

SOLUTION

Physics 126
Section B01

Friday Mar 21 2014
Instructor: Wheelock, M.
CCIS 1-430 12:00 – 12:48

Winter 2014 – Exam 2
Exam is worth a total of 15 points

PLEASE DO NOT OPEN YOUR EXAM UNTIL YOU ARE TOLD TO DO SO.
You may begin filling out your Scan-Tron form.

ON THE SCAN-TRON ANSWER SHEET, PLEASE ENTER THE FOLLOWING:

YOUR NAME [Surname first, then a space, followed by your given name]
STUDENT ID NUMBER [seven digits]
SPECIAL CODES: see next page for exam version number

You MUST fill in the bubbles with the above info or your exam will not be marked. You will not be given extra time at the end of the exam to do so.

There are 15 multiple-choice questions. Please read all answers and select the one best answer. Bubble in your answers in pencil on the Scan-tron Answer Sheet. Answers written on this handout will NOT be marked.

NO GRAPHING CALCULATORS OR PROGRAMMABLE CALCULATORS PERMITTED.

TAKE A DEEP BREATH!
RELAX!

Good luck!

When the exam period is over, please stop working immediately.
Turn in your ScanTron sheet as directed by the instructor.
If you do not turn in your exam promptly it will not be accepted.

IMPORTANT:

On your answer sheet under SPECIAL CODES

ENTER $J = 3$, $K = 3$

Equation sheets are attached at the back.
You may carefully detach them.

Corresponding
question #
on version 99

4

1. A resistor R_1 is connected to a battery. When a second resistor R_2 is added to the circuit in parallel with R_1 , what happens?

A. the voltage across R_1 decreases

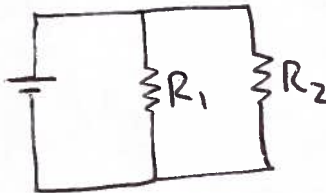
B. the current through R_1 increases

C. the current through the battery increases

D. the equivalent resistance of the circuit increases — R_{eq} decreases

E. all of the above

} no change



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2. What is the total (equivalent) resistance of this group of resistors?

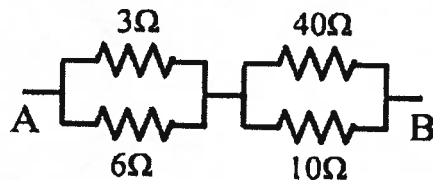
A. 6.4Ω

B. 7.6Ω

C. 10Ω

D. 29.5Ω

E. 59Ω



$$\left(\frac{1}{3} + \frac{1}{6}\right)^{-1} + \left(\frac{1}{40} + \frac{1}{10}\right)^{-1} = 10 \Omega$$

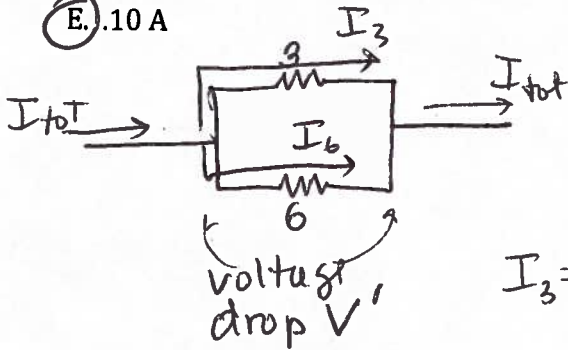
Corresponding question # on version 99

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3. Refer to the previous problem. If a 1.5 V battery is connected across the wires labeled A and B, what current would flow through the 3 Ω resistor?

- A. .025 A
- B. 1.5 A
- C. .50 A
- D. .15 A
- E. .10 A

$$\text{total current } I_{\text{tot}} = \frac{1.5 \text{ V}}{10 \Omega} = .15 \text{ A}$$



$$I_3 + I_6 = I_{\text{tot}}$$

$$\left. \begin{aligned} I_3 &= \frac{V'}{3} \\ I_6 &= \frac{V'}{6} \end{aligned} \right\} I_6 = \left(\frac{1}{2}\right) I_3 \text{ subst.}$$

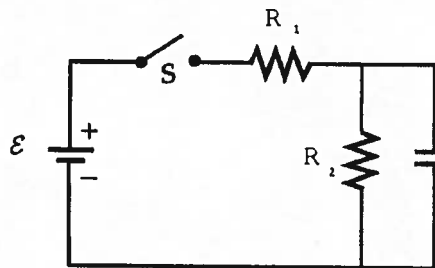
$$\left(\frac{1}{2}\right) I_3 + I_3 = I_{\text{tot}}$$

$$I_3 = \frac{I_{\text{tot}}}{1.5} = \frac{.15 \text{ A}}{1.5} = .10 \text{ A}$$

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4. In the circuit at right, the two resistors are identical. The capacitor is initially uncharged. Immediately after the switch is closed, current through the battery = I. What current flows through the battery after a long time has passed? Give your answer in terms of I.

