Physics 1520, Fall 2011

Quiz 5, Form: A

Name: Key

Date:

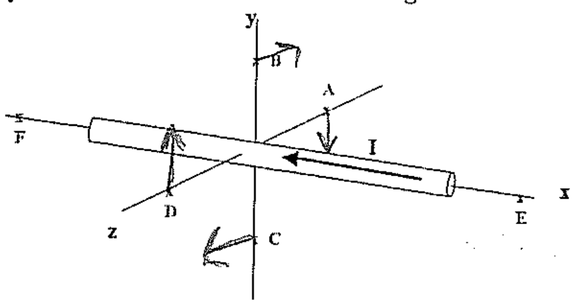
Numeric answers must include units. Sketches must be labeled. All short-answer questions must include your reasoning, for full credit. A correct answer with no reasoning will only receive partial credit.

Section 1. Multiple Choice

MC: 2 pts each

problems: 20 pts. each

Questions 1–2: Current flows through the wire shown below.



1. What is the direction of the magnetic field at point A?

   (a) −z
   (b) +y
   (c) +z
   (d) +x
   (e) −y
   (f) −x
   (g) None of the above because the magnetic field is zero.

2. What is the direction of the magnetic field at point B?

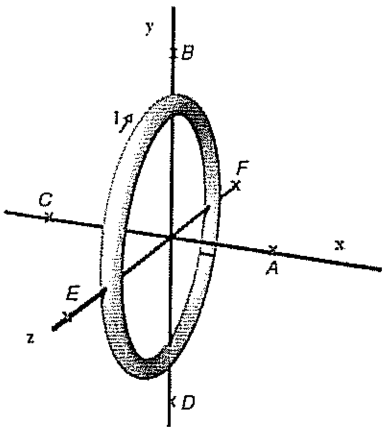
   (a) −y
   (b) +x
   (c) +y
   (d) +z
   (e) −x
   (f) −z

3. Suppose that point G is on the +z axis and is at twice the distance from the wire as point D. The magnetic field at point G will be

   (a) twice the magnetic field at D
   (b) one-fourth the magnetic field at D
   (c) one-eighth the magnetic field at D
   (d) half the magnetic field at D
   (e) equal to the magnetic field at D

$B \propto \frac{1}{r}$

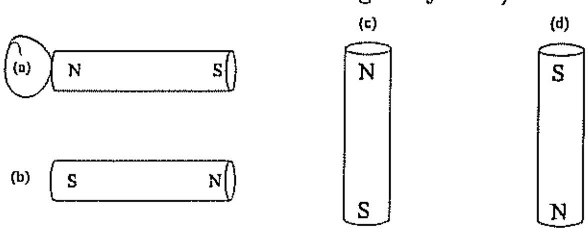
Questions 4–5: Current flows in a loop of wire as shown below.



4. What is the direction of the magnetic field at point A?

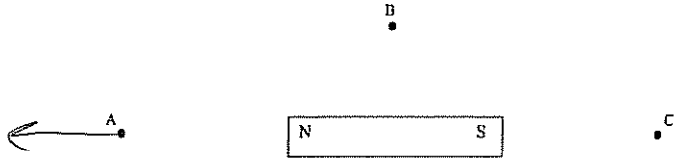
   (a) −y
   (b) −x
   (c) +y
   (d) +z
   (e) +x
   (f) −z
   (g) None of the above because the magnetic field is zero.

5. If you model the current-carrying loop in the previous question as a magnetic dipole, what would be the correct orientation of the dipole? (Note: the horizontal ones are oriented along the x axis, and the vertical ones are oriented along the y-axis.)

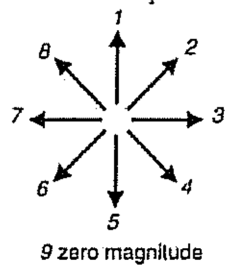


   (a) a
   (b) b
   (c) c
   (d) d
   (e) None of the above.

