 m/s, enters a region of width d = 0.87 m that contains a uniform magnetic field of magnitude B = 1.7 T pointing out of the page, as shown in the figure. The mass and the magnitude of the charge of the particle are unknown.



1) In which direction will the particle be deflected? Show how apply RHR (fingers point in _____ etc) 75%

a. Up
b. Down

Fingers in direction of v (right/positive x)
Palm in direction of B (out of page + z)
Thumb = direction of force on positive charge (down/-y)
Negative charge so force is opposite (up)

2) What is the minimum mass-to-charge ratio ($m\ q$) such that the particle can traverse the whole shaded region and exit through the right? show work starting w/ F=ma, and solve

a. $m\ q$ = 0.0064 kg/C
b. $m\ q$ = 0.0112 kg/C
c. $m\ q$ = 0.00427 kg/C
d. $m\ q$ = 0.00345 kg/C
e. $m\ q$ = 0.00896 kg/C

F= ma
qvBsin(90) = mv^2 / r
m/q = B r / v
= (1 7) (0 87) / (165)
= 8.96e-3

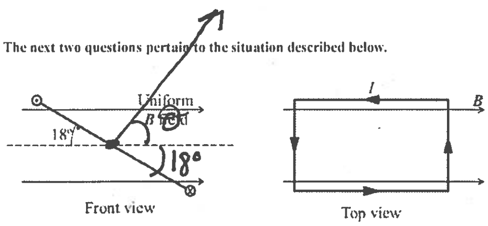
3) Now an electric field of magnitude E = 78 N/C is added to the shaded region. What should the speed of the particle be such that it travels in a straight line across the shaded region?

Show work starting w/ F=ma

a. v = 39.9 m/s
b. v = 1.22 m/s
c. v = 45.9 m/s
d. v = 76.6 m/s
e. v = 4.13 m/s

F = ma
qvB sin(90) - qE = 0
v = E/B
= 78 / 1.7
= 45 9

The next two questions pertain to the situation described below.



A rectangular loop of area $A = 0.0245\ m^2$ and carrying a current $I = 3.9$ A is exposed to a uniform magnetic field of magnitude $B = 4.6$ T, as shown in the figure.

4) What is the magnitude of the torque exerted on the loop? Show work starting w/ expression for torque

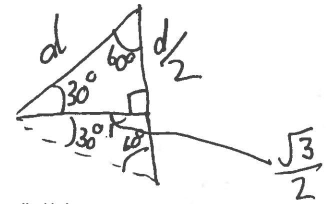
$\theta = 90^\circ - 18^\circ = 72^\circ$

$\tau = IAB\sin\theta$

a. 0.136 Nm
b. 0.153 Nm
c. 0.418 Nm

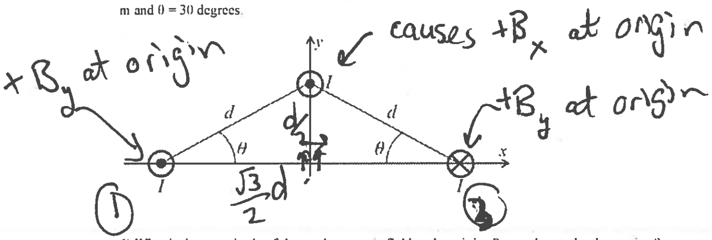
5) As seen from the front, in which direction will the loop rotate? Either show forces on diagram (front view) or explain using dipole moment.

a. Clockwise
b. Counterclockwise



The next two questions pertain to the situation described below.

Three long, straight wires, each carrying a current $I = 4.8$ A, are arranged as shown in the figure, with $d = 2$ m and $\theta = 30$ degrees.



6) What is the magnitude of the total magnetic field at the origin, B_{total}, due to the three wires?
Draw B from each wire, then show calc of x and y components be sure to show angle, and combine to get Btotal

a. $B_{total} = 1.07 \times 10^{-6}$ T
b. $B_{total} = 2.07 \times 10^{-6}$ T
c. $B_{total} = 1.92 \times 10^{-6}$ T
d. $B_{total} = 1.36 \times 10^{-6}$ T
e. $B_{total} = 1.47 \times 10^{-6}$ T

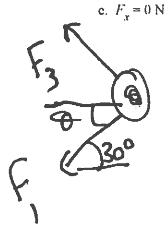
$\vec{B} = B_y\hat{y} + B_x\hat{x} \quad |\vec{B}| = \sqrt{B_x^2 + B_y^2}$

$B_x = \frac{\mu_0 I}{2\pi \frac{d}{2}} \; ; \; B_y = 2 \cdot \left[\frac{\mu_0 I}{2\pi\left(\frac{\sqrt{3}}{2}\right)d}\right]$

7) What is the x component of the net force on one meter of the top wire due to the other two wires?
Draw forces from lower currents, then calculate magnitude using expression for force between two wires, then calculate x component. Be sure to label angles.

a. $F_x = -2.3 \times 10^{-6}$ N
b. $F_x = 3.99 \times 10^{-6}$ N
c. $F_x = -3.99 \times 10^{-6}$ N
d. $F_x = 2.3 \times 10^{-6}$ N
e. $F_x = 0$ N

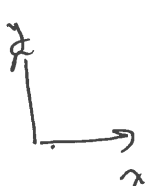
$\{\vec{F}_{tot}\} = (F_{1x} + F_{3x})\hat{x} \quad [F_y \text{ cancels}]$



$|F_{x\,tot}| = 2|F_{1x}| = 2|F_1|\cos\theta$

$= 2 \cdot \frac{\mu_0 I_1 I_2 L}{2\pi d}\cos\theta$

$= 2\frac{\mu_0 I^2 L}{2\pi d}\cos\theta$



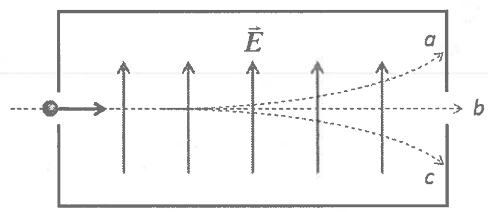
F_{tot} is to the left

Physics 102 Exam 2 –
Spring 2014

1. a
2. e
3. c
4. c
5. a
6. e
7. c
8. d
9. a
10. b
11. c
12. b
13. b
14. a
15. b
16. a
17. c
18. b
19. c
20. b
21. a
22. b
23. a
24. d
25. a

The next three questions pertain to the situation described below.

Mass spectrometers often contain a device called a velocity selector, which consists of a chamber with perpendicular $\vec{E}$ and $\vec{B}$ fields. The magnitudes of the fields are such that only particles with speed $v_b = 1 \times 10^5\ m/s$ travel along a straight line trajectory b through the opening at the far end of the chamber.



7) Given the $\vec{E}$ field pointing up, which direction of the $\vec{B}$ field would give the observed trajectory b? You may assume that the particle charge Q is positive.

a. *out of the page*
b. *to the right*
c. *to the left*
d. *into the page*
e. *the B field is zero*

8) Does your answer to the previous problem change if the charge Q is <u>negative</u>?

