PHYS 202 Spring 2025 Test #2 Equations Sheet Answer Key

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.

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: $R = \rho\frac{L}{A}$

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

| 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: |
|---|---|---|---|
| $V = k\frac{Q}{r}$. | $V = \frac{EPE}{Q}$ | $E = k\frac{\lvert Q\rvert}{r^2}$ | $\vec{E} = -\frac{\Delta V}{\Delta X}$ |

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

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 = τ = RC, Discharging Equations: $q = q_0 e^{-\frac{t}{RC}}$ $V = V_0 e^{-\frac{t}{RC}}$

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I. Select the correct answer for the following multiple-choice questions and write your answer in the line next to the question number. Show your work for 10, 15, & 18. 25

C 1. What is the SI unit for *electromotive force*?
d 2. What is the SI unit for the RC time constant?
Answers for 1,2
a. newton b. coulomb c. volt d. second e. farad f. ohm

f 3. Electric potential is defined as,
b 4. Electric current is defined as,
Answers for 3,4
a. Energy per unit area
b. Charge per unit time
c. Charge per unit area
d. Charge per unit volume
e. Energy per unit time
f. Energy per unit charge

d 5. The *kilo-watt-hour* is a unit for
a. Force b. Charge c. Power d. Energy e. Voltage

6-7) An appliance draws a current of 600 mA when connected to a 120-volt outlet.
d 6. What is the resistance of the appliance in SI unit?
C 7. What is the power of the appliance in SI unit?
Answers for 6,7
a. 0.2 b. 5 c. 72 d. 200 e. 2000 f. 72,000

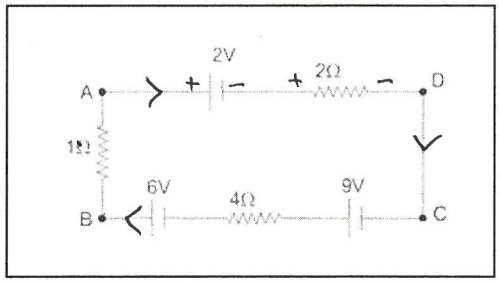
B 8. In a string of Christmas tree lights, when one of the bulbs is removed, rest of the bulbs stay on. In this string, bulbs are connected in:
A. Series B. Parallel

C 9. Which one of the following biomedical applications deals with the brain?
a. EKK b. ECG c. EEG d. ERG e. CEG

3 10. Show the direction of current for the circuit shown in the diagram below?

f 11. Determine the magnitude of the current for the circuit shown?
a. 0.14 A b. 0.71 A c. 0.83 A
d. 2.2 A e. 2.4 A f. 1.86

$I = \frac{\Sigma V}{\Sigma R} = \frac{13}{7}$




f 12. What is the potential difference, $V_A - V_C$?
a. 0.55 volt b. 9.0 volt c. 1.2 volt
d. 8.0 volt e. 2.3 volt f. 5.71 volt

$V_A - 2 - 2 \times (1.86) = V_C$
$V_A - 2 - 3.71 = V_C$
$V_A - V_C = 2 + 3.71 = 5.71$

25

a 13. Three resistors with different resistances are connected in series and then the combination is connected to a 6V battery. Which one of the following is the same across all the resistors?

a. Current b. Voltage c. Charge d. Resistance e. Capacitance

$R = \rho L / A$

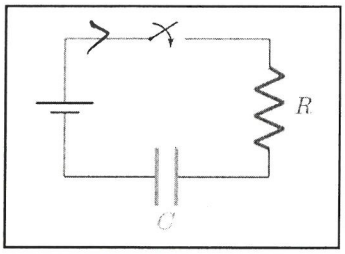
L, R

1/3 L, 3 A → 1/9

f 14. A single strand of nichrome wire has length, L and resistance, R. What will be the resistance if this wire is folded into a thicker wire of 3 strands?

a. 9R b. 4R c. 3R d. R e. R/4 f. R/9

15-18) A 12-V battery, capacitor (uncharged), resistor, and switch are connected in series as shown below.