6. A bar magnet is shown below.



Which arrow points in the direction of the magnetic field at point A?



(a) 1

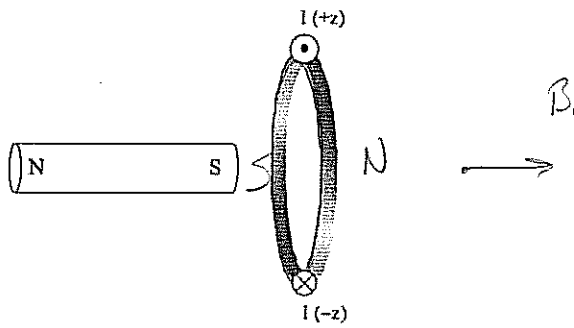
(b) 3

(c) 5

(d) 7

(e) None of the above because the magnetic field is zero.

7. Suppose that current flows through the coil in the direction shown, and a magnet is brought close to the coil.



Bfue to loop

Will the coil and magnet attract, repel, or not exert forces on each other?

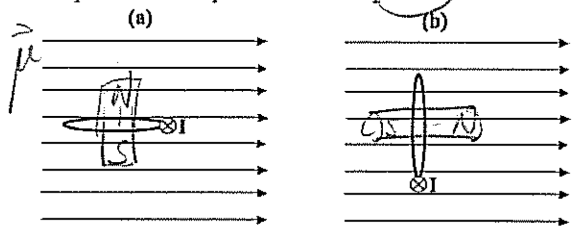
(a) They will not exert forces on each other at all.

(b) They will attract.

(c) They will repel.

S of magnet will repel the S side of the coil.

8. A side view of a current-carrying loop in a magnetic field is shown below. For which orientation of the loop is the torque on the loop zero?

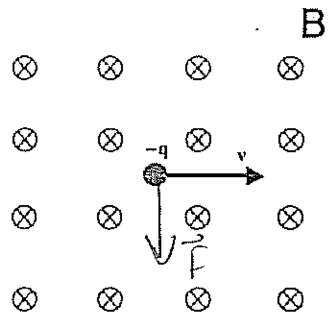


(a) a
(b) b
(c) the torque on the loop is zero in both cases
(d) the torque on the loop is **not** zero in both cases

9. What type of medical imaging uses the fact that a "spinning" proton has a magnetic dipole moment so that the proton precesses around the applied magnetic field? It gives off radiation (i.e. light) when it "flips" its orientation relative to the magnetic field.

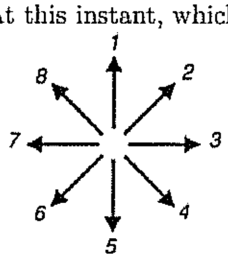
(a) CT (or "CAT" scan)
(b) PET
(c) EKG
(d) Ultrasound
(e) MRI

10. An *electron* moves in the direction shown in a uniform magnetic field.



Use "left-hand rule" for an electron with fingers in dir. of $\vec{v}$ and palm facing $\vec{B}$.

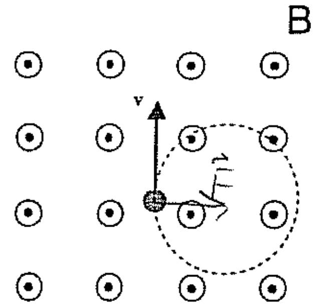
At this instant, which arrow points in the direction of the force on the electron by the magnetic field?



9 zero magnitude

(a) 3
(b) 1
(c) 7
(d) 5
(e) 9

11. A particle moving in a magnetic field follows the path shown below. Is this particle positively charged, negatively charged, or neutral?



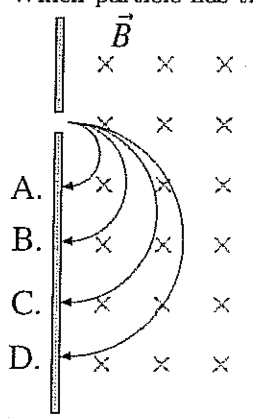
$\vec{F}_{mag}$ is given by right-hand rule, so it's a positive charge.