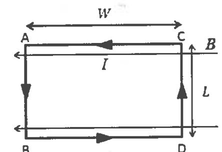
a. No
b. Yes

9) As shown in the figure, two other particles travel along the dotted trajectories a and c. Which of the following statements must be true? Again assume Q is positive.

a. $v_a > v_b > v_c$
b. $v_a = v_b = v_c$
c. $v_a < v_b < v_c$

The next three questions pertain to the situation described below.

Front view



Top view

A rectangular loop of length $L = 0.445\ m$ and width $W = 0.285\ m$ carries a current $I = 3.9\ A$ is exposed to a uniform magnetic field of magnitude $B = 5.5$ T, as shown in the figure.

18) What is the magnitude of the force experienced on wire segment **AB**?

a. $F_{AB} = 2.09\ N$
b. $F_{AB} = 3.26\ N$
c. $F_{AB} = 9.55\ N$
d. $F_{AB} = 8.97\ N$
e. $F_{AB} = 5.74\ N$

$F = ILB \underbrace{\sin\theta}_{=1}$

3.9A 0.445 m 5.5 T

19) What is the magnitude of the torque exerted on the loop?

a. 2.56 Nm
b. 1.06 Nm
c. 0.93 Nm

$\tau = IAB \sin\theta \leftarrow 70°$

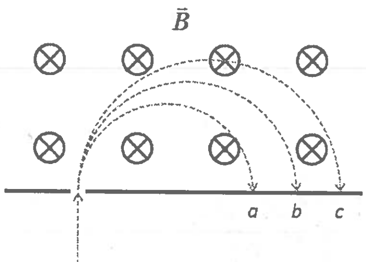
$L \cdot W = 0.445 \times 0.285$

20) As seen from the front, in which direction will the loop rotate?

a. Counterclockwise
b. Clockwise

The next two questions pertain to the situation described below.

Consider a beam of identical particles with the same charge Q and mass m travelling along the dotted trajectories as they enter a region containing a uniform $\vec{B}$ field pointing into the page.



10) What is the sign of the charge of the particles?

a. *negative*
b. *the sign cannot be determined*
c. *positive*

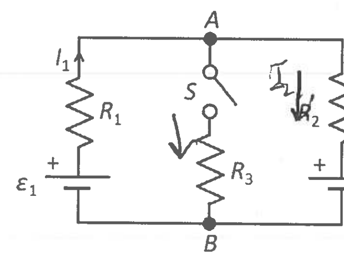
11) Particles moving along which trajectory have the largest speed?

a. *trajectory c*
b. *trajectory a*
c. *trajectory b*

$r = \frac{mv}{qB}$

The next three questions pertain to the situation described below.

Consider the following circuit: $R_1 = 10\ \Omega$, $R_2 = 8\ \Omega$, $R_3 = 3\ \Omega$, $\varepsilon_1 = 17\ V$ *and* $\varepsilon_2 = 8\ V$. Initially the switch is open.



$-I_2R_2 = V_2 = 4V$

$-\varepsilon_2 = -8V$

12) You connect a voltmeter at points A and B in the circuit. What is the electric potential difference, $\Delta V_{AB} = V_A - V_B$, measured between those points?

a. $\Delta V_{AB} = 12\ V$
b. $\Delta V_{AB} = 17\ V$
c. $\Delta V_{AB} = 9\ V$

$+\varepsilon_1 - I_1R_1 - I_2R_2 - \varepsilon_2 = 0; \quad I_1 = I_2$

$\Rightarrow I = \frac{\varepsilon_1 - \varepsilon_2}{R_1 + R_3} = 0.5A; \quad V_2 = IR_2 = 4V$

13) Now the switch is closed. Using the same voltmeter as above, you measure the electric potential difference $\Delta V_{AB} = V_A - V_B = 3.33\ V$. In which direction does the current flow through resistor R_3?

a. *no current flows*
b. *up*
c. *down*

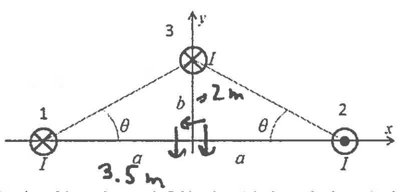
14) What is the current I_1 through resistor R_1 after the switch is closed?

a. $I_1 = 0.8\ A$
b. $I_1 = 1.7\ A$
c. $I_1 = 1.4\ A$

The next three questions pertain to the situation described below.

Three long, straight wires, are arranged as shown in the figure:

$a = 3.5\ m$, $b = 2\ m$ and $\theta = 30^{0}$. Each wire carries a current $I = 8.8$ A



21) Which vector best represents the direction of the total magnetic field at the origin due to the three wires?

a. *Figure B*
b. *Figure C*
c. *Figure D*
d. *Figure E*
e. *Figure A*

22) What is the magnitude of the total magnetic field at the origin, B_{total}, due to the three wires?

a. $B_{total} = 9.76 \times 10^{-7}$ T
b. $B_{total} = 1.24 \times 10^{-6}$ T
c. $B_{total} = 1.34 \times 10^{-6}$ T
d. $B_{total} = 1.75 \times 10^{-6}$ T
e. $B_{total} = 1.89 \times 10^{-6}$ T

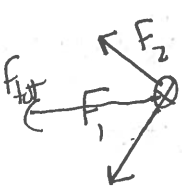
$$B_y = B_1 + B_2 = 2B_1 = 2\frac{\mu_0 I}{2\pi a}$$

$$B_x = B_3 = \frac{\mu_0 I}{2\pi b} \Rightarrow B^2 = B_x^2 + B_y^2 = \frac{\mu_0^2 I^2}{(2\pi)^2}\left[\frac{4}{a^2} + \frac{1}{b^2}\right]$$

$$\Rightarrow B = \frac{\mu_0 I}{2\pi}\sqrt{\frac{4}{a^2} + \frac{1}{b^2}}$$

23) What is the direction of the net force on one meter of Wire 3 due to the other two wires?

a. +x-direction
b. 0
c. +y-direction
d. -y-direction
e. -x-direction

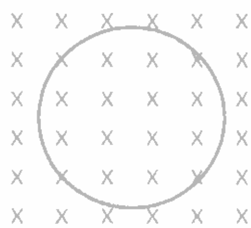


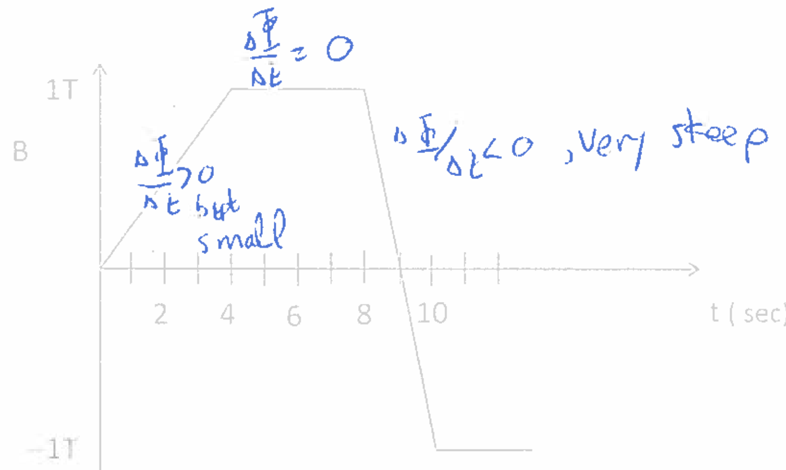
KEY
Exam 2 – Fall 2014

1. b
2. d
3. a
4. c
5. c
6. a
7. a
8. a
9. c
10. a
11. a
12. a
13. c
14. c
15. b
16. c
17. a
18. c
19. a
20. a
21. a
22. c
23. e
24. c
25. a