15. Show the current in the diagram soon after the switch is closed.

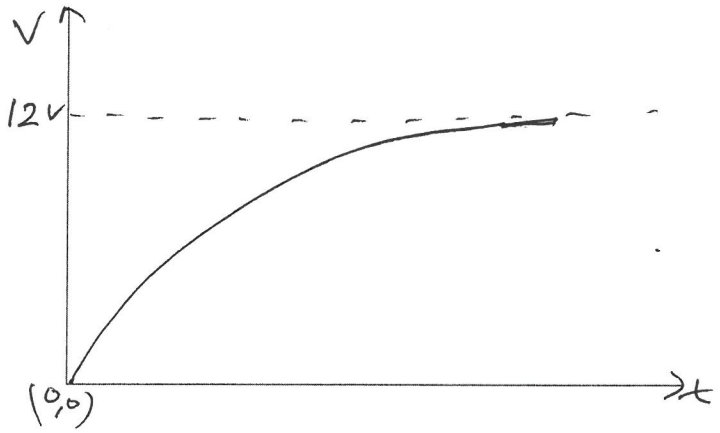
a 16. What will be the potential difference across the capacitor at the instant, the switch is closed?

e 17. What will be the potential difference across the capacitor after a long time, from the instant the switch is closed?

Answers for 19 & 20

a. 0 b. 4V c. 6 V d. 8V e. 12V

18. Sketch the potential difference (voltage) across the capacitor as a function of time:




II. A 70-inch smart tv consumes 110-W of power while on. Estimate the yearly cost of electricity for using it for 90 minutes (1.5h) a day, 22 days a month. Assume a cost of 14 cents per kWH.

110 W = 0.110 kW

# of hrs = 1.5 × 22 × 12 = 396 H

kwh → 0.110 kW × 396 H = 43.56 kWH

cost = 43.56 × $0.14

cost = $6.10

III. An electric heater that draws 0.75 A current when connected to a 120-V outlet is used to heat a 0.15 kg liquid at 19°C. If it takes 75 seconds for a final temperature of 65°C, what is the specific heat of the liquid?

$$IVt = mc\Delta T$$

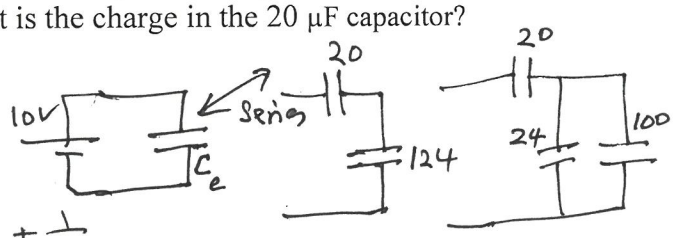
$$0.75 \times 120 \times 75 = 0.15 \times c \times (65-19)$$

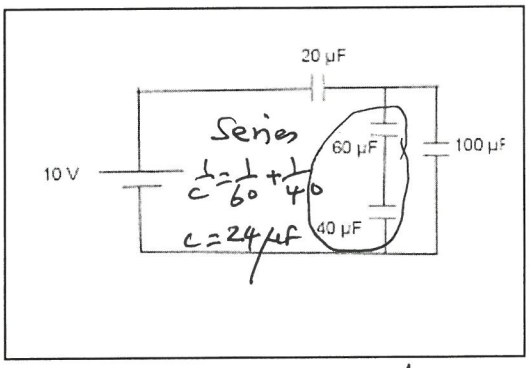
$$6750 = 0.15 \times c \times 46$$

$$\frac{6750}{0.15 \times 46} = c = 978 \ J/kg.C^\circ$$

Specific heat: $c = 978 \ \frac{J}{kg.C^\circ}$

IV. a. What is the equivalent capacitance of all the capacitors in the circuit below?
b. What is the charge in the 20 μF capacitor?




$$\frac{1}{C_e} = \frac{1}{20} + \frac{1}{124}$$

a. $C_e = 17.2 \ \mu F$

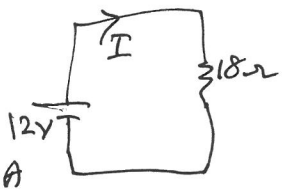
$$Q_e = C_e \cdot V = 17.2\mu \times 10 = 172 \ \mu C$$

Since 20 & 124 are in Series, each one will have the same charge.