(a) positively charged
(b) negatively charged
(c) neutral

12. In the previous question, if the magnetic field is *increased* in magnitude, then the radius of the particle's path will be

(a) the same, since the radius of the path does not depend on the strength of the magnetic field.
(b) larger
(c) smaller

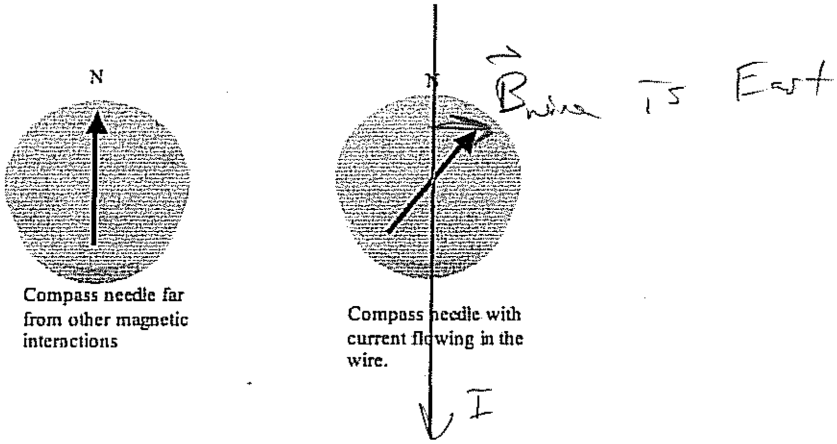
13. The figure below shows four particles moving to the right as they enter a region of uniform magnetic field, directed into the paper as noted. All particles move at the same speed and have the same charge. Which particle has the largest mass?



$r \propto m$, since $r = \frac{mv}{|q|B}$

(a) A
(b) B
(c) C
(d) D

14. A long current-carrying wire is placed *on top of* a compass, as shown below.



As a result, the compass deflects eastward. In what direction is current flowing through the wire?

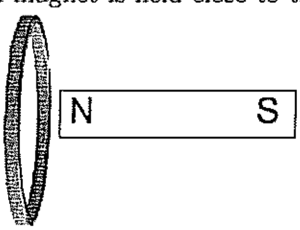
(a) Current is flowing toward the *north.*

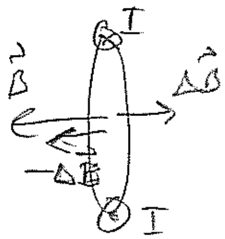
(b) Current is flowing toward the *south.*

(c) Neither, because the current through the wire must be negligible.

(d) Neither, because the compass cannot possibly deflect in the direction shown for a wire in this configuration.

15. A magnet is held close to the wire coil shown below.





$\vec{B}$ is decreasing so $\Delta\vec{B}$ is opposite $\vec{B}$.

If the magnet is moved away from the coil (in the +x direction), the induced current in the coil *at the top of the coil* will flow

(a) into the page (in the $-z$ direction)

(b) out of the page (in the $+z$ direction)

(c) None of the above because the induced current in the coil will be zero in this case.

16. For the previous question, if your hold the magnet at rest at the position shown, the induced current in the coil *at the top of the coil* will flow

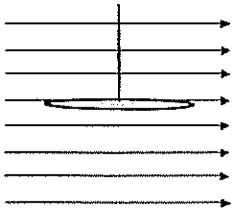
(a) into the page (in the $-z$ direction)

(b) out of the page (in the $+z$ direction)

(c) None of the above because the induced current in the coil will be zero in this case.

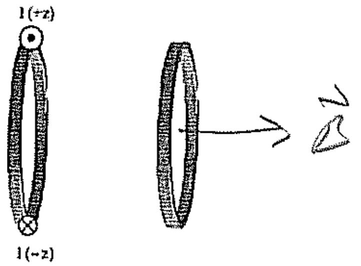
$\vec{B}$ must change, but $\vec{B}$ is constant if the magnet is at rest.