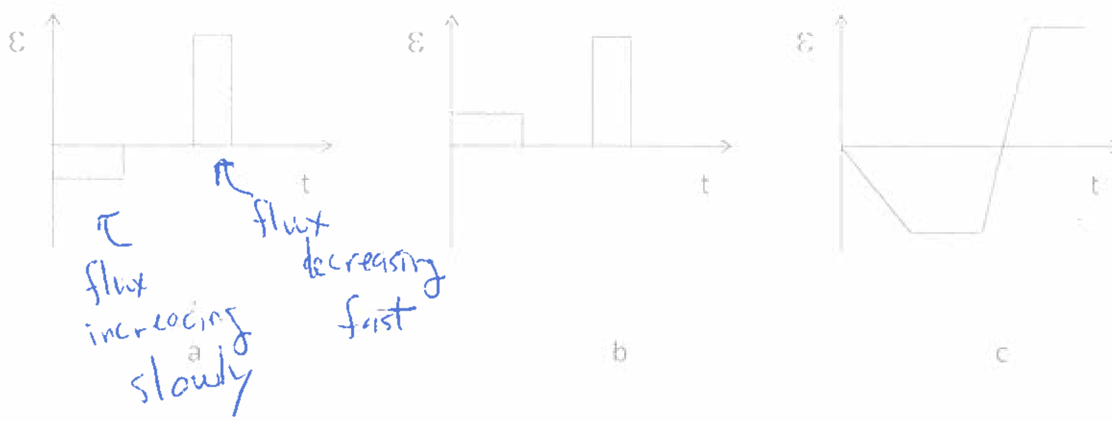
The following 3 questions refer to the following situation.

7. A conducting ring sits in an external magnetic field. Initially the magnetic field is zero. The field is varied with time according to the graph with a positive B field pointing into the page.



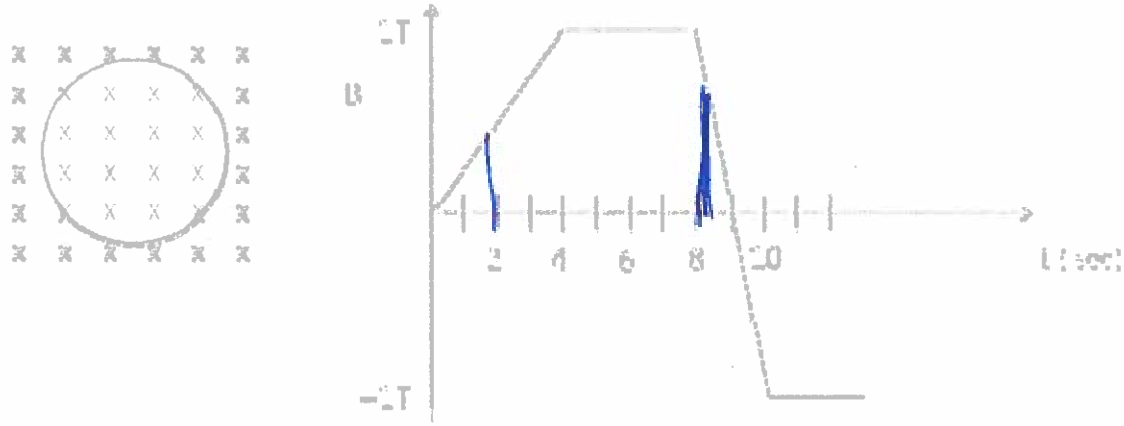


Which graph below best represents the EMF induced in the loop versus time?



a. a
b. b
c. c

The following 2 questions continue from the previous page.



8. Relate the magnitude of the current in the loop at t=2 seconds to the magnitude of the current in the loop at t=9 seconds.

a. I(2 sec) > I(9 sec)
b. I(2 sec) < I(9 sec)
c. I(2 sec) = I(9 sec)

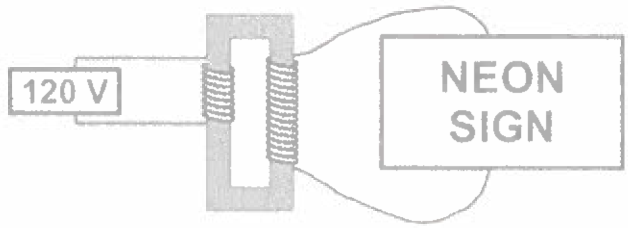
$\left|\frac{\Delta \Phi}{\Delta t}\right|$ much larger at 9s

9. The current generated at t=2 seconds and t=9 seconds are

a. in the same direction
b. in opposite directions
c. no current is generated at those times

Φ increasing at 2s
decreasing at 9s

26. A step-up transformer is used to supply adequate voltage to a neon sign.



The transformer is designed to have an output voltage of 1200 V when the primary is connected to a 120 V source. How many turns must the secondary winding have if the number of primary turns is 50?

a. 10 turns
b. 50 turns
c. 100 turns
d. 500 turns
e. 1000 turns

$$\frac{V_s}{V_p} = \frac{N_s}{N_p}$$

$$\Rightarrow N_s = N_p \cdot \frac{V_s}{V_p} = 50 \cdot \frac{1200}{120}$$

$$= 500$$

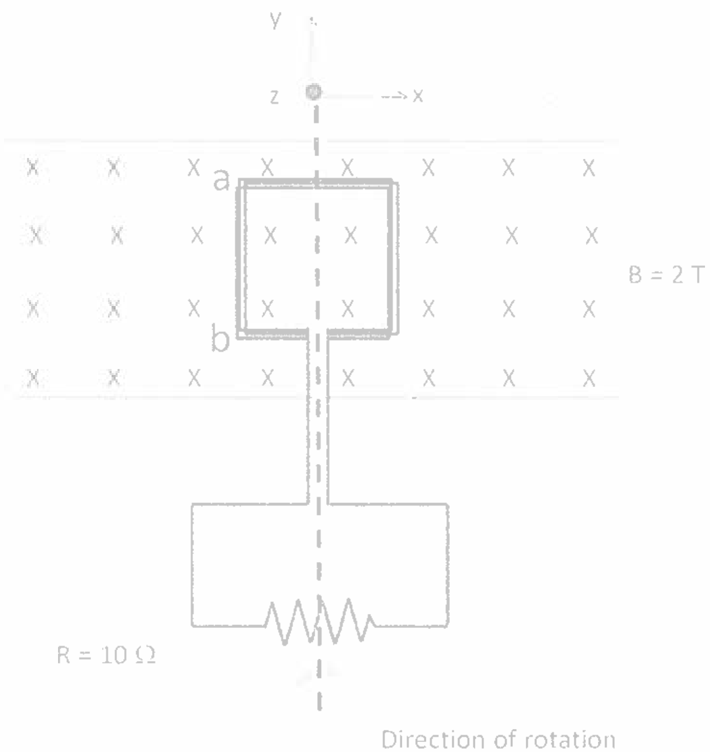
Did you bubble in your name, exam version, and network ID?
Check to make sure you have bubbled in all your answers.

