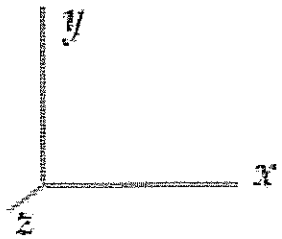
Physics 1520, Spring 2014
Quiz 4B, Form: A

Name: Key
Date: _____

To specify directions, use the coordinate system shown below.

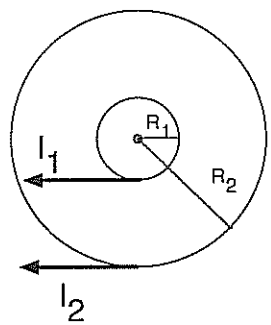


Note the following terminology for directions:

- to the right ($+x$)
- to the left ($-x$)
- upward or toward the top of the page ($+y$)
- downward or toward the top of the page ($-y$)
- out of the page ($+z$) $\odot$
- into the page ($-z$) $\otimes$

Section 1. Multiple Choice

Questions 1–2: Two different loops of wire are connected to different batteries. The loops are concentric, meaning that their centers and their axes are aligned, as shown below.



$\otimes \vec{B}_1$ $\otimes \vec{B}_2$ Both are into the page at the center of the loops.

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

The current in the outer loop is 2 A in the clockwise direction, and its radius is 4 cm. The current in the inner loop is also 2 A in the clockwise direction, and its radius is 1 cm.

1. What is the magnitude of the *net* magnetic field at the center of the loops (neglect Earth's magnetic field)?

   (a) 3.1×10^{-5} T
   (b) 9.4×10^{-5} T
   (c) 1.6×10^{-4} T
   (d) 1.3×10^{-4} T
   (e) 3.9×10^{-5} T

$$B_{net_z} = -\frac{\mu_0 (2A)}{2(0.01m)} + \frac{-\mu_0 (2A)}{2(0.04m)}$$

$$= -1.26 \times 10^{-4} T - 3.1 \times 10^{-5} T$$

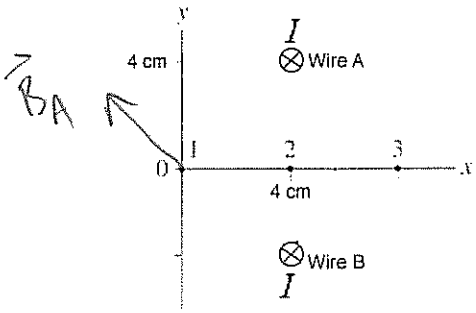
$$= \boxed{-1.6 \times 10^{-4} T}$$

2. For the previous question, what is the direction of the net magnetic field at the center of the loops (neglect Earth's magnetic field?

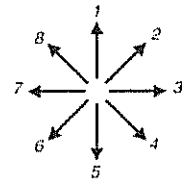
(a) $+x$
(b) $-x$
(c) $-y$
(d) $+z$
(e) $-z$

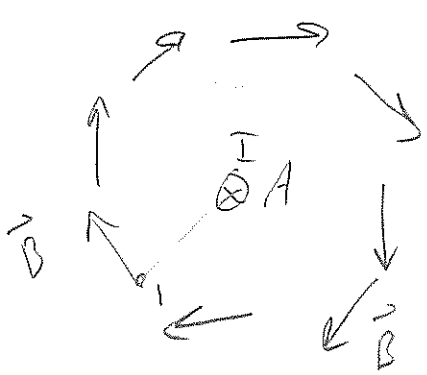
Both $\vec{B}_1$ and $\vec{B}_2$ are into the page.

Questions 3–5: An end view of two long current carrying wires is shown below. The current is 2 A in each wire.



3. Which of these arrows is closest to the magnetic field *due to wire A* at point **1**?

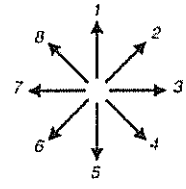


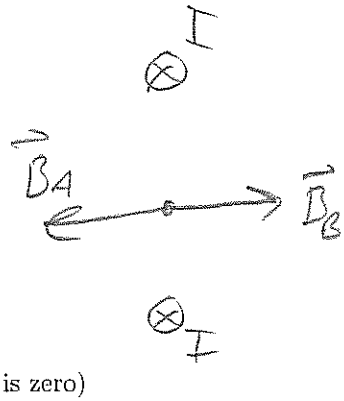


$\vec{B}$ is tangent to a circle around the wire.

