## Restroom breaks are NOT allowed during the test. If you need one, take it before starting the test.
## Internet access and Phone Use are not allowed.
Only a calculator is allowed for calculations.
Turn off your cell phone. Everything you write must be your own work.

| $v = v_0 + at$ | $x = \bar{v}\,t$ $x = \frac{1}{2}(v+v_0)t$ | $x = v_0 t + \frac{1}{2}at^2$ | $v^2 = v_0^2 + 2ax$ | $\vec{F} = m\vec{a}$ $\vec{E} = \dfrac{\vec{F}}{q}$ |
|---|---|---|---|---|

0. Heat transfer:  $Q = mc\Delta T$        $Q = mL$

1. Ohm's law:  V = IR          2. Electric Power = P = IV        3. Electrical energy =IVt

4. Resistance in terms of resistivity and dimensions:  $R = \rho\dfrac{L}{A}$

5. Capacitors:   $C = \dfrac{q}{V}$.        $C = \kappa\varepsilon_0\dfrac{A}{d}$.     $Energy = \dfrac{1}{2}qV = \dfrac{1}{2}CV^2 = \dfrac{1}{2}\dfrac{q^2}{C}$.

| 6. Electric potential due to a point charge (Q) at a distance r: | 7. Electric potential in terms of EPE and point charge (Q): | 8. Electric field due to a point charge (Q) at a distance r: | 9. Electric field (E) from potential gradient: |
|---|---|---|---|
| $V = k\dfrac{Q}{r}$. | $V = \dfrac{EPE}{Q}$ | $E = k\dfrac{|Q|}{r^2}$ | $\vec{E} = -\dfrac{\Delta V}{\Delta X}$ |

| 10. Combination | Resistors | Capacitors |
|---|---|---|
| Series | $R_s = R_1 + R_2 + R_3 + ...$ | $\dfrac{1}{C_S} = \dfrac{1}{C_1} + \dfrac{1}{C_2} + \dfrac{1}{C_3} + ....$ |
| Parralel | $\dfrac{1}{R_p} = \dfrac{1}{R_1} + \dfrac{1}{R_2} + \dfrac{1}{R_3} + ....$ | $C_P = C_1 + C_2 + C_3 + ......$ |

11. Magnitude of the electron charge = $|e|$ =1.6 x 10^-19 C.
    Proton mass and charge: $m_p$ = 1.673 x 10^-27 kg, $q_p$ = 1.6 x 10^-19 C]

12. 1 Btu = 1055 J    1 calorie = 4.2 J     1 food Calorie = 1000 calorie

RC circuits:

Time constant = $\tau$ = RC        Discharging Equations:    $q = q_0 e^{-\frac{t}{RC}}$        $V = V_0 e^{-\frac{t}{RC}}$

PHYS 202    Spring 2026    Test #2    Name: __Answer Key__

2 pt each

I. Circle OR <u>Underline</u> the correct answer for the following multiple-choice questions.

1. What is the SI unit for capacitance?
. newton        . coulomb        . volt        . second        (. farad)        . ohm

2. The *kilo-watt* is a unit for
. Force        . Charge        (. Power)        . Energy        . Voltage

3. The electron-volt is a unit for
. Force        . Charge        . Power        (. Energy)        . Voltage

4. What is given by the area under the Current versus Time graph?
. Voltage        . Power        (. Charge)        . Time constant

5. In a string of Christmas tree lights, when one of the bulbs is removed, rest of the bulbs stay off. In this string, bulbs are connected in:
(. Series)                . Parallel

6. Which one of the following biomedical applications deals with the eye?
. EKK        . ECG        . EEG        (. ERG)        . CEG

7. When different circuit elements are connected in parallel, which one of the following is the same across all the elements?
. Current        (. Voltage)        . Charge        . Resistance        . Capacitance

8. A metal wire of length L and cross-sectional area A, has a resistance R. This wire is folded into half and both folds are used as the new wire. What is the resistance of the folded, new wire?
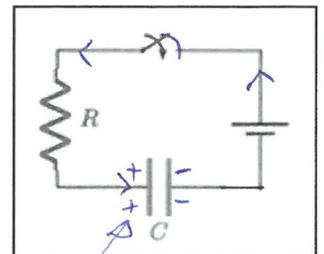4R        2R        R        ½ R        (¼ R)

$R = \rho \frac{L}{A}$, new $R = \rho \cdot \frac{L/2}{2A}$
$= \rho \frac{L}{A} \cdot \frac{1}{4}$

9. Which one of the following is placed between capacitor plates to increase the capacitance?
. Conductor        (. Dielectric)        . Resistance        . Semiconductor        . Superconductor

10-12) A 9-V battery, capacitor (uncharged), resistor, and switch are connected in series as shown.

10. Show the closed switch and the current in the diagram soon after the switch is closed.



11. What will be the potential difference across the capacitor after a long time, from the instant the switch is closed?
0        3V        6 V        8V        (9V)

12. Show the charges in the capacitor plates.

II. An appliance draws a current of 900 mA when connected to a 120-volt outlet.
Estimate the yearly cost of electricity for using it for 30 minutes a day, 24 days a month.
Assume a cost of 14 cents per kWH.