KEY
Fall 2011 – Exam 2

1. a
2. b
3. b
4. b
5. b
6. c
7. a
8. b
9. b
10. a
11. c
12. a
13. c
14. d
15. a
16. b
17. d
18. e
19. d
20. c
21. a
22. a
23. d
24. b
25. b
26. d

The next three questions pertain to the following situation.

A coil consisting of 5 square turns connected in series rotates at 60 revolutions per second ($\omega = 2\pi 60$ radians per second). The magnetic field B = 2 T points in the –z direction (into the page). At t = 0, the plane of the coil lies in the x-y plane: a side of the coil is labeled with points "a" and "b." The rotation is around the y axis, such that at t=0 side a-b is moving out of the page. The loops have an area of 100 cm^2 and no resistance of their own. A 10 Ω resistor is connected across the coils as shown.



1. At t = 0

a. the current flows clockwise, directly from point b to point a.
b. the current flows counterclockwise, directly from point a to point b.
c. the current is zero.

$\Phi = \cos(\omega t)$
$|\mathcal{E}| = \mathcal{E}_0 |\sin(\omega t)|$

2. The maximum value of the current is

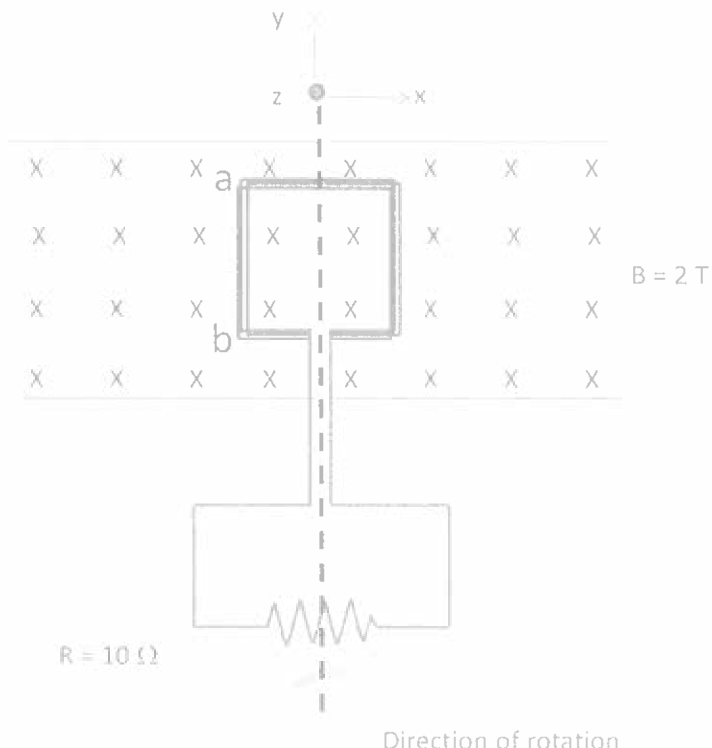
a. 0 A
b. 1.00 A
c. 2.56 A
d. 100.53 A
e. 3.77 A

$\Phi = BA\cos\phi$
$= B \cdot A \cos(\omega t)$
$\mathcal{E} = \omega N(\text{Area}) B \sin(\omega t)$
$2\pi(60)$ 5 $100\text{ cm}^2 = 0.01\text{ m}^2$ 2T

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

$I = \frac{\mathcal{E}}{R} = \frac{2\pi(60)(0.01)2(5)}{10} = 3.77\text{ A}$

The next question continues from the previous page.



3. Once the coil has rotated forward by 45°

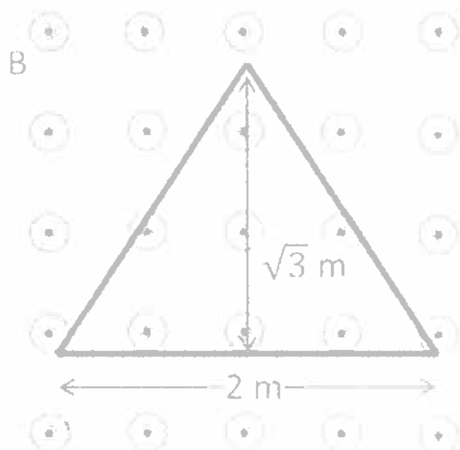
a. the current flows clockwise, directly from point b to point a.
b. the current flows counterclockwise, directly from point a to point b.
c. the current is zero.

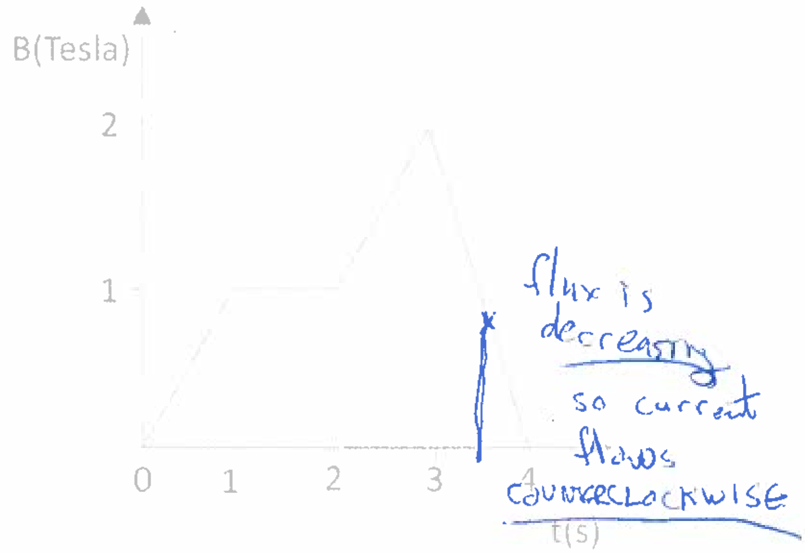
flux is decreasing from rotation, so current flows to increase flux (into page)

flux into page comes from a CLOCKWISE current.

The next two questions pertain to the following situation.

A triangular conducting coil lies in a uniform magnetic field B which varies in time as shown in the graph of B (Tesla) versus t (seconds). At t = 1 s, the magnetic field is pointing out of the page. The triangle has height h = $\sqrt{3}$ m, and the base of the triangle has length L = 2 m.





4. Which statement best represents the situation at t = 3.5 s?

a. The magnitude of the induced emf is 4.5 V, and the current flows counterclockwise.
b. The magnitude of the induced emf is 4.5 V, and the current flows clockwise.
c. The magnitude of the induced emf is 3.5 V, and the current flows counterclockwise.
d. The magnitude of the induced emf is 3.5 V, and the current flows clockwise.
e. There is no induced emf.