17. A spinning coil in a magnetic field is used as an electric generator. At an instant when the coil is in the orientation shown below, the *magnetic flux* through the coil is



(a) zero.
(b) equal to the maximum possible flux
(c) greater than zero, but not equal to the maximum possible flux.

Questions 18–20: A primary coil has current flowing through it as shown below.



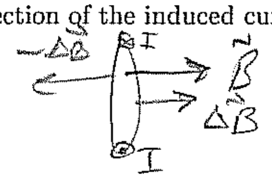
You connect an ammeter to the secondary coil (i.e. pickup coil) and measure the induced current through the secondary coil.

18. If the current in the primary coil is constant, then the direction of the induced current in the top of the secondary coil is

(a) out of the page, in the +z direction.
(b) into the page, in the –z direction.
(c) None of the above because the induced current is zero.

there is no change in flux in the pickup coil.

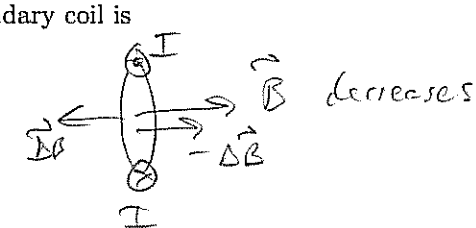
19. If the current in the primary coil increases, then the direction of the induced current in the top of the secondary coil is



(a) out of the page, in the +z direction.
(b) into the page, in the –z direction.
(c) None of the above because the induced current is zero.

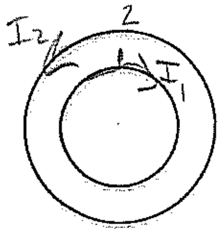
20. If you have a constant current in the primary coil and then suddenly disconnect the primary coil from the battery so that its current quickly drops to zero, then at the moment you disconnect the primary coil, then the direction of the induced current in the top of the secondary coil is

(a) out of the page, in the +z direction.
(b) into the page, in the –z direction.
(c) None of the above because the induced current is zero.



Section 2. Problem Solving

21. Two concentric current loops lie in the same plane as shown below. Each loop is connected to a separate battery (not shown). The smaller loop has a radius of 3.0 cm and a current of 12 A that flows clockwise around the loop. The net magnetic field at the center of the loops is zero. The bigger loop has a radius of 4.0 cm.



$\vec{B}_1$ is into the page in the $-z$ dir.

$\vec{B}_2$ is out of the page in the $+z$ dir.

Since $\vec{B}_{net} = \vec{B}_1 + \vec{B}_2 = 0$

(a) In what direction does current flow around the bigger loop? (clockwise or counterclockwise) You MUST explain your reasoning in complete sentences.

The $\vec{B}_{net} = 0$, so $\vec{B}$ due to outer loop is opposite $\vec{B}$ due to inner loop so that they cancel. Thus, I in the outer loop is opposite I in the inner loop.

+8

(b) What is the current in the bigger loop?

$$B_1 = \frac{\mu_0 I_1}{2R_1} = \frac{(4\pi \times 10^{-7}\ \frac{T\cdot m}{A})(12A)}{2\ (0.03m)} = 0.000251\ T = 2.51 \times 10^{-4}\ T$$

