Physics 212, Spring 2009

Quiz 5, Form: A

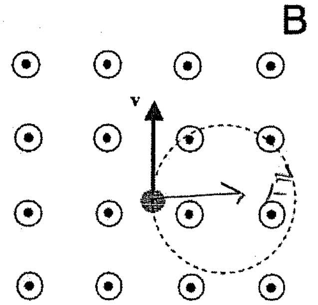
Name: Key

Date:

Magnitude of the charge of an electron or proton: $e = 1.6 \times 10^{-19}$ C.
Permeability of free space: $\mu_0 = 4\pi \times 10^{-7}$ T m/A

Section 1. Multiple Choice

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



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

$F_{net} = \frac{mv^2}{R}$

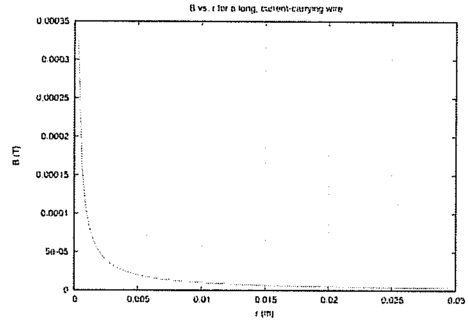
$qvB = \frac{mv^2}{R}$

$R = \frac{mv}{qB}$ $\quad R \propto \frac{1}{B}$

2. 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

3. Suppose that in lab, you measure B at various distances r from a wire.



When you fit a curve to the data, you get the function $B = \frac{1\times10^{-7}}{r}$. By comparing this to the theoretical equation for the magnetic field due to a current-carrying wire $B = \frac{\mu_0}{4\pi}\frac{2I}{r}$, find the current in the wire in this experiment.

(a) 2 A
(b) 1×10^{-7} A
(c) 0.25 A
(d) 1 A
(e) 0.5 A

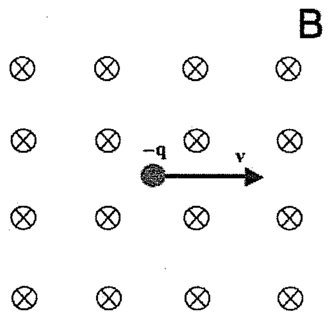
$B = \frac{1\times10^{-7}}{r}$ $\quad B = \frac{\mu_0}{4\pi}\frac{2I}{r}$

So $1\times10^{-7} = \frac{\mu_0}{4\pi} 2I$

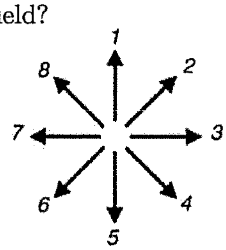
$I = \frac{1\times10^{-7}}{\left(\frac{\mu_0}{4\pi}\right) 2}$

$= \frac{1\times10^{-7}}{(1\times10^{-7})\,2} = \frac{1}{2}$

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



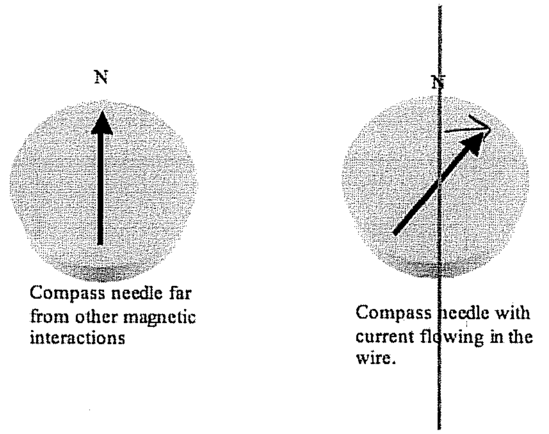
At this instant, which arrow points in the direction of the force on the electron by the magnetic field?



