Physics 2145 Spring 2022 Test 2 (4 pages)

Name: Solution **March 16, 2022** **Total Score:** 120 /120

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e = 1.602 x 10^{-19} C $\quad I = \frac{\Delta q}{\Delta t}$ $\quad I = \frac{V}{R}$ $\quad R = \rho\frac{L}{A}$ $\quad P = IV = \frac{V^2}{R} = I^2R$

series: $R_{eq} = \sum_i R_i$ $\quad$ parallel: $\frac{1}{R_{eq}} = \sum_i \frac{1}{R_i}$ $\quad C = \frac{Q}{V}$

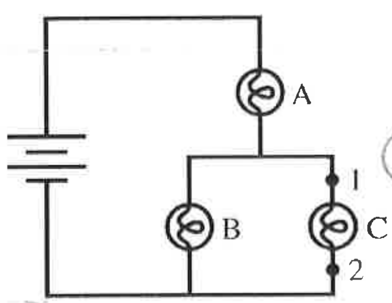
Discharging $\quad Q = Q_0 e^{-\frac{t}{RC}}$ $\quad I = I_0 e^{-\frac{t}{RC}}$ $\quad V_C = V_{C0} e^{-\frac{t}{RC}}$

Charging $\quad Q = Q_f\left(1 - e^{-\frac{t}{RC}}\right)$ $\quad I = I_0 e^{-\frac{t}{RC}}$ $\quad V_C = V_{Cf}\left(1 - e^{-\frac{t}{RC}}\right)$

B 1. (5) To simultaneously measure the current in a resistor and the voltage across the resistor, you must place an ammeter in ________ with the resistor and a voltmeter in __________ with the resistor.

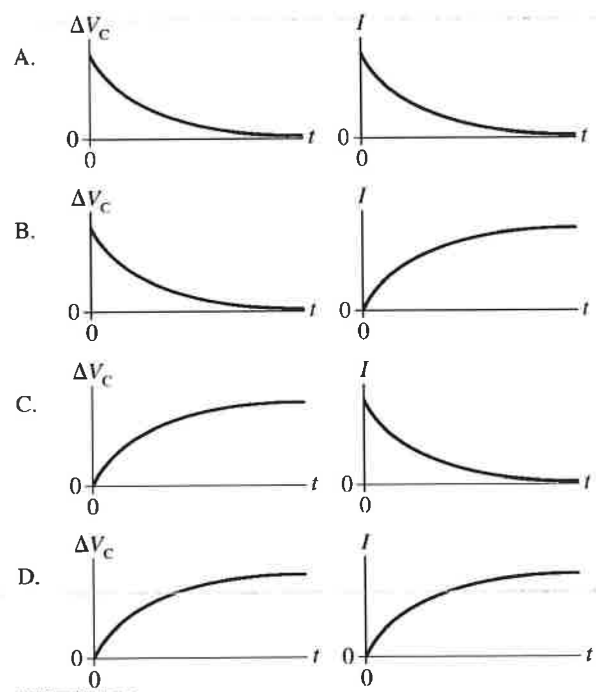
A) series, series
B) series, parallel
C) parallel, series
D) parallel, series

D 2. (5) The three bulbs in the circuit below are identical. Which of the following is true?



A) $V_A = V_B$
B) $I_A = I_B$
C) $V_A < V_B$
D) $V_A > V_B$

A 3. (5) A capacitor is discharged through a resistor. Which of the graphs at the right represent best the capacitor voltage and the current?



B 4. (5) A capacitor is discharged through a resistor. After 50 ms, the current has fallen to one third of its initial value. The circuit's time constant is approximately

A) 17ms B) 45 ms C) 55 ms D) 150 ms

τ: I = 37% I_0
37% later than 33%

20/20 points for this page

5. (20) A copper wire of diameter 1.0mm and length 20cm carries a current of 3.0A. The resistivity of copper is $1.7\times10^{-8}\ \Omega m$.

a) (5) Calculate the resistance of the wire.

$$R = \rho \frac{L}{A} = 1.7\times10^{-8}\ \Omega m \ \frac{0.2m}{\frac{\pi}{4}(10^{-3}m)^2} = 4.3\times10^{-3}\ \Omega$$

b)(5) Calculate the potential difference between the ends of the wire.

$$I = \frac{V}{R} \qquad V = IR = 0.013\ V = 13\ mV$$

c)(5) Calculate the power dissipated in the wire.

$$P = I^2R = 0.039W$$

d) (5) How many electrons per second pass through the cross section of the wire?

$$I = \frac{\Delta q}{\Delta t} = \frac{Ne}{\Delta t}$$

$$N = \frac{I\Delta t}{e} = \frac{3A\cdot 1s}{1.6\times10^{-19}C} = 1.875\times10^{19}$$