$$B_2 = B_1 = 2.51 \times 10^{-4}\ T$$

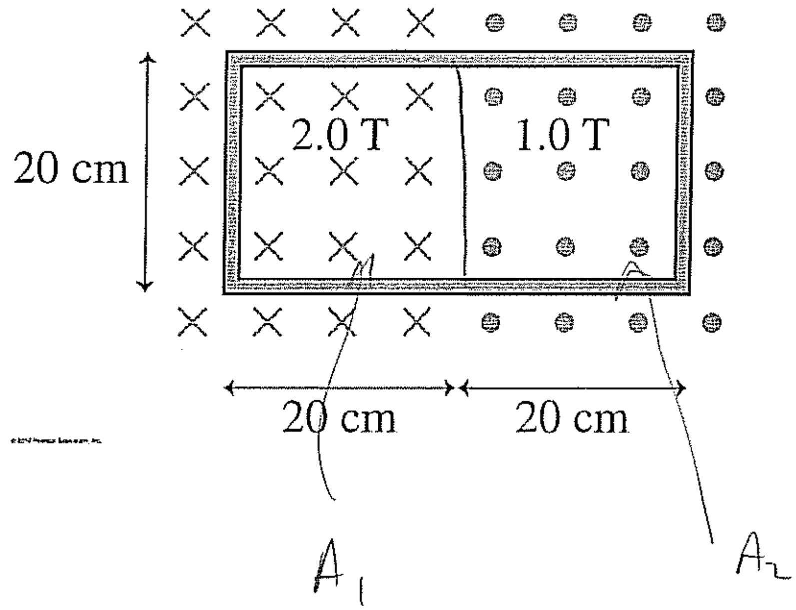
+12

$$B_2 = \frac{\mu_0}{2}\frac{I_2}{R_2}$$

$$I_2 = \frac{B_2 (2) R_2}{\mu_0} = \frac{(2.51 \times 10^{-4} T)(2)(0.04m)}{4\pi \times 10^{-7}\ \frac{T\cdot m}{A}}$$

$$\boxed{I_2 = 16A}$$

22. What is the magnetic flux through the loop shown below? For full credit, you must show all of your calculations.



$\Phi_1 = B_1 A_1 \cos\theta_1$

$= -(2.0T)(0.2m)(0.2m)$

$= -(2T)(0.4m^2)$

$= -0.8\ T\cdot m^2$ (+8)

$\Phi_2 = B_2 A_2 \cos\theta_2$

$= (1T)(0.2m)(0.2m)$

$= 0.4\ T\cdot m^2$

(+8)

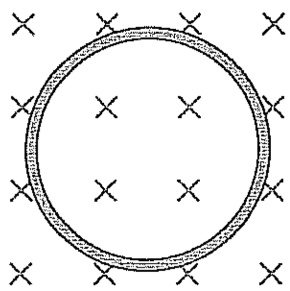
$\Phi_{total} = -0.8\ T\cdot m^2 + 0.4\ T\cdot m^2$

$= -0.4\ T\cdot m^2$

(+4)

or $0.4\ T\cdot m^2$ into the page

23. A 10-cm loop is in a magnetic field that is *decreasing* at a rate of 0.50 T/s. The loop's resistance is 0.10 Ω.



Diameter = 10 cm = 0.1 m

$R = 0.05\,m$; where $R \equiv$ radius

$\frac{\Delta B}{\Delta t} = 0.5 \frac{T}{s}$

(a) What is the induced emf around the loop?

$$\mathcal{E} = \frac{\Delta \Phi}{\Delta t} = \frac{\Delta(BA\cos\theta)}{\Delta t} = \frac{A\Delta B}{\Delta t} = \pi R^2 \left(\frac{\Delta B}{\Delta t}\right)$$

$$= \pi (0.05\,m)^2 (0.5 \tfrac{T}{s})$$

$$= \boxed{0.0039\ V} = 3.9\ mV$$

(+6)

(b) What is the magnitude of the induced current?

$\mathcal{E} = \Delta V = IR$ R is resistance

$R = 0.1\,\Omega$

$$I = \frac{0.0039V}{0.1\,\Omega} = 0.039\ A$$

(+6)

(c) What is the direction of the induced current? For full credit, you must explain your reasoning.

$\vec{B}$ is into the page and is decreasing. So, $\Delta\vec{B}$ is out of the page, and $-\Delta\vec{B}$ is into the page. Point thumb into the page, and induced current flows in direction of fingers curling around the loop. Current flows clockwise!

(+8)