9 zero magnitude

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

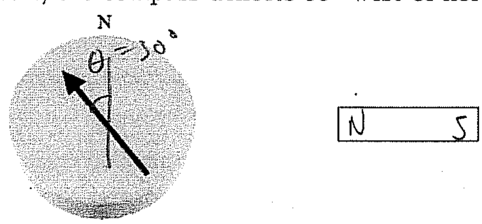
5. A long current-carrying wire is placed *on top of* a compass, as shown below.



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.

6. You place a compass on the table so that it points toward geographic N. You then place a magnet (i.e. magnetic dipole) along the E-W axis of the compass, as shown below. As a result, the compass deflects 30° west of north.

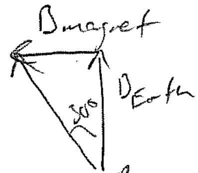


Compass needle is deflected due to the nearby magnet.

Label the magnet with its N and S poles. Which pole is nearest to the compass?

(a) N
(b) S

7. What is the magnitude of the magnetic field at the location of the compass, due to the magnet in the previous question? (Note: Earth's magnetic field is approximately 2.0×10^{-5} T, parallel to Earth's surface at the location of the compass.)



(a) 2.0×10^{-5} T
(b) 1.7×10^{-5} T
(c) 3.5×10^{-5} T
(d) 1.0×10^{-5} T
(e) 1.2×10^{-5} T

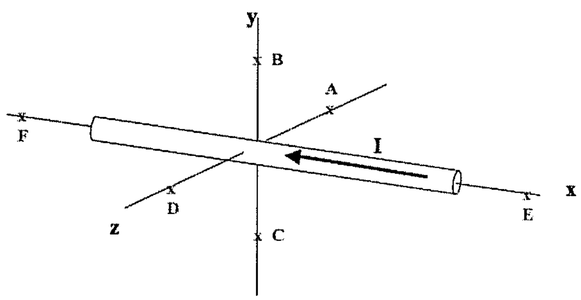
$\tan 30 = \frac{B_{magnet}}{B_{Earth}}$

$B_{magnet} = 2 \times 10^{-5} \tan 30$

8. Suppose that you stick two identical bar magnets together end-to-end using bar magnets identical to the one in the previous question. If placed at the same location as before, the deflection of the compass needle would be

(a) larger than with just one magnet
(b) smaller than with just one magnet
(c) the same as with just one magnet

Questions 9–11: Current flows through the wire shown below.



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

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

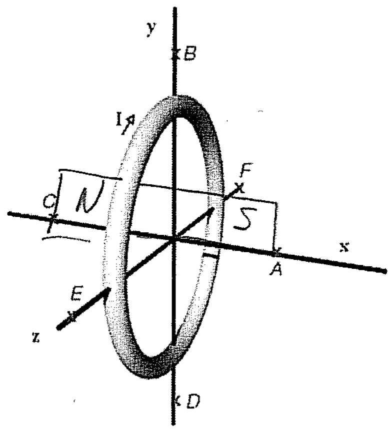
10. What is the direction of the magnetic field at point B?

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

11. 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

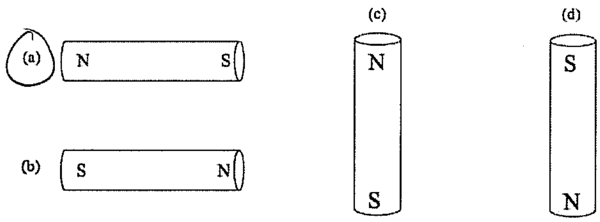
Questions 12–13: Current flows in a loop of wire as shown below.



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

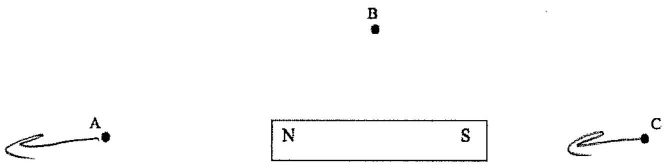
(a) –y
(b) –x
(c) +y
(d) +z
(e) +x
(f) –z
(g) None of the above because the magnetic field is zero.

13. 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.)