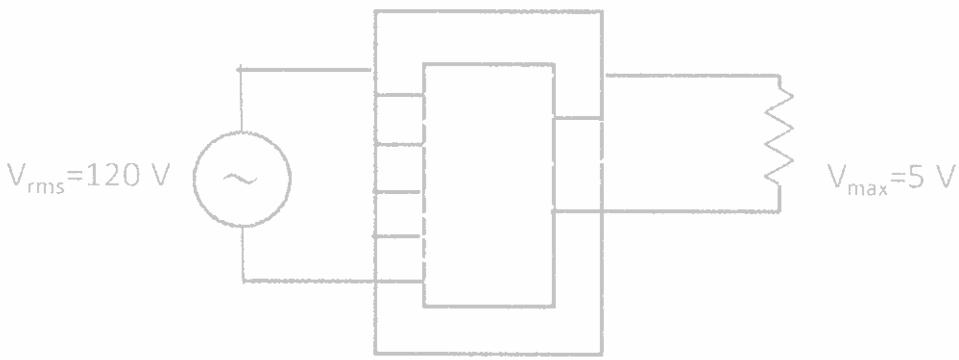
$$\left|\frac{\Delta \Phi}{\Delta t}\right| = \frac{A(\Delta B)}{\Delta t} = \frac{\sqrt{3}\,m^2(2T)}{1s} = 3.5V$$

5. The current is zero

a. between t = 1s and t = 2s.
b. at t = 0.5 s.
c. at t = 3.5 s.

Φ = constant when B = constant

15. There is a transformer inside the charger for your cell phone that is designed to reduce the voltage supplied by an electrical outlet. The outlets in your house provide V_{rms}=120 V AC power, while the charger requires V_{max}=5 V AC power. How many turns should there be on the secondary side of the charger if there are 100 primary turns?



a. 3
b. 6
c. 1700

$$\frac{N_s}{N_p} = \frac{V_s}{V_p}$$

$$\Rightarrow N_s = N_p \cdot \frac{V_s}{V_p} = 100 \frac{5}{120} = 4.2$$

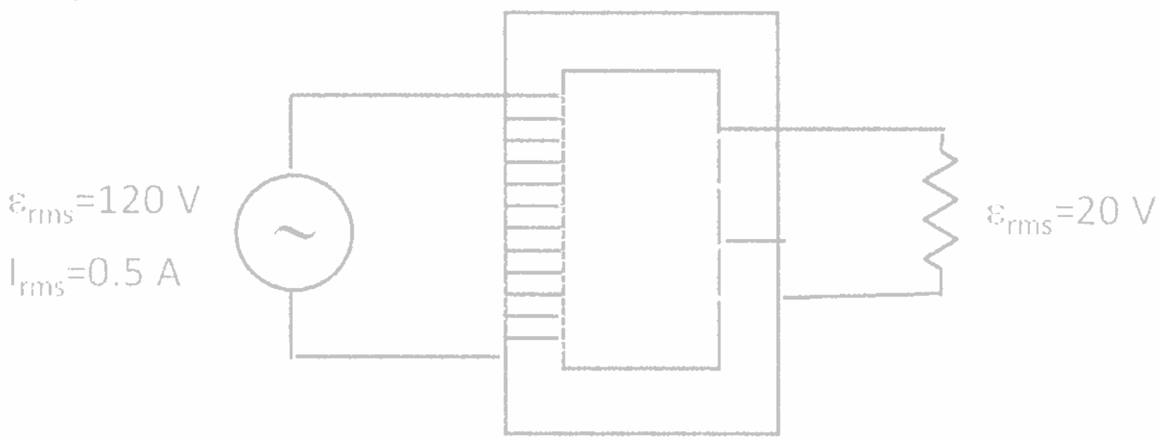
max voltage, ok if smaller

KEY
Spring 2012 - Exam 2

1. c
2. e
3. a
4. c
5. a
6. b
7. a
8. b
9. c
10. c
11. e
12. a
13. d
14. c
15. a
16. c
17. e
18. e
19. b
20. b
21. a
22. b
23. a
24. e
25. b
26. a

The following situation pertains to the next two questions:

A transformer is used in the power supply for your computer to reduce the voltage supplied by a wall outlet. 120 V rms from the outlet is applied to the primary side of the transformer, and 20 V rms is produced on the secondary side of the transformer, which is connected to the computer. The rms current on the primary side of the transformer is 0.5 A.



3. What is the rms current on the secondary side of the transformer?

a. 0.08 A
b. 3 A
c. 0.5 A

This is a tricky question we didn't really talk about in class.

$\frac{V_s}{V_p} = \frac{20V}{120V} \Rightarrow$ factor of 6

Power is conserved, so IV is the same $\Rightarrow I_s = 6 I_p = 3A$

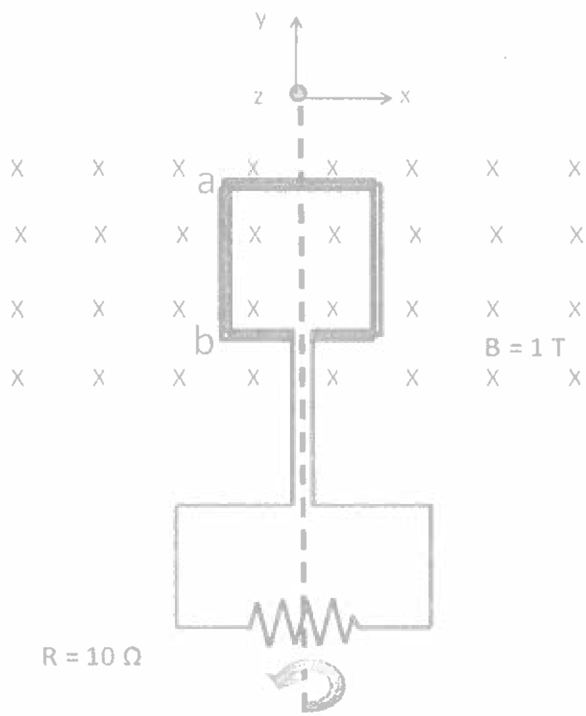
4. How much power is supplied to the computer?

a. 60 W
b. 10 W
c. 1.6 W

$P = IV = 20V \cdot 3A = 60W$

The following situation pertains to the next three questions:

A generator coil rotates in a uniform and constant magnetic field of B = 1T. The coil has 10 windings and the rotation frequency of the coil in the field is f = 0.5 Hz (ω = 3.14 rad/s). The resistance of all conductors in the circuit can be neglected. However, there is an external load resistor of R = 10 Ω. The coil rotates around the y-axis in the direction indicated by the circular arrow in the drawing below. Looking along the y-axis, the rotation is counterclockwise (i.e., the side *ab* of the wire loop moves into the page). The area of the coil is 1 m^2.