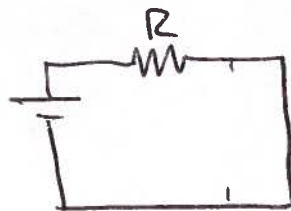
- A. I
- B. 2I
- C. (1/2)I
- D. (3/2)I
- E. zero



← initially, capacitor behaves like ideal wire

Initially:

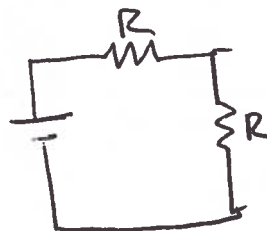
$$I_0 = \frac{\epsilon}{R}$$



← negligible current through R2

After a long time:

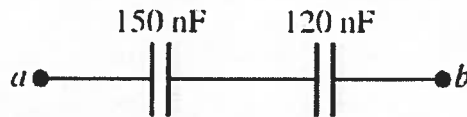
$$I_f = \frac{\epsilon}{2R} = \left(\frac{1}{2}\right) I_0$$



← no current through branch containing capacitor

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5. In the circuit at right, suppose the wires labeled **a** and **b** are connected to a 12.0 V battery. When fully charged, how much energy would be stored in the 150 nF capacitor?
 1 nF = 10^{-9} F



- (A) 2.13×10^{-6} J
 B. 4.80×10^{-6} J
 C. 1.08×10^{-5} J
 D. 6.32×10^{-5} J
 E. 1.39×10^{-6} J

$$C_{\text{tot}} = \left(\frac{1}{150} + \frac{1}{120} \right)^{-1} = 66.7 \text{ nF}$$

$$Q_{\text{tot}} = C_{\text{tot}} V = (66.7 \text{ nF})(12 \text{ V}) = 800 \text{ nC}$$

Capacitors in series $\rightarrow Q_{\text{tot}} = Q$ on each plate.

$$\text{Energy stored} = \frac{Q^2}{2C} = \frac{(800 \times 10^{-9})^2}{(2)(150 \times 10^{-9})} = 2.13 \times 10^{-6} \text{ J}$$

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6. A solenoid with radius = 0.018 m has 1200 turns per meter, and is constructed from a long wire with total resistance $R = 4.0 \Omega$. The solenoid functions as an electromagnet when it is connected to a battery. Approximately what battery voltage would be needed in order to develop a .0030 T magnetic field inside the solenoid?

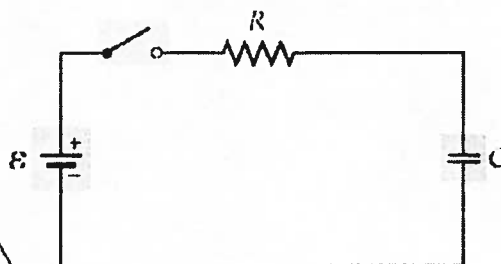
- A. 1.5 V
 B. 2 V
 C. 6.5 V
 (D) 8 V
 E. 12 V

$$\text{Solenoid: } B = \mu_0 n I \quad \leftarrow V = IR$$

$$= \mu_0 n \left(\frac{V}{R} \right)$$

$$V = \frac{BR}{\mu_0 n} = \frac{(0.0030)(4)}{(4\pi \times 10^{-7})(1200)} = 7.96 \text{ V}$$

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7. The battery voltage, resistance and capacitance for five RC circuits are given below. After the switch is closed, which circuit will take the longest time for the capacitor to charge up to 50% of its final (equilibrium) charge?



	Voltage	R	C
A.	12 V	12 Ω	2 μF
B.	12 V	6 Ω	1 μF
C.	9 V	2 Ω	4 μF
D.	9 V	6 Ω	2 μF
E.	1.5 V	12 Ω	1 μF

longest time
→ largest time constant
→ look for largest value of $\tau = RC$

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8. Refer to diagram in the previous problem. In example E, the voltage is 1.5 V, $R = 12 \Omega$, and $C = 1.0 \mu\text{F}$. After the switch is closed, how long would it take for the voltage across the capacitor to reach 1.0 V? $1 \mu\text{s} = 10^{-6} \text{ s}$