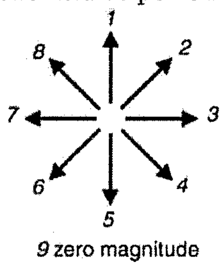


(a) a
(b) b
(c) c
(d) d
(e) None of the above.

Questions 14–15: A bar magnet is shown below.

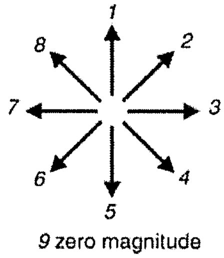


14. Which arrow points in the direction of the magnetic field at point A?



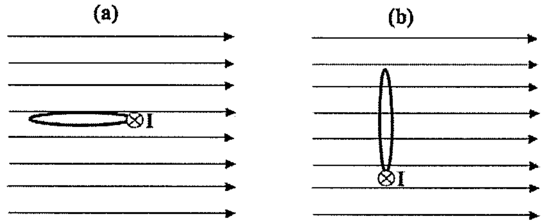
(a) 1
(b) 7
(c) 5
(d) 3
(e) None of the above because the magnetic field is zero.

15. Which arrow points in the direction of the magnetic field at point C?



(a) 5
(b) 3
(c) 1
(d) 7
(e) None of the above because the magnetic field is zero.

16. 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

17. 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

18. If you make a coil by wrapping a wire around your finger to make 10 loops, the magnetic dipole moment of the coil will be

    (a) one-hundredth the magnetic dipole moment of one loop

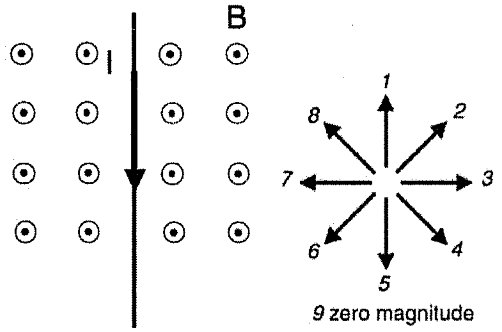
    (b) one-tenth the magnetic dipole moment of one loop

    (c) 10 times the magnetic dipole moment of one loop

    (d) 100 times the magnetic dipole moment of one loop

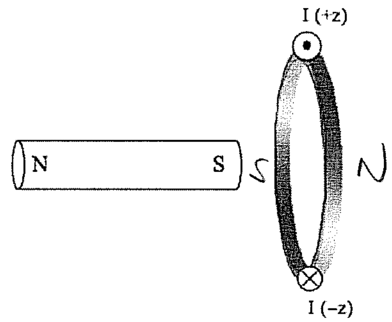
    (e) the same as the magnetic dipole moment of one loop

19. Which arrow points in the direction of the magnetic force on the wire shown below?



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

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



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.

Section 2. Problem Solving

21. A set of four identical neodymium magnets (stuck together end-to-end) create a magnetic field of magnitude 4.8×10^{-4} T at a point along its axis that is 2 cm from the magnet. What is the magnetic field at a point on its axis that is 5 cm from the magnet?

+15

$r = 0.02\,m$ $\quad$ $r = 0.05\,m$

$B = 4.8 \times 10^{-4}\,T$ $\quad$ $B = ?$

Find μ.

$B = \frac{\mu_0}{4\pi}\frac{2\mu}{r^3}$

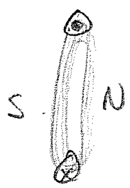
$\mu = \frac{B r^3}{2\left(\frac{\mu_0}{4\pi}\right)} = \frac{(4.8\times10^{-4})(0.02)^3}{2(1\times10^{-7})}$

$= 0.0192\ \frac{T \cdot m}{A}$

$B = \frac{\mu_0}{4\pi}\frac{2\mu}{r^3}$

$= \frac{(1\times10^{-7})(0.0192)2}{(0.05)^3} = \boxed{3.1\times10^{-5}\,T}$

22. If you replace the set of magnets with a coil of wire with 20 turns and a radius 0.01 cm, what must be the current in the coil in order to have the same magnetic dipole moment as the set of magnets?



