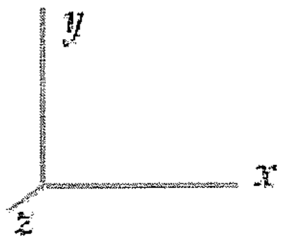
Physics 1520, Fall 2013 Name: Key
Quiz 4, Form: A Date: ______

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

1. You have an aluminum wire ($\rho_{Al} = 2.8 \times 10^{-8}\ \Omega \cdot \mathrm{m}$) and copper wire ($\rho_{Cu} = 1.7 \times 10^{-8}\ \Omega \cdot \mathrm{m}$) of the same length. If the wires have the same resistance, which wire has the greater radius?

   (a) The aluminum wire

   (b) The copper wire.

   (c) Neither; they have the same radius.

   (d) More information about the wires is required in order to answer the question correctly.

   $R = \rho \frac{L}{A} = \frac{\rho L}{\pi r^2}$

   $\pi r^2 = \frac{\rho L}{R}$ so $r \propto \sqrt{\rho}$

2. In 8 s, 9.6×10^{20} electrons pass a cross section of wire, traveling with a drift velocity in the $+x$ direction. What is the conventional current?

   (a) 12 A, to the right

   (b) 12 A, to the left

   (c) 8.1 A, to the left

   (d) 19 A, to the left

   (e) 19 A, to the right

   $I = \frac{\Delta Q}{\Delta t}$

   $\Delta Q = (9.6 \times 10^{20}\ e^-)\left(\frac{1.6 \times 10^{-19}\ C}{e^-}\right)$

   $= 153.6\ C$

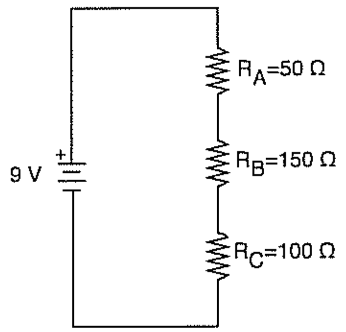
   $I = \frac{153.6\ C}{8\ s}$

   $= \boxed{19.2\ A}$

   I is opposite $\vec{v}$ of electrons.

   $\vec{I} \longleftarrow \quad \longrightarrow \vec{v}_{drift}$

Questions 3–4 pertain to the following circuit.



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

(a) $I_C > I_B > I_A$

(b) $I_A > I_B > I_C$

(c) $I_A > I_C > I_B$

(d) $I_B > I_C > I_A$

(e) $I_A = I_B = I_C$

Resistors are in series

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

(a) $\Delta V_C > \Delta V_B > \Delta V_A$

(b) $\Delta V_A > \Delta V_B > \Delta V_C$

(c) $\Delta V_A > \Delta V_C > \Delta V_B$

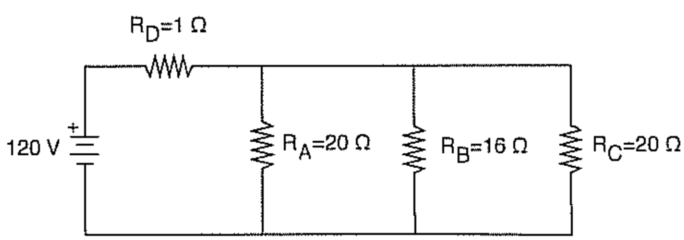
(d) $\Delta V_B > \Delta V_C > \Delta V_A$

(e) $\Delta V_A = \Delta V_B = \Delta V_C$

$\Delta V = IR$

greater R has greater ΔV.

Questions 5–6 pertain to the following circuit.



5. What is the current through the battery?

(a) 17 A

(b) 2.1 A

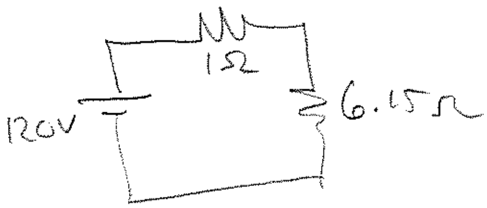
(c) 120 A

(d) 5.7 A

(e) 4.0 A

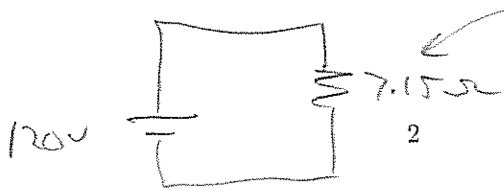
Find R_{eq}.