- A. 4.0 μs
- B. 8 μs
- C. 12 μs
- D. 13 μs
- E. 18 μs

$$q(t) = Q(1 - e^{-t/\tau})$$

$$Q = CV \rightarrow \phi V(t) = \phi V(1 - e^{-t/\tau})$$

$$\frac{V(t)}{V} - 1 = -e^{-t/\tau}$$

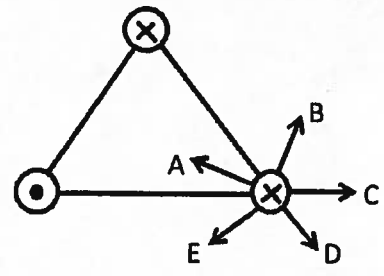
$$\ln\left(1 - \frac{V(t)}{V}\right) = -\frac{t}{\tau} \quad \leftarrow \tau = RC$$

$$t = -\tau \ln\left(1 - \frac{V(t)}{V}\right)$$

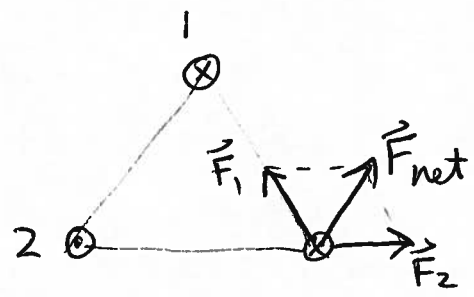
$$= -(12)(1 \times 10^{-6}) \ln\left(1 - \frac{1.0}{1.5}\right) = 13 \times 10^{-6} \text{ s}$$

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9. The diagram at right shows a cross-section through three current-carrying wires that are perpendicular to the page, with current directions as shown. All three currents are equal in magnitude. Which arrow best approximates the direction of the net magnetic force acting on the wire in the lower right corner?

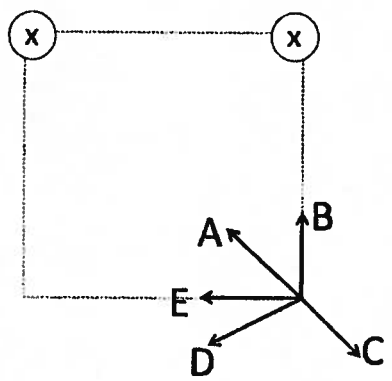


- A. arrow A
- B. arrow B
- C. arrow C
- D. arrow D
- E. arrow E

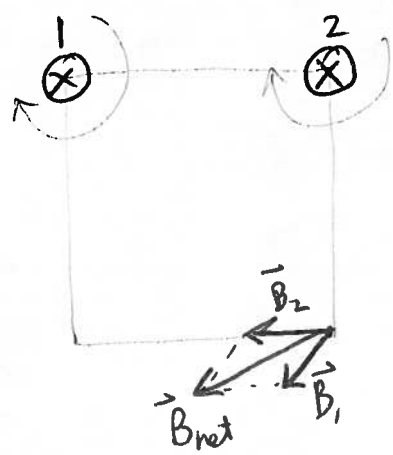


13

10. The diagram at right shows a cross-section through two current-carrying wires that are perpendicular to the page. The wires carry equal currents, directed into the page as shown. Which arrow best approximates the direction of the net magnetic field at the lower right corner of the square?



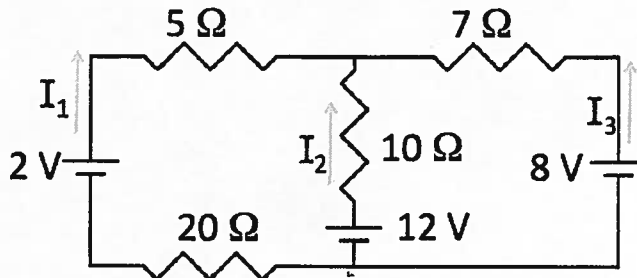
- A. arrow A
- B. arrow B
- C. arrow C
- D. arrow D
- E. arrow E



11. Consider the complex circuit in the diagram below, and the six numbered equations that follow.

14

Which set of equations could be used to solve for the three unknown currents? (Do NOT solve the equations.)

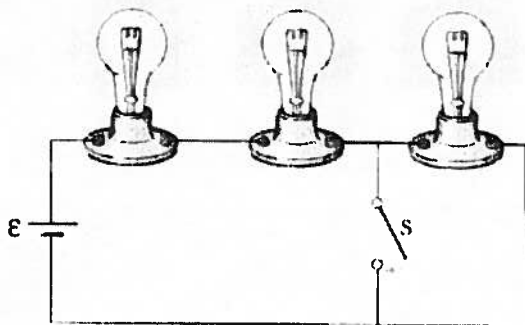


- A. Equations 2, 3 and 6
- B. Equations 1, 3 and 6
- C. Equations 1, 4 and 5
- D. Equations 3, 4 and 6
- E. Equations 1, 3 and 5**

