PHYS 2140 Exam 2a Solutions

October 22, 2025

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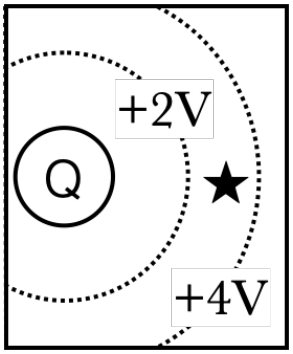
2 1. **B** If these two charges move closer together, their potential energy
A) increases **B)** decreases

2. The figure shows a charge Q (sign unknown) and two equipotential lines.

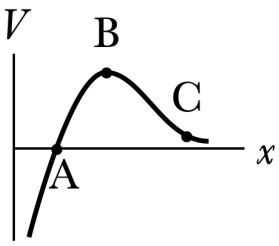


2 (a) **A** The charge Q is
A) negative **B)** positive

2 (b) **A** What direction does the electric field point at the star?
A) left ← **B)** right →
A) ~~down ↓~~ **B)** ~~up ↑~~

2 (c) **A** What is the potential V_∞ at infinity if there are no other charges in the universe?
A) positive **B)** zero **C)** negative

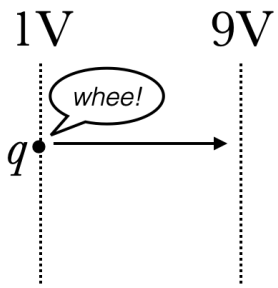
3. Here is a graph of the potential along a line.



4 (a) **A** At which point is the electric field greatest in magnitude?
A) A **B)** B **C)** C

4 (b) **B** At which point is the electric field zero?
A) A **B)** B **C)** C **D)** None of these

4. A charge q spontaneously moves from ~~$-1\,\text{V}$ to $-9\,\text{V}$~~ $1\,\text{V}$ to $9\,\text{V}$.



2 (a) **B** Which could be the charge q?

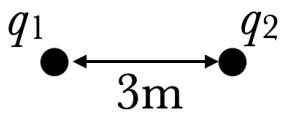
A) $+3\,\mu\text{C}$ **B)** $-3\,\mu\text{C}$

4 (b) **A** What is the change in the potential energy of this charge?

A) $-24\,\mu\text{J}$ **B)** $-0.37\,\mu\text{J}$ **C)** $+0.37\,\mu\text{J}$ **D)** $+24\,\mu\text{J}$

4 5. **B** Two charges are 3 m apart, they are $q_1 = -9\,\mu\text{C}$ and $q_2 = 7\,\mu\text{C}$. What is the potential energy of the two charges?

A) $-12\,\text{kV}$ **B)** $-190\,\text{mJ}$ **C)** $-60\,\text{mJ}$ **D)** $-8\,\text{kJ}$

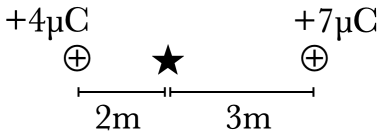


$$PE = k\frac{q_1 q_2}{d}$$

$$PE = (9\times10^9)\frac{(-9\times10^{-6})(7\times10^{-6})}{3}$$

$$= -0.189\,\text{J}$$

4 6. **D** Two positive charges sit on a line as shown. What is the electric potential at the star, assuming $V_\infty = 0$?



A) $50\,\text{mV}$ **B)** $2\,\text{kV}$ **C)** $3\,\text{kV}$ **D)** $39\,\text{kV}$

A) ~~$12\,\text{kV}$~~ **B)** ~~$20\,\text{kV}$~~ **C)** ~~$44\,\text{kV}$~~ **D)** ~~$50\,\text{mV}$~~

$$V = (9\times10^9)\frac{+4\times10^{-6}}{2} + (9\times10^9)\frac{+7\times10^{-6}}{3}$$

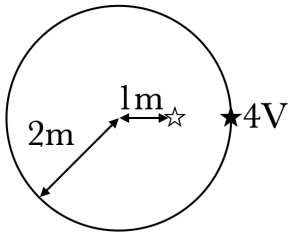
$$= 18{,}000\,\text{V} + 21{,}000\,\text{V}$$

$$= 39{,}000\,\text{V}$$

4

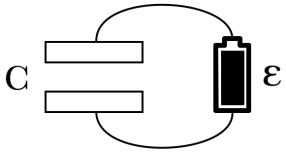
7. **D** This *conducting* sphere has a radius of 2 m and a net positive charge. The potential at the surface is 4 V. What is the potential 1 m from the center?