$\frac{1}{20} + \frac{1}{16} + \frac{1}{20} \rightarrow 6.15\,\Omega$



$R_{eq} = 1 + 6.15 = 7.15\,\Omega$

$I = \frac{120V}{7.15\,\Omega} = \boxed{16.8\,A}$



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

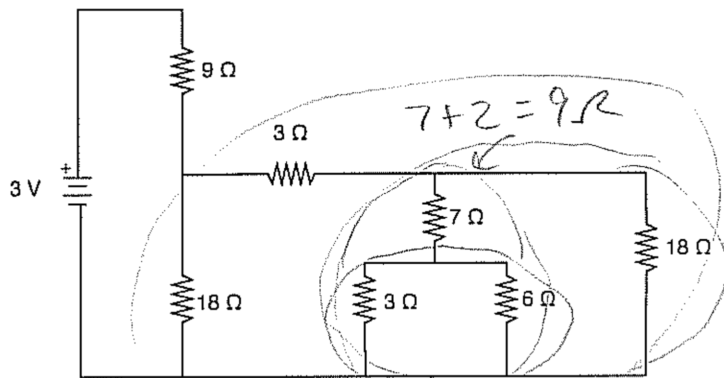
(a) 7.5 A
(b) 2.2 A
(c) 0.93 A
(d) 46 A
(e) 6.4 A

$\Delta V_D = (16.8A)(1\Omega) = 16.8V$

So $\Delta V_A = \Delta V_B = \Delta V_C = 120V - 16.8V = 103V$

$I_B = \frac{103V}{16\Omega} = \boxed{6.4A}$

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



$7+2=9\Omega$

$\left(\frac{1}{9}+\frac{1}{18}\right)^{-1} = 6\Omega.$

$\left(\frac{1}{3}+\frac{1}{6}\right)^{-1} = 2\Omega$

$6+3=9\Omega.$

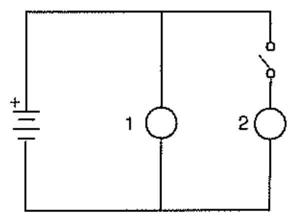
(a) 15 Ω
(b) 64 Ω
(c) 12 Ω
(d) 18 Ω
(e) 16 Ω

$\left(\frac{1}{18}+\frac{1}{9}\right)^{-1} = 6\Omega$

9Ω
6Ω

$R_{eq} = 9+6 = \boxed{15\Omega}$

8. What happens to bulb 1 when the switch is closed?

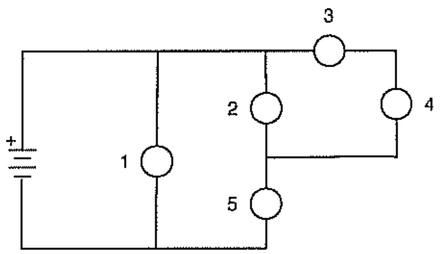


P_1 stays the same.

Although current through battery doubles, it splits between the bulbs so I_1 and ΔV_1 stay 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 9–11: Identical bulbs are connected together to a battery as shown below.



9. 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.

10. Rank the bulbs from brightest to least bright.

   (a) $1 = 5 > 2 > 3 = 4$

   (b) $1 = 5 = 2 > 3 = 4$

   (c) $1 > 5 = 2 > 3 = 4$

   (d) $1 > 2 > 3 = 4 > 5$

   (e) $1 > 5 > 2 > 3 = 4$

I_1 is greatest since its path has least R.

I splits between 2 and 3 so $I_5 > I_2$.

3,4 have same current since they are in series. $I_2 > I_3$ since $R_2 < R_{3+4}$.