(a) 4
(b) 7
(c) 3
(d) 5
(e) 8

4. Which of these arrows is closest to the *net* magnetic field at point **2**?



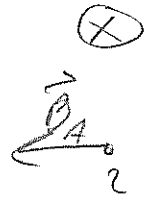


Since $r_A = r_B$ and $I_A = I_B$, then $B_A = B_B$ and $B_{net} = 0$.

(a) 1
(b) 3
(c) 5
(d) 7
(e) 9 (the net magnetic field is zero)

5. What is the magnitude of the magnetic field *due to wire A* at point **2**?

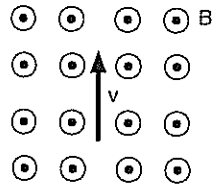
(a) 7.1×10^{-6} T
(b) 1.0×10^{-5} T
(c) 3.1×10^{-5} T
(d) 5.0×10^{-6} T
(e) 2.2×10^{-5} T



$B_A = \frac{\mu_0 I}{2\pi r}$

$= \frac{(4\times10^{-7}\ \frac{T\cdot m}{A})(2A)}{2\pi(0.04m)} = 1\times10^{-5}\ T$

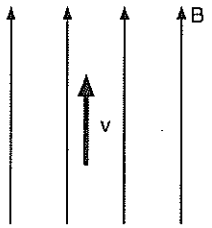
6. What is the direction of the magnetic force on an *electron* with the velocity shown below?



Use your left hand!

(a) $+x$
(b) $-x$
(c) $+z$
(d) $-z$
(e) The magnetic force is zero.

7. What is the direction of the magnetic force on a *proton* with the velocity shown below?

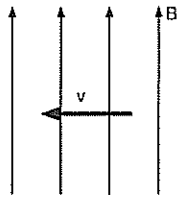


$\theta = 0°$

$F = qvB\sin\theta = 0$

(a) $+x$
(b) $-x$
(c) $+z$
(d) $-z$
(e) The magnetic force is zero.

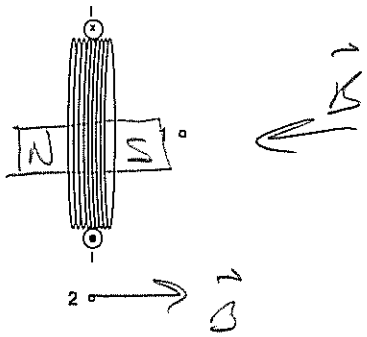
8. What is the direction of the magnetic force on a *proton* with the velocity shown below?



Use your right hand!

(a) $+x$
(b) $-x$
(c) $+z$
(d) $-z$
(e) The magnetic force is zero.

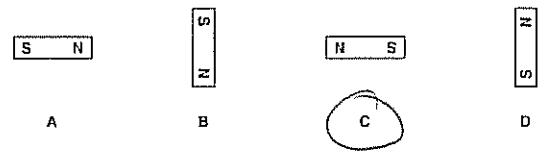
Questions 9–11: Current flows through a coil of wire in the direction shown below.



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

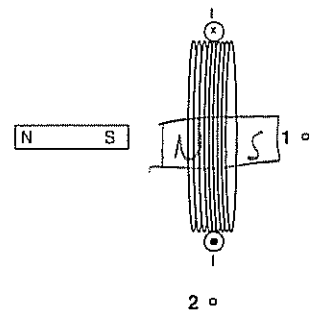
(a) $+x$
(b) $-x$
(c) $+y$
(d) $-y$
(e) The magnetic field is zero.

10. If you model the coil as a magnetic dipole, which of these magnetic dipoles best represents the polarity of the coil?



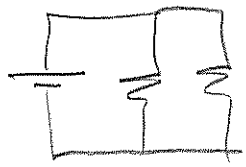
(a) A
(b) B
(c) C
(d) D
(e) None of the above.