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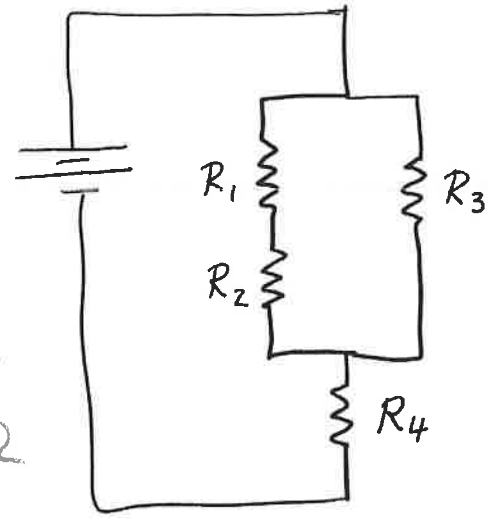
6. a) (20) In the circuit in the figure, R_1=5 Ω, R_2= 15Ω, R_3=30Ω, and R_4=8Ω. Find the equivalent resistance of the circuit.



Series: $R_1 + R_2 = 5\,\Omega + 15\,\Omega = 20\,\Omega$

Parallel: $\frac{1}{R_{123}} = \frac{1}{R_{12}} + \frac{1}{R_3} = \frac{1}{20\,\Omega} + \frac{1}{30\,\Omega} = \frac{3+2}{60\,\Omega}$ $R_{123} = 12\,\Omega$

Series: $R_{eq} = R_{123} + R_4 = 12\,\Omega + 8\,\Omega$

$\boxed{R_{eq} = 20\,\Omega}$

b) (20) The battery provides a potential difference of 60V. Calculate the total current. Calculate the potential drop across each of the resistors and the current through each resistor. Put the answers in the table below.

$I_{tot} = \frac{V_{bat}}{R_{eq}} = \frac{60V}{20\,\Omega} = 3A$

All current through $R_4 \rightarrow V_4 = R_4 I_4 = 8\,\Omega \cdot 3A = 24V$

Leaves $60V - 24V = 36V$ for (123)

R_3 sees $36V \rightarrow I_3 = \frac{V_3}{R_3} = \frac{36V}{30\,\Omega} = 1.2A$

This leaves $3A - 1.2A = 1.8A$ for 1&2

$V_1 = I_1 R_1 = 1.8A \cdot 5\,\Omega = 9V$

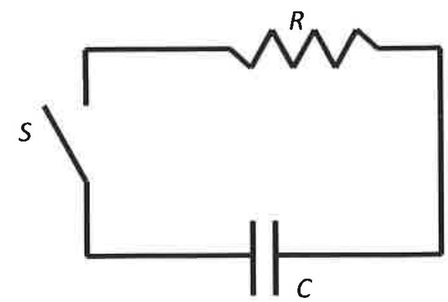
$V_2 = I_2 R_2 = 1.8A \cdot 15\,\Omega = 27V$

adds: 36V correct

I total = 3A	
V_1= 9V	I_1= 1.8A
V_2= 27V	I_2= 1.8A
V_3= 36V	I_3= 1.2A
V_4= 24V	I_4= 3A

40 /40 points for this page

7) (40) A capacitor of capacitance C= 3 μF has been charged so that the potential difference between its plates is 120 V. The capacitor is then connected to an 8 k Ω resistor as shown. The switch *S* is closed and the capacitor begins to discharge.



a)(5) Calculate the time constant of the circuit.

$\tau = RC = 8\times10^{3}\,\Omega \cdot 3\times10^{-6}\,F = 24\times10^{-3}\,s$
$= 24\,ms$

b) (5) Determine the charge on the capacitor when the switch is closed at *t*=0.

$C = \frac{Q}{\Delta V}$ $\quad Q = C\Delta V = 3\mu F \cdot 120\,V = 360\,\mu C$

c)(5) Calculate the current through the resistor immediately after the switch is closed.

$I_0 = \frac{\Delta V}{R} = \frac{120\,V}{8\times10^{3}\,\Omega} = 15\,mA$

d)(10) Calculate the current 15 ms after the switch is closed.

$I = I_0 e^{-\frac{t}{RC}} = 15\,mA\, e^{-\frac{15\,ms}{24\,ms}} = 8\,mA$

e) (15) Calculate the time after which the potential difference between the capacitor plates has decreased to one fifth its maximum value.

$\Delta V = \Delta V_{C_0} e^{-\frac{t}{RC}}$

$\frac{1}{5}\Delta V_{C_0} = \Delta V_{C_0} e^{-\frac{t}{RC}}$

$\frac{1}{5} = e^{-\frac{t}{RC}}$

$\ln\frac{1}{5} = -\frac{t}{RC}$

$t = -RC\ln\frac{1}{5} = RC\ln 5$

$t = 38.6\,ms$

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