- ① $I_1 + I_2 + I_3 = 0$
- 2. $I_1 + I_2 = I_3 \times$
- ③ $I_2(10\ \Omega) - 12V - I_1(20\ \Omega) + 2V - I_1(5\ \Omega) = 0$
- 4. $I_1(5\ \Omega) + I_2(10\ \Omega) - 12V + 8V - I_3(7\ \Omega) = 0 \times$
- ⑤ $I_3(7\ \Omega) - 8V - I_1(20\ \Omega) + 2V - I_1(5\ \Omega) = 0$
- 6. $I_3(7\ \Omega) + 8V + 12V + I_2(10\ \Omega) = 0 \times$

12. Three identical light bulbs are wired to a voltage source as shown. When the switch S is open, the battery supplies 120 W of power. After the switch S is closed,

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$$P = \frac{V^2}{R}$$

↓
short circuit;
third bulb goes
out.

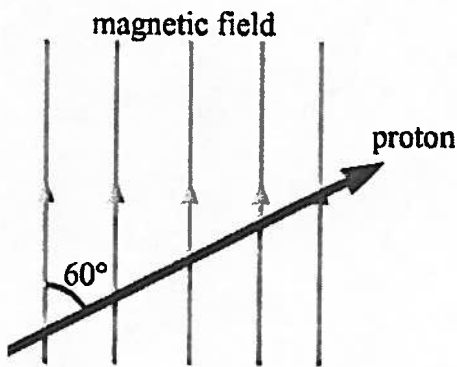
$$P_0 = \frac{\epsilon^2}{3R} = 120\text{ W}$$

$$P_f = \frac{\epsilon^2}{2R} = \left(\frac{3}{2}\right)P_0 = 180\text{ W}$$

- A. 180 W**
- B. 120 W
- C. 80W
- D. 270W
- E. You would need to know the battery voltage to answer this question.

13. Suppose a proton is ejected by the Sun and eventually approaches Earth. The proton enters Earth's magnetic field with a speed of 3.5×10^5 m/s in the direction shown below. If the magnitude of Earth's magnetic field is 2.5×10^{-5} T, what would be the magnitude of the magnetic force on the proton?

- A. 5.9×10^{-19} N
- B. 1.4×10^{-18} N
- C. 1.2×10^{-18} N
- D. 7.0×10^{-19} N
- E. zero



$$F = qvB \sin \theta$$

$$= (1.6 \times 10^{-19})(3.5 \times 10^5)(2.5 \times 10^{-5}) \sin 60^\circ$$

$$= 1.2 \times 10^{-18} \text{ N}$$

14. Refer to proton in the previous problem. After entering the magnetic field in the direction shown, what would happen to the proton's speed and direction of motion?

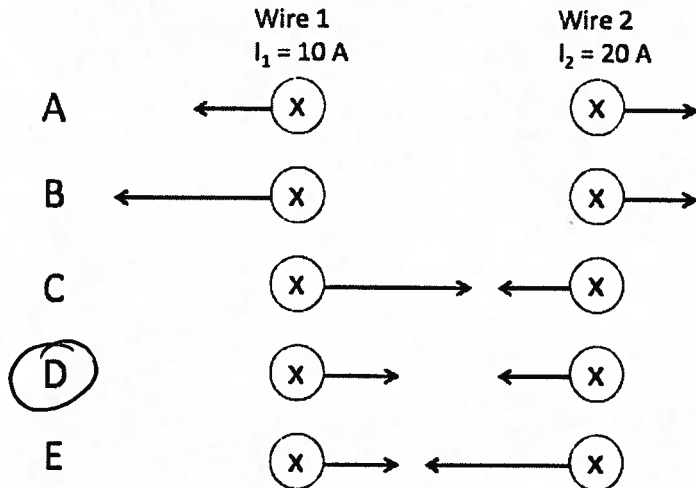
- A. the proton would be deflected out of the page, with the same speed
- B. the proton would be deflected out of the page, and the speed would decrease
- C. the proton would be deflected toward the top of the page, with the same speed
- D. the proton would be deflected toward the top of the page, and the speed would increase
- E. the proton would be deflected into the page, with the same speed

Use RHR #1

Force is perpendicular to the direction of motion, so the speed does not change

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15. Two long, current-carrying wires are perpendicular to the page. Wire 1 carries $I_1 = 10$ A and wire 2 carries $I_2 = 20$ A. Both currents are directed into the page as shown. Which of the five diagrams (below) best illustrates the forces that the wires exert on each other? Consider the direction and relative magnitudes of each force.



Parallel currents attract each other.
Forces are equal in magnitude
and opposite in direction.

MAKE SURE YOU HAVE BUBBLED IN your name, student ID, exam version number, and answers on the ScanTron sheet.

Turn in the ScanTron sheet only. You may keep this handout. Do not discuss your exam with anyone until after you have left the room.