Direction of rotation, ω = 3.14 rad/s

10. For the situation shown above, which statement is correct concerning the magnitude of the current?

a. The current reaches its maximum value in the clockwise direction.
b. The current reaches its maximum value in the counter-clockwise direction.
c. The current is zero.

currently at max flux

11. When the generator coil has rotated by an angle of 30 degrees starting from the situation shown above, what is the direction of the current?

a. from a to b
b. from b to a
c. zero

flux into the page is decreasing due to rotation
⇒ current flows to increase that flux in
⇒ clockwise

12. What is the maximum current through the resistor?

a. 3.14 A
b. 2.67 A
c. 1.33 A
d. 1.0 A
e. 0.1 A

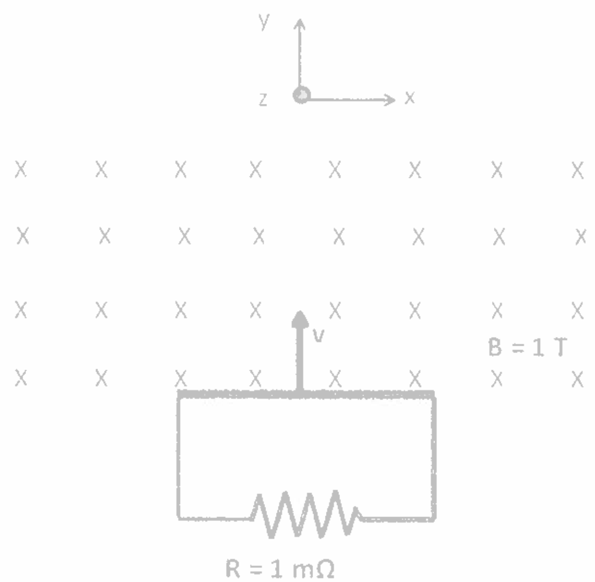
$\mathcal{E}_{max} = N \cdot (\text{Area}) B \omega$

$I_{max} = \frac{\mathcal{E}_{max}}{R} = \frac{10(1)(1)3.14}{10}$

$= 3.14$ A

The following situation pertains to the next two questions:

A metal frame with an internal resistance of 1 mΩ enters a region of a uniform magnetic field B = 1 T. The area of the frame is 1 m^2. The velocity of the frame, v, is constant. At t = 0, the upper edge of the frame reaches the boundary of the magnetic field. From this point of time it takes 10 seconds for the frame to fully enter the magnetic field. After 30 seconds of uniform motion the frame exits the magnetic field region again.



13. From Lenz's rule, what is the relation between the currents induced in the metal frame on entrance to and upon exit from the magnetic field?

a. Entrance: clockwise Exit: clockwise
b. Entrance: clockwise Exit: counterclockwise
c. Entrance: counterclockwise Exit: clockwise

flux ⊗ increasing
⇒ current flows in B ⊙

flux ⊗ decreasing
⇒ current flows with B ⊗

14. What is the maximum magnitude of the induced current?

a. 1000.0 A
b. 100.0 A
c. 10.0 A
d. 1.0 A
e. 0.1 A

$$|\mathcal{E}| = \left|\frac{\Delta\Phi}{\Delta t}\right|$$

$$= \left|\frac{\Phi(t=0) - \Phi(t=10\,s)}{10\,s}\right|$$

$$= \frac{(\text{Area})\,B}{10\,s}$$

$$= 0.1 \left(\frac{T\,m^2}{s}\right) = V$$

$$I = \frac{\mathcal{E}}{R} = \frac{0.1\,V}{1\cdot 10^{-3}\,\Omega}$$

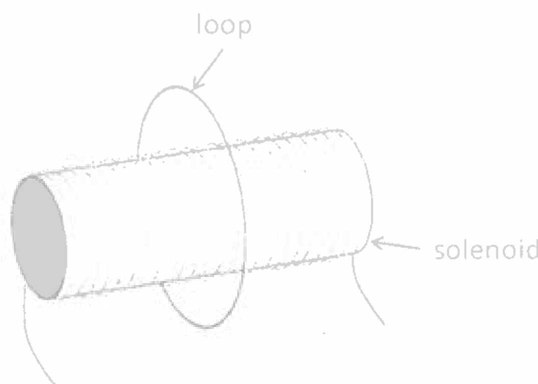
$$= 100\ A$$

KEY
Exam 2 – Fall 2012

1. c
2. a
3. b
4. a
5. e
6. b
7. e
8. b
9. d
10. c
11. b
12. a
13. c
14. b
15. b
16. c
17. b
18. e
19. b
20. e
21. b
22. c
23. b
24. e
25. b
26. a
27. a

The next three questions pertain to the following situation:

A single circular loop of wire of radius r_{loop} = 5 cm is placed around a very long solenoid as shown in the figure. The solenoid has a radius r_{sol} = 1 cm, a length L = 40 cm, 10000 turns of wire, and is driven by a current I = 0.2 A.



4. Calculate the flux Φ through the loop.

a. $\Phi = 1.2\times10^{-7}$ Wb
b. $\Phi = 2.0\times10^{-6}$ Wb
c. $\Phi = 6.7\times10^{-6}$ Wb
d. $\Phi = 5.5\times10^{-5}$ Wb
e. $\Phi = 9.5\times10^{-5}$ Wb

B field only inside solenoid

$$\Rightarrow \Phi = B \cdot A_{sol} = B \cdot \pi r_{sol}^2$$

$$B_{sol} = n \mu_0 I = \frac{N}{L} \mu_0 I$$

$$= \frac{N}{L} \mu_0 I \cdot \pi r_{sol}^2$$

$$= \frac{10^4}{0.4\,m} (4\pi) 10^{-7} \frac{Tm}{A} (0.2)(0.01)^2 \pi$$

$$= (2) \pi^2 \cdot 10^{-7} \text{ Wb}$$

5. Which of the following will NOT change the flux Φ through the loop?

a. decreasing the current I in the solenoid ← changes B
b. increasing the radius r_{loop} of the loop ← only adds Area where B = 0
c. tilting the loop relative to the solenoid ← tilting increases Area cutting through solenoid but then $\cos\phi \neq 1$, exactly cancels

6. Calculate the energy U stored in the solenoid.

a. U = 2.0 mJ
b. U = 0.37 mJ
c. U = 12.8 mJ

Hmm, not sure we have done this in class yet...

$$B = \frac{N}{L} \mu_0 I = \frac{10^4}{0.4\,m} \cdot 4\pi\times10^{-7} \cdot 0.2 = 2\pi \cdot 10^{-3} \text{ T}$$

Energy = (energy density)(Volume)

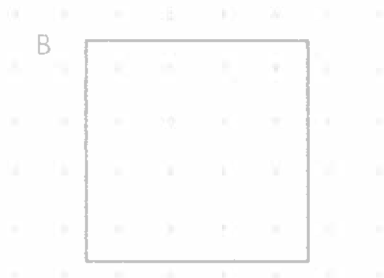
$$= \boxed{\frac{1}{2\mu_0} B^2 (\pi r_{sol}^2 \cdot L)}$$

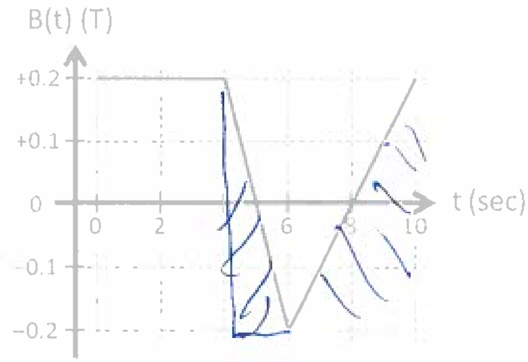
$$= \frac{1}{2 \cdot 4\pi \cdot 10^{-7}} (2\pi \cdot 10^{-3})^2 \cdot \pi (0.01)^2$$

$$= \frac{0.4 \cdot \pi^3 \cdot 4 \cdot 10^{-6} \cdot 10^{-4}}{2 \cdot 4\pi \cdot 10^{-7}}$$

The next two questions pertain to the following situation:

A loop of wire of area $A = 0.01$ m^2 lies in the plane of the page. The loop sits in a spatially uniform magnetic field B, which varies with time according to the graph below. A positive B corresponds to a magnetic field pointing out of the page; a negative B corresponds to a field pointing into the page.