11. If you unscrew Bulb 2 from its socket, Bulb 5 will:

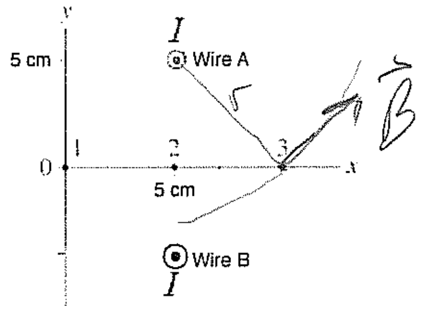
   (a) become brighter.

   (b) become dimmer (but not go out completely)

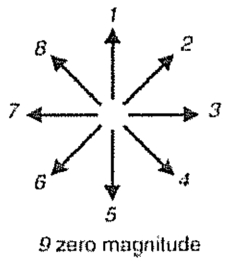
   (c) go completely out because no current will flow through the bulb.

$R_{3+4} > R_{2+3+4}$ since 2 + 3,4 are in parallel. thus removing bulb 2 increases the resistance in the path that contains bulb 5. Thus I_5 decreases.

Questions 12–14: An end view of two long current carrying wires is shown below. The current is 2 A in each wire.



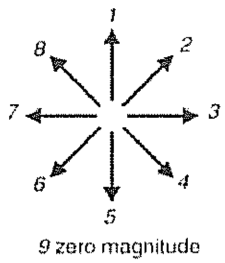
12. Which of these arrows is closest to the magnetic field *due to wire A* at point 3?

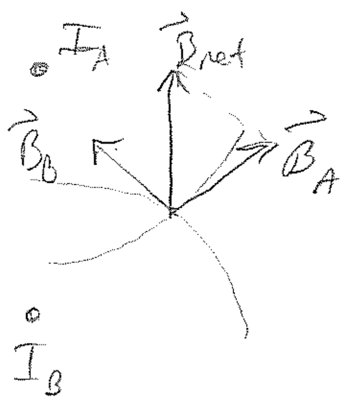


$\vec{B}$ is tangent to a circle around wire A.

(a) 2
(b) 3
(c) 4
(d) 6
(e) 7

13. Which of these arrows is closest to the *net* magnetic field at point 3?





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

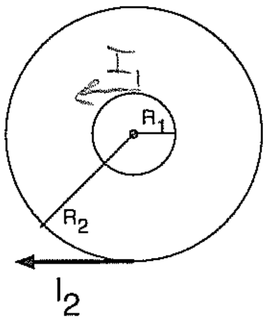
14. What is the magnitude of the magnetic field *due to wire A* at point 3?

(a) 1.8×10^{-5} T
(b) 8.0×10^{-6} T
(c) 5.7×10^{-6} T
(d) 2.5×10^{-5} T
(e) 1.1×10^{-5} T

$$B = \frac{\mu_0 I}{2\pi r} = \frac{\left(4\pi\times10^{-7}\,\frac{T\cdot m}{A^2}\right)(2A)}{2\pi\,(0.0707m)} = \boxed{5.66\times10^{-6}\ T}$$

$$r = \sqrt{0.05^2+(0.05)^2} = 0.0707m$$

Questions 15–16: 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.



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

15. Suppose that $I_1 = 2A$ flows counterclockwise in the inner loop. If the radius of the inner loop is 1 cm, what is the magnitude of the *net* magnetic field at the center of the loops (neglect Earth's magnetic field)?

(a) 3.0×10^{-5} T
(b) 9.4×10^{-5} T
(c) 1.3×10^{-4} T
(d) 6.3×10^{-5} T
(e) 4.0×10^{-5} T

$B_{1z} = +\frac{\mu_0 I}{2R} = \frac{(4\pi \times 10^{-7})(2A)}{2(0.01m)} = +1.26\times 10^{-4}T$

$B_{2z} = -\frac{\mu_0 I}{2R} = \frac{-4\pi\times 10^{-7}(2A)}{2(0.04m)} = -3.14 \times 10^{-5}T$

$B_{netz} = B_{1z} + B_{2z} = \boxed{9.42 \times 10^{-5}T}$

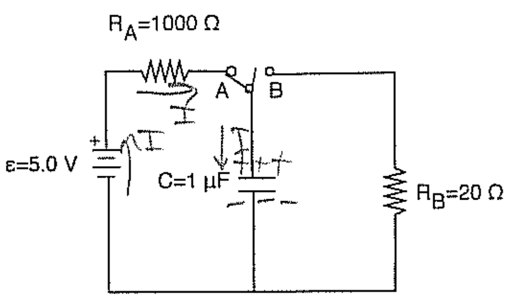
16. For the previous question, what is the direction of the net magnetic field at the center of the loops (neglect Earth's magnetic field?