11. A second magnetic dipole is placed near the coil as shown below. Will the dipole and coil attract or repel?



(a) They will attract.
(b) They will repel.
(c) Neither. They will not exert forces on one another.

12. You have an aluminum wire ($\rho_{Al} = 2.8 \times 10^{-8}\ \Omega \cdot \text{m}$) and copper wire ($\rho_{Cu} = 1.7 \times 10^{-8}\ \Omega \cdot \text{m}$) of the same length and radius. If you connect the two wires in parallel, which wire will dissipate more energy in 30 s?



$R = \frac{\rho L}{A}$ so $R_{Al} > R_{Cu}$

$P = \frac{\Delta V^2}{R}$ less R, more P.

(a) The aluminum wire
(b) The copper wire.
(c) Neither, because they have the same radius.
(d) Neither, because they have the same length.

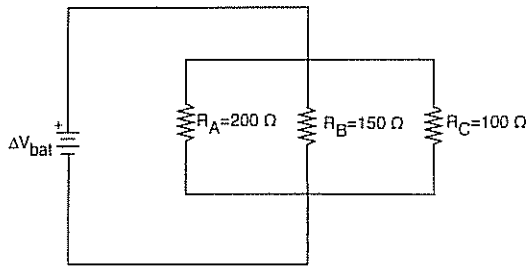
13. A typical flashlight battery will produce a 0.5 A current for about 3 h before "losing its charge." (I use quotes because this common saying is not correct. The battery loses its chemical potential energy.) Determine the total number of electrons that have moved past a cross section of wire connecting the battery and bulb during this 3 h time interval?

$(0.5\ \frac{C}{s})\left(\frac{1\ elec}{1.6\times10^{-19}\ C}\right)(3\ h)\left(\frac{3600\ s}{1\ h}\right)$

$= 3.375 \times 10^{22}$ elect.

(a) 3.1×10^{18} electrons
(b) 6.8×10^{22} electrons
(c) 9.4×10^{18} electrons
(d) 3.4×10^{22} electrons
(e) 1.1×10^{22} electrons

Questions 14–15:



14. Rank the resistors in terms of the current through each resistor.

ΔV is the same, $I = \frac{\Delta V}{R}$.

less R, greater I.

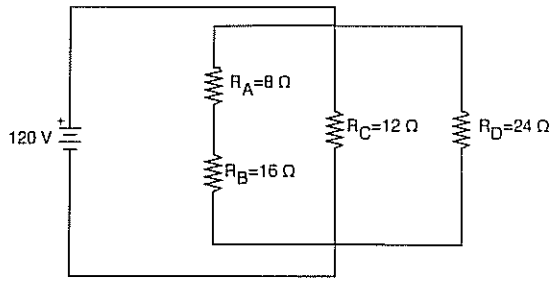
(a) $I_A = I_B = I_C$
(b) $I_A > I_B > I_C$
(c) $I_C > I_A > I_B$
(d) $I_B > I_C > I_A$
(e) $I_C > I_B > I_A$

15. Rank the resistors in terms of the voltage across each resistor.

they are in parallel

(a) $\Delta V_A = \Delta V_B = \Delta V_C$
(b) $\Delta V_C > \Delta V_A > \Delta V_B$
(c) $\Delta V_A > \Delta V_B > \Delta V_C$
(d) $\Delta V_B > \Delta V_C > \Delta V_A$
(e) $\Delta V_C > \Delta V_B > \Delta V_A$

Questions 16–17 pertain to the following circuit.



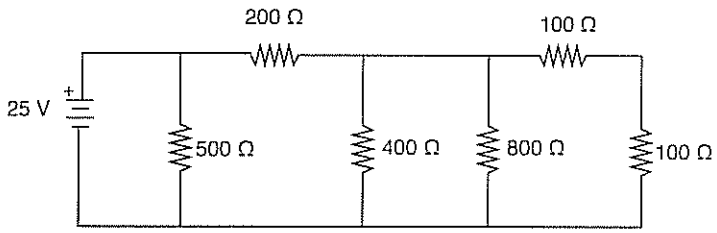
16. What is the current through the battery?