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$I = 900 mA = 0.9 A \qquad P = IV = 0.9 \times 120 = 108 W = 0.108 kW$

$V = 120v$

# of hours $= \dfrac{30}{60} \times 24 \times 12 = 144 H$

$kwH \rightarrow 0.108 kw \times 144 H = 15.55 kwH$

$Cost = 15.55 \times 0.14$

$Cost = \$2.18$

III. A lightning bolt strikes a tree, moving 31.5 C of charge through a potential difference
of 95.9 MV. What mass of water could be raised from 17.8°C to the boiling point and
then boiled by this energy?

11

Specific heat of water = 4186 J/(kg.C⁰) Latent heat of vaporization of water = 2.256 x 10⁶ J/kg.

$V = \dfrac{EPE}{q} \rightarrow EPE = qV = mc\Delta T + mL_v$

$31.5 \times 95.9 \times 10^6 = m \left[ 4186 \times (100 - 17.8) + 2.256 \times 10^6 \right]$

$3.021 \times 10^9 = m \left[ 344,089 + 2.256 \times 10^6 \right]$

$3.021 \times 10^9 = m \left[ 2.6 \times 10^6 \right]$

$\dfrac{3.021 \times 10^9}{2.6 \times 10^6} = M = 1.16 \times 10^3 kg$

IV. Suppose one wished to capture the picture of a bullet (moving at 500 m/s) that was
passing through an apple. The duration of the flash is related to the RC time constant, τ.
What size capacitor would one need in the RC circuit to succeed, if the resistance of the
flash tube was 10.0 Ω? Assume the apple is a sphere with a diameter of 8.0 cm.
(Time constant = τ = RC, which is also the time it takes the bullet to pass through an
apple)

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$\tau = RC, \qquad t = \dfrac{d}{v} = \dfrac{8 \times 10^{-2}}{500} = 0.00016 = \tau$
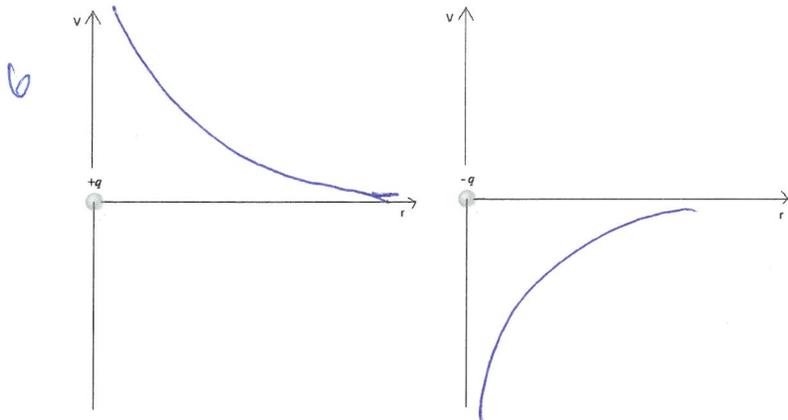
$0.00016 = 10 \times C$

$\dfrac{0.00016}{10} = C = \dfrac{0.000016 F}{}$

$\boxed{C = 16 \mu f}$

## V. At a distance $r$ from a point charge $q$, the electric potential, $V$ is given by: $V = k\frac{q}{r}$.

1. Sketch the electric potential, $V$ as a function of distance for a positive charge and a negative charge below:
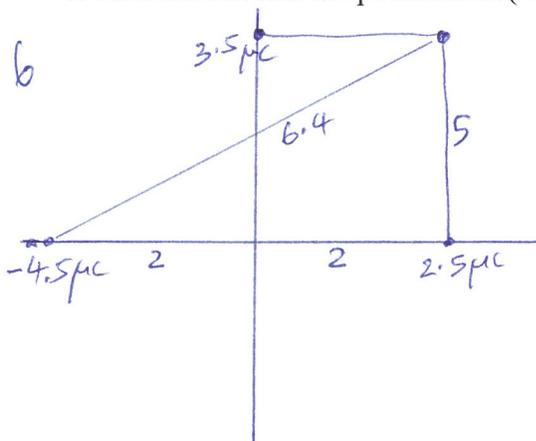
**6**



2. Three-point charges lie in a Cartesian coordinate system as follows:

+2.5 μC at (2 m, 0), –4.5 μC at (-2 m, 0), and 3.5 μC at (0, 5 m).   $\mu = 10^{-6}$