A) 0V **B)** 1V **C)** 2V **D)** 4V **E)** 16V



All points in a conductor are at the same potential.

8. This capacitor has a capacitance of $C = 9\,\mu$F. If it is hooked up to a $\mathcal{E} = 5$ V battery,



4 (a) **B** what is the charge on the positive plate?

A) 550 nC **B)** 45 μC **C)** 1.8 MC

4 (b) How much energy is stored in this capacitor?

$$PE = \frac{1}{2}C(\Delta V)^2 = \frac{1}{2}(9\,\mu\text{F})(5\,\text{V})^2 = 112\,\mu\text{J}$$

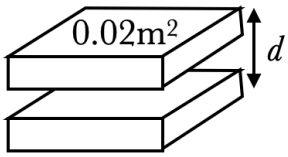
2 (c) **A** To increase the capacitance of this capacitor, we should move the plates

A) closer together **B)** farther apart

2 (d) **B** If we increase the capacitance of this capacitor while it is connected to the battery, the energy in the capacitor will

A) decrease **B)** increase

9. These parallel plates have a capacitance of $4\,\mu$F. Each plate has an area of $0.02\,\text{m}^2$.



4 (a) What is the distance between the plates?

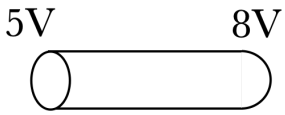
The capacitance is

$$C = \frac{\epsilon_0 A}{d} \implies d = \frac{\epsilon_0 A}{C} = \frac{(8.85 \times 10^{-12})(0.02)}{4 \times 10^{-6}} = 4.4 \times 10^{-8}\,\text{m}$$

4 (b) **E** If I fill the space between the plates with paper ($\kappa = 5$) what is the capacitance now?

A) $0.8\,\mu$F **B)** $4\,\mu$F **C)** $9\,\mu$F **D)** $12\,\mu$F **E)** $20\,\mu$F

10. On this wire, the potential on the ~~left~~ right is 8 V and the potential on the ~~right~~ left is 5 V.



2 (a) **A** What direction does the conventional current I point?

A) left ← **B)** right →

2 (b) **B** What direction do electrons move inside?

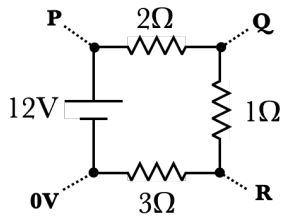
A) left ← **B)** right →

Full credit if opposite (a) and word "opposite" appears

4 (c) **A** If the current through the wire is 8 mA, what is the resistance of the wire?

A) $375\,\Omega$ **B)** $1000\,\Omega$ **C)** $2700\,\Omega$ **D)** $24\,\text{k}\Omega$

11. Here's a simple loop with three resistors; the current through the battery is $I = 2\,\text{A}$. If the potential at the negative terminal of the battery is zero, find the potential at these three points. (The answers are all integers.)



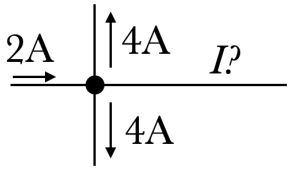
2 (a) point P: **12**

2 (b) point Q: **8**

2 (c) point R: **6**

4 12. **B** Four wires meet at a junction as shown. What is the current I in the right wire?

A) $2\,\text{A} \leftarrow$ **B)** $6\,\text{A} \leftarrow$ **C)** $10\,\text{A} \leftarrow$
D) $2\,\text{A} \rightarrow$ **E)** $6\,\text{A} \rightarrow$ **F)** $10\,\text{A} \rightarrow$

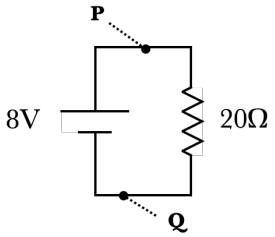


4 13. **C** A wire has a resistivity of $8 \times 10^{-4}\,\Omega\text{m}$, a resistance of $7\,\Omega$, and a cross-sectional area of $A = 0.02\,\text{m}^2$. How long is the wire? *(Remember that $R = \rho L/A$)*