(a) 2 A
(b) 20 A
(c) 10 A
(d) 5 A
(e) 7.5 A

17. What is the current through the 16 Ω resistor?

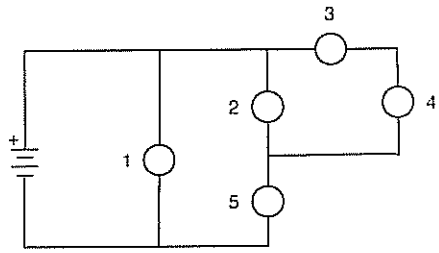
(a) 2 A
(b) 20 A
(c) 10 A
(d) 5 A
(e) 7.5 A

18. What is the total (i.e. equivalent) resistance of the resistors in the circuit below?



(a) 2100 Ω
(b) 160 Ω
(c) 114 Ω
(d) 193 Ω
(e) 814 Ω

Questions 19–20: Identical bulbs are connected to a battery as shown below.

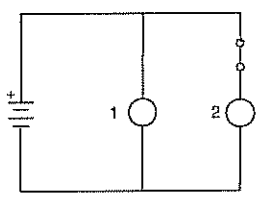


19. Bulbs 2 and 5 are connected
    (a) in parallel.
    (b) in series.
    (c) neither in series nor in parallel.
    (d) both in series and in parallel.

20. If you unscrew Bulb 5 from its socket, Bulb 2 will:
    (a) become brighter.
    (b) become dimmer (but not go out completely)
    (c) have the same brightness as before.
    (d) go completely out because no current will flow through the bulb.

No current will flow through bulb 2.

21. Identical bulbs are connected to a battery as shown below. What happens to bulb 1 when the switch is opened?

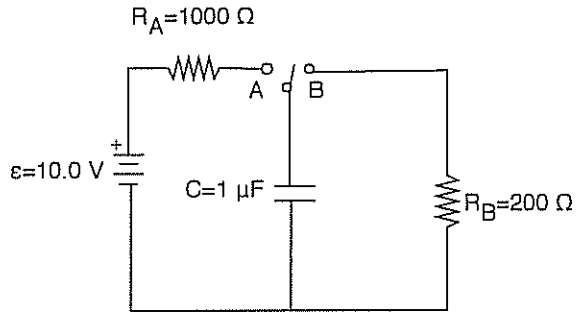


This was observed in lab.

Also $P_1 = I_1 \Delta V_1$ stays the same.

    (a) It becomes brighter.
    (b) It becomes dimmer (but does not go out completely).
    (c) Its brightness stays the same.
    (d) The bulb goes out completely because no current flows through the bulb.

Questions 22–25: For the circuit below, when the switch is at position A, the capacitor charges through resistor A. When the switch is at position B, the capacitor discharges through resistor B.



22. What is the maximum charge on each capacitor plate when it is fully charged?

(a) 0.1 μC
(b) 1 μC
(c) 10 μC
(d) 200 μC
(e) 1000 μC

$Q = C\Delta V$
$= (1\mu F)(10V)$
$= 10\ \mu C$

23. When the capacitor charges, what is the direction of the current flowing through resistor A?

(a) to the right
(b) to the left
(c) None of the above because the current is zero while the capacitor is charging.

24. Does it take a longer time for the capacitor to charge or for it to discharge?

(a) It takes longer to charge.
(b) It takes longer to discharge.
(c) It takes the same amount of time to charge and discharge.

$\tau = RC$. $R_A > R_B$

25. When the capacitor is charging, how long does it take for the voltage across the capacitor to reach 90% of its maximum value?

(a) 1.0 ms
(b) 2.3 ms
(c) 0.11 ms
(d) 0.69 ms
(e) 0.99 ms

$\Delta V_c = \Delta V_{max}\left(1 - e^{-\frac{t}{RC}}\right)$

$0.9 = 1 - e^{-\frac{t}{RC}}$

$-0.1 = -e^{-\frac{t}{RC}}$

$\ln(0.1) = \frac{-t}{RC}$

$t = -RC\ln(0.1) = (1000\,\Omega)(1\times10^{-6}\,F)\ln(0.1)$

$= 0.0023\ s$

$= 2.3\ ms$