**3** a. Show the location of the charges in the coordinate system.

b. Find the net electric potential at (2 m, 5 m). Coulomb constant = $k = 9 \times 10^9$ (SI).
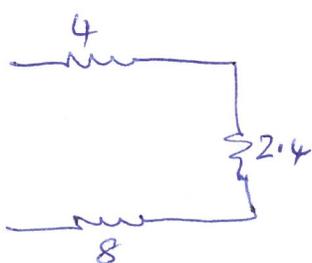
**6**



$$V = \frac{kq}{r} = 9 \times 10^9 \times \left( \frac{2.5 \times 10^{-6}}{5} + \frac{3.5 \times 10^{-6}}{2} - \frac{4.5 \times 10^{-6}}{6.4} \right)$$

$$V = 4.5k + 15.75k - 6.33k$$

$$\boxed{V = 13.9 \text{ kv}}$$
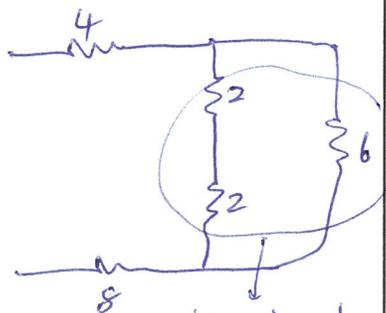
## VI. What is the equivalent resistance of all the resistances in the circuit below?
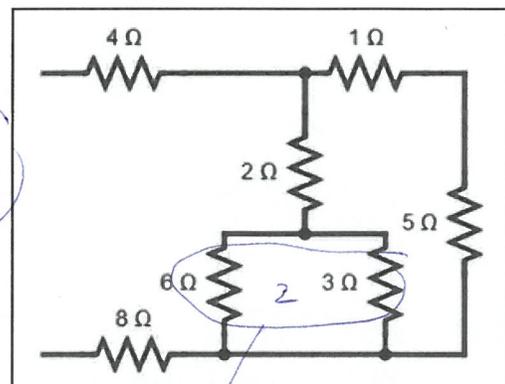
**10**



$8 + 2.4 + 4$

$\boxed{14.4 \, \Omega}$

$\frac{1}{6} + \frac{1}{4} = \frac{1}{R}$

$R = 2.4$
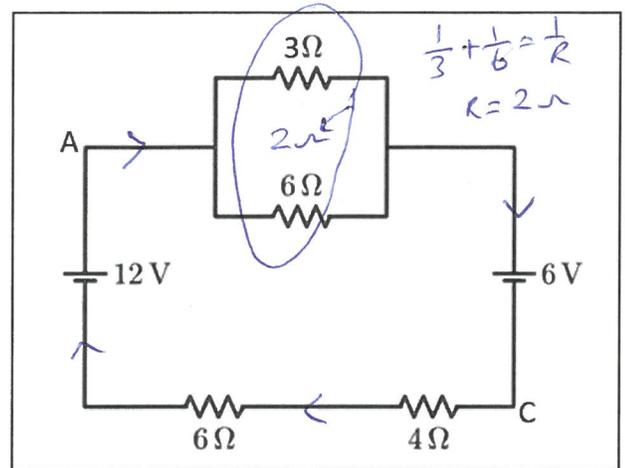
$\frac{1}{6} + \frac{1}{3} = \frac{1}{R} \xrightarrow{3} R = 2$

VII. Consider the circuit shown in the diagram below.

a. Show the direction of current in the circuit.

b. Determine the magnitude of the current.

$$I = \frac{\Sigma v}{\Sigma R} = \frac{12-6}{6+4+2} = \frac{6}{12} = 0.5A$$

$$I = 0.5A, \text{ clockwise.}$$

*(margin marks: 2, 3)*

Circuit diagram annotations:
$3\Omega$
$\frac{1}{3} + \frac{1}{6} = \frac{1}{R}$
$R = 2\Omega$
$2\Omega$
$6\Omega$
A
$12\,V$
$6\,V$
$6\Omega$    $4\Omega$    C

c. What is the voltage across and current through the 3-ohm resistor?

$$V_3 = V_{3//6} = V_2 = 0.5 \times 2 = 1\,\text{Volt}$$

$$I = \frac{V}{R} = \frac{1}{3} = 0.33\,A$$

*(margin mark: 4)*

d. What is the potential difference, $V_A - V_C$?

$$V_A - 0.5 \times 2 - 6 = V_C$$

$$V_A - 1 - 6 = V_C$$

$$V_A - V_C = 7\,volt$$

*(margin mark: 4)*

VIII. Kirchhoff's Rules.

For the circuit shown:
1. Assign unknown currents.
2. Identify the low and high potentials for the resistors and batteries.
3. Write down the potential differences across the resistors in terms of the assigned currents and the given resistance values.
4. Write down the junction rule equation using the assigned currents.

$$X = y + z$$

5. Write down the loop rule equation, for 2 different loops. [No need to solve simultaneous ./equations]

*(margin marks: 1, 1, 2, 2, 6)*

Circuit diagram annotations:
$6V$
A    E    $2\Omega$    B
$2z$
$1\Omega$ ($ix$)
$1\Omega$ ($iy$)    $y$
$2V$
$9V$
$z$
$3x$
D    $3\Omega$    F    $6z$    $6\Omega$    C

$$6 + 2 = x + 3x + y \qquad 9 + y = 2z + 2 + 6z$$

$$\boxed{8 = 4x + y} \qquad \boxed{7 = 8z - y}$$

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