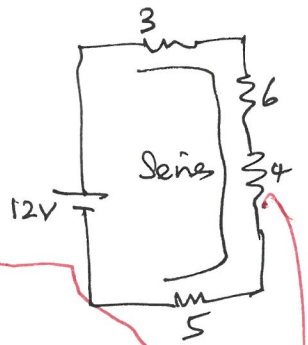
b. 172 μC

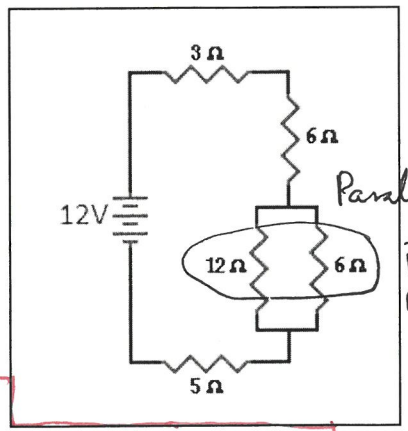
V. a. What is the equivalent resistance of all the resistances in the circuit below?
b. What is the voltage across the 12- ohm resistance?

a. 18Ω




(b) $I = \frac{12}{18} = \frac{2}{3} A$




$$V_{12\Omega} = 12 - V_3 - V_6 - V_5$$

$$= 12 - 3 \times \frac{2}{3} - 6 \times \frac{2}{3} - 5 \times \frac{2}{3}$$

$$= 12 - 2 - 4 - 3.33$$

$V_{12\Omega} = 2.67$ volt

OR

$V_4 = V_{12\&6} = 4 \times \frac{2}{3} 3$

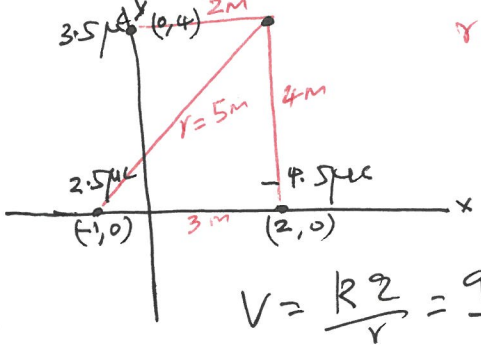
$V_4 = 2.67$ volt

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

1. Identify electric potential as a vector or scalar and state its SI unit.

scalar, volt

2. Three-point charges lie in a Cartesian coordinate system as follows:
+2.5 μC at (-1 m, 0), –4.5 μC at (2 m, 0), and 3.5 μC at (0, 4 m).
a. Show the location of the charges in the coordinate system.
b. Show the distance between each of the charges and the point (2 m, 4 m).
c. Find the net electric potential at (2 m, 4 m). Coulomb constant = k = 9 x $10^9$ (SI).




$r = \sqrt{3^2+4^2} = \sqrt{25} = 5m$

$V = \frac{kq}{r} = \frac{9\times10^9 \times 3.5\times10^{-6}}{2} + \frac{9\times10^9 \times 2.5\times10^{-6}}{5} - \frac{9\times10^9 \times 4.5\times10^{-6}}{4}$

$V = 15.75\times10^3 + 4.5\times10^3 - 10.125\times10^3$

$V = 10.125\times10^3$ volt

VII. Kirchhoff's Rules.

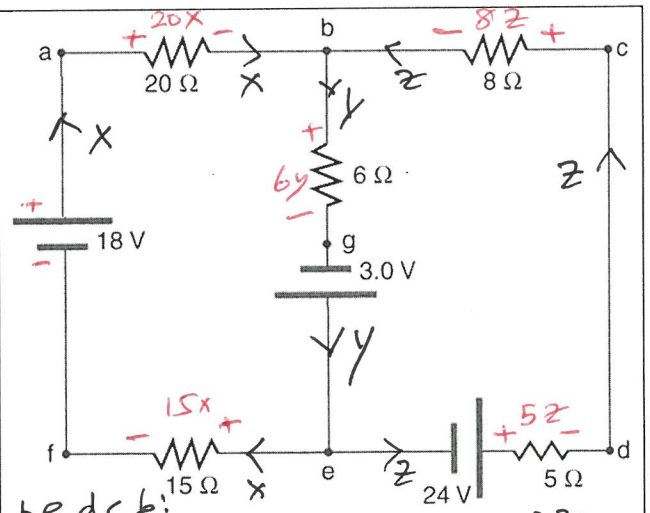
For the circuit shown:
1. Assign unknown currents.
2. Identify the low and high potentials for the resistors and batteries.
3. Write down the potential differences across the resistors in terms of the assigned currents and the given resistance values.
4. Write down the junction rule equation using the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

$X + Z = Y$

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

abefa: $18 + 3 = 20X + 6y + 15X$

$21 = 35X + 6y$




bedcb: $3 + 24 = 6y + 5z + 8z$

$27 = 6y + 13z$