8. At which of the following times is the induced emf ε in the loop maximum?

a. $t = 2$ s
b. $t = 5$ s
c. $t = 7$ s

9. Calculate the magnitude of the induced emf ε in the loop at time $t = 8$ s.

a. $\varepsilon = 0$ mV
b. $\varepsilon = 1.0$ mV
c. $\varepsilon = 6.67$ mV
d. $\varepsilon = 37.5$ mV
e. $\varepsilon = 62.5$ mV

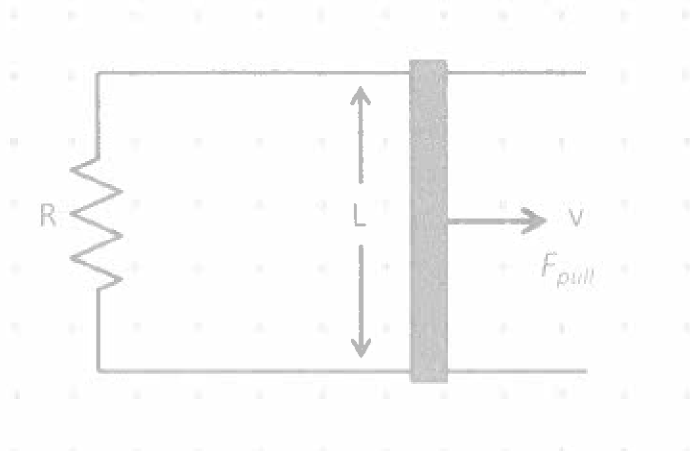
$$|\mathcal{E}| = \frac{\Delta \Phi}{\Delta t} = \frac{(\text{Area})\,\Delta B}{\Delta t}$$

$$= \frac{(0.01)(0.4)}{4}$$

$$= 10^{-3}\ \text{V}$$

The next three questions pertain to the following situation:

A metal bar slides on a conducting track with width L = 5 cm and a resistor R = 2 Ω in a uniform magnetic field B = 0.1 T out of the page. The bar is pulled to the right with a force $F_{pull} = 2\times10^{-5}$ N, such that the bar slides in that direction at a *constant speed* v.



15. Calculate the magnitude of the current I in the sliding bar.

a. I = 4 mA
b. I = 1.5 mA
c. I = 0.25 mA
d. I = 17.5 mA
e. I = 0 mA

$|\varepsilon_{bar}| = BLv$

$I = \frac{\varepsilon}{R} = \frac{BLv}{R} = \frac{(0.1)(0.05)v}{2}$

Whoops... (don't know v)

start again

$F = ILB$

$\Rightarrow I = \frac{F}{LB} = \frac{2\times10^{-5}}{(0.05)(0.1)} = 4\times10^{-3}$ A

16. What is the correct expression for the speed v of the sliding bar?

a. $v = \frac{LB}{F_{pull}R}$

b. $v = \frac{F_{pull}R}{LB}$

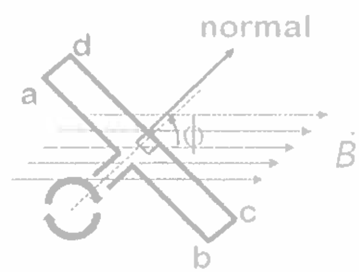
c. $v = \frac{F_{pull}R}{(LB)^2}$

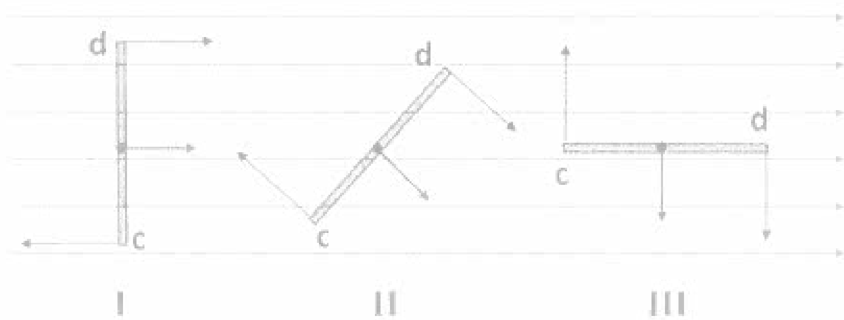
$I = \frac{\varepsilon}{R} = \frac{BLv}{R}$

$\Rightarrow v = \frac{IR}{LB} = \frac{R}{LB}\left(\frac{F}{LB}\right)$

$= \frac{FR}{(LB)^2}$

17. A rectangular loop in a generator rotates at a constant angular frequency in uniform magnetic field as shown below. The bottom panel shows cross sectional views of the loop at three different moments. In which configuration is the magnitude of the induced current largest?





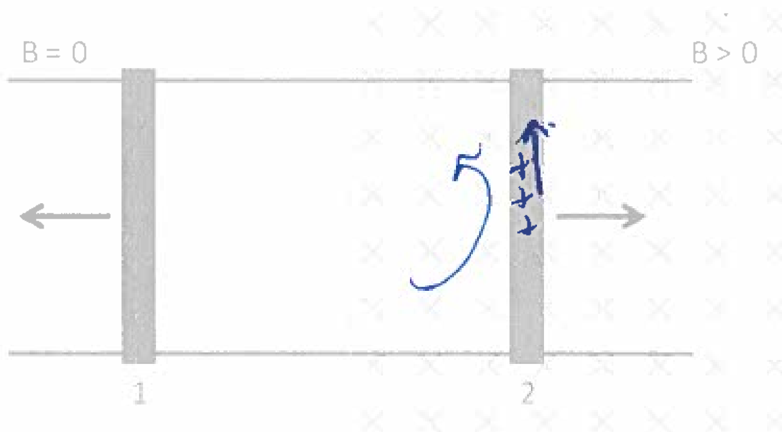
a. I
b. II
c. III

flux changes fastest at moment
when flux is 0

The next two questions pertain to the following situation:

Consider a circuit consisting of *two* vertical metal bars labeled 1 and 2 that slide on two horizontal conducting rails, as shown in the figure. There is a uniform magnetic field B directed into the page ***over the right half of the circuit only***. (There is NO magnetic field over the left half.)

Initially both sliding bars 1 and 2 are at rest.



21. The sliding bar 2 is now moved to the right. In what direction does the current flow around the circuit?

a. clockwise
b. counterclockwise
c. there is no current

22. Now sliding bar 2 is at rest and sliding bar 1 is moved to the left. In what direction does the current flow around the circuit?

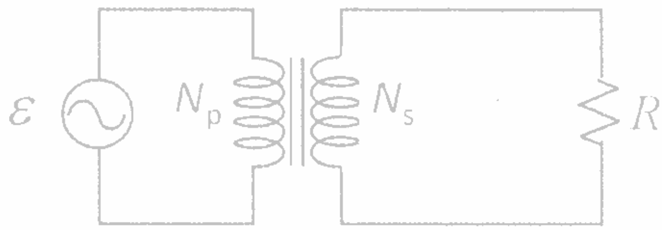
a. clockwise
b. counterclockwise
c. there is no current

no force on charges if B=0! (bar 1)

(and bar 2 is At rest)

The next three questions pertain to the following situation.