A) $2.3 \times 10^{-6}\,\text{m}$ **B)** $5.7 \times 10^{-3}\,\text{m}$ **C)** $1.8 \times 10^{2}\,\text{m}$ **D)** $4.4 \times 10^{5}\,\text{m}$

$$R = \frac{\rho L}{A} \implies L = \frac{AR}{\rho} = \frac{(0.02)(7)}{8 \times 10^{-4}} = \boxed{175\,\text{m}}$$

14. Consider this battery connected to a resistor. The current through the battery is 0.4 A.



4 (a) **B** What is the power emitted by the resistor?

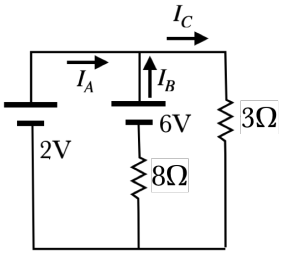
A) 0.4 W **B)** 3.2 W **C)** 240 W **D)** 1280 W

$$P = \frac{(\Delta V)^2}{R} = \frac{(8)^2}{20} = 3.2\,\text{W}$$

2 (b) **C** Where is the current larger?

A) In wire P **B)** In wire Q
C) Both wires have the same current

15. Consider this circuit.



4 (a) **C** Which of the following is true?

A) $I_A = I_B + I_C$ **B)** $I_B = I_A + I_C$ **C)** $I_C = I_A + I_B$

4 (b) Write a loop rule equation involving the two batteries. (Remember it should equal zero.)

$$+2 - 6 + 8I_B = 0 \quad \text{or} \quad -2 + 6 - 8I_B = 0$$

4 (c) Find I_A.

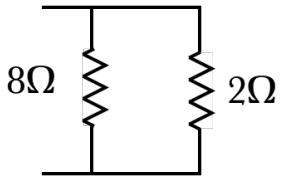
Other loop rules:

- $2 - 3I_C = 0$
- $6 - 3I_C - 8I_B = 0$

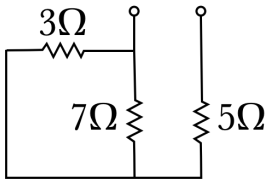
The loop rule from part a let's us show that $4 = 8I_B \implies I_B = \frac{1}{2}$. The large loop around the circuit gives the equation $2 - 3I_C = 0 \implies I_C = \frac{2}{3}$. The junction rule is $I_A + I_B = I_C$, so $I_A = I_C - I_B = \frac{2}{3} - \frac{1}{2} = \boxed{\frac{1}{6}\,\text{A}}$.

4 16. **C** What is the equivalent resistance of these two resistors?

A) 0.1 Ω **B)** 0.63 Ω **C)** 1.6 Ω **D)** 5 Ω **E)** 10 Ω



17. Consider this set of resistors, with two terminals marked.



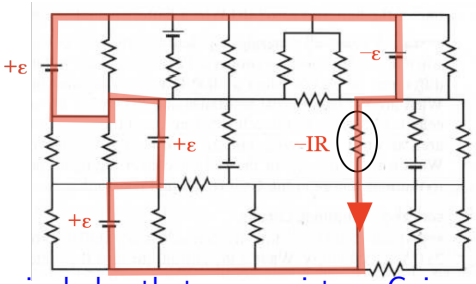
4 (a) **C** Which pair of resistors are in parallel with each other?

A) 3 Ω and 5 Ω **B)** 5 Ω and 7 Ω **C)** 3 Ω and 7 Ω
D) None of these

4 (b) **E** What is the equivalent resistance of this set of resistors?

A) 1.48 Ω **B)** 3.33 Ω **C)** 5.48 Ω
D) 5.58 Ω **E)** 7.1 Ω **F)** 15 Ω

2 XC 18. In this circuit, all the batteries are 12 V and all the resistors are 4 Ω. What is the current through the circled resistor? Include the *direction* (up or down).



There is a simple loop through the resistor which only includes that one resistor. Going clockwise around this loop gives us $+12 + 12 + 12 - 12 - 4I = 0 \implies 24 = 4I \implies \boxed{I = 6\,\text{A}}$