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

B_{netz} is $+$

17-20

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.



17. What is the voltage across the capacitor when it is fully charged?

(a) 1.0 V
(b) 2.0 V
(c) 3.0 V
(d) 5.0 V
(e) 10.0 V

The same as the battery.

18. Which capacitor plate in the diagram will become positively charged?
    (a) the bottom plate (the one toward the bottom of the page)
    (b) the top plate (the one toward the top of the page)
    (c) They will both be positively charged.
    (d) Neither plate will be positively charged.
19. When the switch is changed to position B, the capacitor will discharge. What will be the direction of conventional current through resistor B while the capacitor is discharging?
    (a) upward, toward the top of the page
    (b) downward, toward the bottom of the page
    (c) Current will travel in both directions (upward and downward) at the same time.

+ charge will flow toward bottom plate, clockwise.

20. When the capacitor is discharging, how long does it take for the voltage across the capacitor to drop to half of its initial value?
    (a) 2.0×10^{-5} s
    (b) 1.0×10^{-5} s
    (c) 6.9×10^{-6} s
    (d) 2.9×10^{-5} s
    (e) 1.4×10^{-5} s

$\Delta V_c = \Delta V_{c\,max}\, e^{-t/(RC)}$

$\frac{\Delta V_c}{\Delta V_{c\,max}} = 0.5 = e^{-\frac{t}{RC}}$

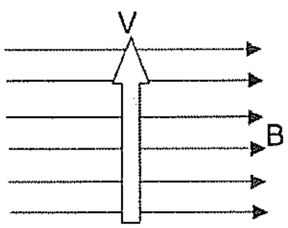
$\ln(0.5) = \frac{-t}{RC}$

$t = -RC\ln(0.5)$

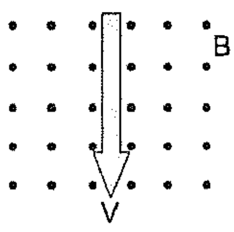
$= -(20)(1\times10^{-6}F)\ln(0.5)$

$\approx \boxed{1.4\times10^{-5}\ s}$

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

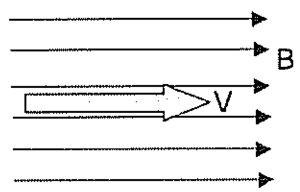


    (a) $+x$
    (b) $-x$
    (c) $+z$
    (d) $-z$
    (e) The magnetic force is zero.
22. What is the direction of the magnetic force on a *proton* with the velocity shown below?



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

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

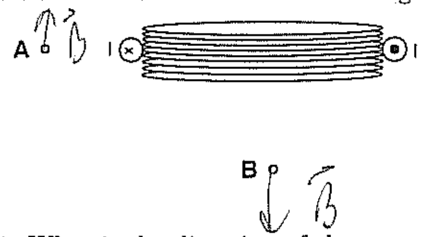


$\vec{v}$ $\vec{B}$ $\theta = 0$

$F = qvB\sin\theta$ and $\sin(0) = 0$

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

Questions 24–25: Current flows through a coil of wire in the direction shown below.



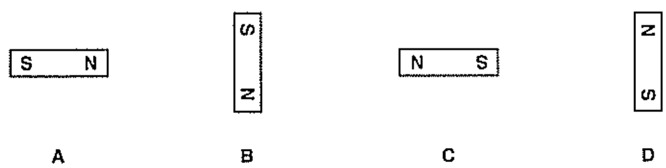
for pt. B.
use R.H.R.
fingers curl around coil in dir. of I.

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

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

$\vec{B}_A$ is opposite $\vec{B}_B$.

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



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