A transformer consists of a primary coil of N_p = 150 turns and a secondary coil of unknown turns N_s as shown. The generator voltage is given as $\varepsilon = 120\sin(120\pi t)$ Volts. The secondary coil is connected to a load of resistance R = 13 Ω.



23. Find N_s for which the maximum induced voltage in the secondary coil is 20 V.

a. $N_s = 900$
b. $N_s = 60$
c. $N_s = 25$

$$\frac{N_s}{N_p} = \frac{V_s}{V_p} \Rightarrow N_s = N_p \cdot \frac{V_s}{V_p}$$
$$= 150 \cdot \frac{V_s}{120\,V}$$
$$= 150\left(\frac{20}{120}\right) V$$
$$= \frac{150}{6} V$$
$$= 25\ V$$

25. If the generator is replaced with a 24 V battery, what is the maximum voltage, V_{max}, across the secondary coil of 300 turns?

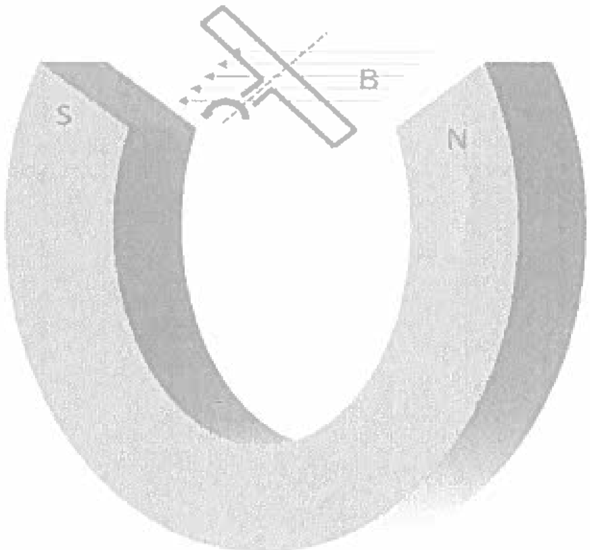
a. $V_{max} = 0$ V
b. $V_{max} = 12$ V
c. $V_{max} = 48$ V

No changing B field from a battery!

KEY
Exam 2 – Spring 2013

1. b
2. b
3. c
4. b
5. bc
6. a
7. d
8. b
9. b
10. a
11. c
12. a
13. b
14. c
15. a
16. c
17. c
18. a
19. b
20. b
21. b
22. c
23. c
24. b
25. a
26. a

The next two questions pertain to the situation described below.



A coil of wire turns between the poles of a permanent magnet as shown in the diagram. The coil has $N = 34$ turns of wire. The magnet produces a constant field of magnitude $B = 0.119\ T$. The coil has a cross-sectional area $A = 0.0411\ m^2$.

8) The coil is driven at an angular frequency $\omega = 4.08\ rad/s$. What is the peak *emf*, ε, this generator can produce?

Just write down correct formula, then show inserted numbers and final result.

a. $\varepsilon = 0.02\ V$
b. $\varepsilon = 5.7\ V$
c. $\varepsilon = 16.5\ V$
d. $\varepsilon = 0.678\ V$
e. $\varepsilon = 0.166\ V$

$$\mathcal{E}_{max} = \omega N A B$$
$$= (4.08)(34)(0.0411)(0.119)$$
$$= 0.678\ V$$

9) If the coil is driven in the counter-clockwise direction, in what direction is the induced field at the instant shown?

Explain using flux and Lens' law.

a. *The induced field is directed toward the left.*
b. *The induced field is directed toward the right.*
c. *There is no induced field.*

flux to the left is decreasing due to rotation,
so induced flux will ~~[illegible]~~ be to the left

The next four questions pertain to the situation described below.

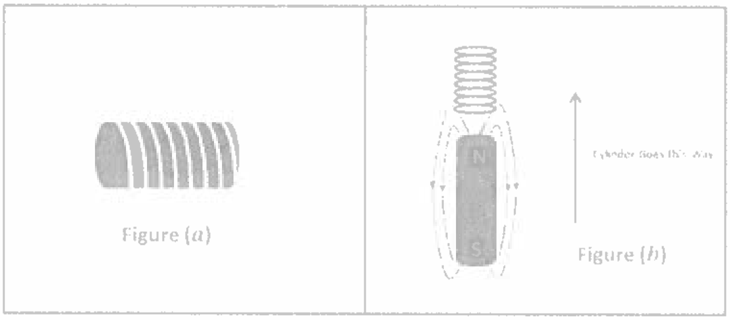


Figure (*a*) Figure (*b*)

22) In figure (*a*) above, a coil is produced by wrapping a copper wire around a cylinder of iron. The iron cylinder is fixed within the wire. Which of the following statements is true:

Briefly explain reason (2 sentences)

a. *Neither of these.*
b. *The iron will behave like a magnet if current flows through the wire.*
c. *The wire will have an induced current if the iron is magnetized.*

23) In figure (*b*) above, a magnetic iron cylinder moves through the coil in the direction shown. Which of the following statements is true:

Explain using flux and Lens's law

a. *The induced current flows right to left across the front of the coil.*
b. *The induced current flows left to right across the front of the coil.*
c. *There is no induced current.*

flux in ↑ direction is ~~[illegible]~~ increasing, so current flows to produce B ↓

24) In figure (*b*) the cylinder moves through the coil for $t = 3.95\ s$ and produces $|\varepsilon| = 0.119\ V$. What is the magnitude of the change flux?

Show equation, and values used for variables.

a. $\Delta\Phi = 0.94\ T\,m^2$
b. $\Delta\Phi = 0.235\ T\,m^2$
c. $\Delta\Phi = 0.0301\ T\,m^2$
d. $\Delta\Phi = 0.47\ T\,m^2$
e. $\Delta\Phi = 0.157\ T\,m^2$

$$|\varepsilon| = \frac{\Delta\Phi}{\Delta t}$$

$$\Rightarrow \underline{\Delta\Phi} = |\varepsilon|\Delta t = (0.119)(3.95)$$

25) In figure (*b*) the coil has a diameter $d = 0.0411\ m$ and 100 turns of wire. The resistance per unit length is $34.3\ \Omega/m$. The *emf* is $|\varepsilon| = 0.119\ V$. What is the magnitude current in the coil?

Show equations used, and values input to get answer

a. $I = 269\ \mu A$
b. $I = 844\ \mu A$
c. $I = 53.7\ \mu A$
d. $I = 3470\ \mu A$
e. $I = 537\ \mu A$

$$R = (\text{resistance per unit length})(\text{length})$$

circumference of each loop

$$= \left(34.3\ \frac{\Omega}{m}\right)\left(N_{turns} \cdot \pi d\right)$$

$$= (34.3)(100)\pi(0.0411)$$

$$= 442.66\ \Omega$$

$$I = \frac{\varepsilon}{R} = \frac{0.119\ V}{442.66\ \Omega} = 269\times10^{-6}\ A$$

Physics 102 Exam 2 --
Spring 2014

1. a
2. e
3. c
4. c
5. a
6. e
7. c
8. d
9. a
10. b
11. c
12. b
13. b
14. a
15. b
16. a
17. c
18. b
19. c
20. b
21. a
22. b
23. a
24. d
25. a