$\mu = NIA$

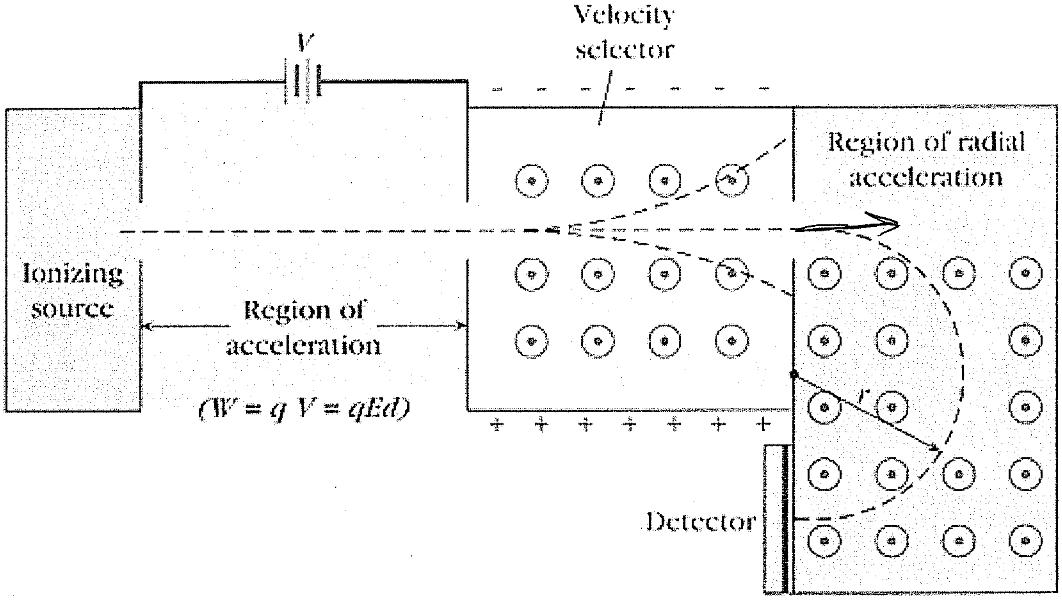
$0.0192 = (20) I \pi (0.01)^2$

$I = \frac{0.0192}{20\pi(0.01)^2} = \boxed{3.1\ A}$

+10

25

23. Suppose that you only want charged particles of speed 1×10^4 m/s to travel with uniform motion through the region of crossed electric and magnetic fields shown in the picture below.



If the electric field is 20,000 N/C in the region, what must be the magnetic field?

$$V = \frac{E}{B} \qquad B = \frac{E}{V} = \frac{20000 \frac{N}{C}}{1\times10^{4} \frac{m}{s}} = 2\ T$$

+5

24. Sketch a free-body diagram showing the electric force (i.e. coulomb force) and the magnetic force on the charged particle when it is in that region?

Assume a positively charged particle

$\vec{F}_{elec}$

$\vec{F}_{mag}$

q must be positive in order to be deflected downward in region of uniform magnetic field (no electric field)

+5

25. The particle then enters the region of uniform magnetic field (no electric field) of magnitude 0.2 T where it travels in a circle. If the radius of the circle is 0.029 m, what is the mass of the particle if it is singly ionized?

$$F_{net} = \frac{mv^2}{R}$$

$$qvB = \frac{mv^2}{R}$$

$$m = \frac{qBR}{v}$$

$$m = \frac{(1.6\times10^{-19}C)(0.2)(0.029)}{1\times10^{4}} = \boxed{9.28\times10^{-26}\ kg}$$

+15

Note: this is the mass of an Fe atom!

$$(9.28\times10^{-26}\ kg)\left(6.02\times10^{23} \frac{atoms}{mol}\right) = \boxed{56 \frac{g}{mol}}$$