Exam Total	
	/200

PHYS 2135 Exam II
October 15, 2019

Name: _____ Section: _____

For questions 1-5, select the best answer. For problems 6-9, solutions must begin with an Official Starting Equation, when appropriate. Work for problems must be shown and answers provided in the given boxes. Calculators are not allowed.

(8) A **1.** A 30 W light bulb and a 60 W are connected in series across a low-voltage power line. Which statement is true?
[A] The two bulbs draw the same current.
[B] The 30 W bulb draws a larger current than the 60 W bulb.
[C] The 60 W bulb draws a larger current than the 30 W bulb.
[D] This question cannot be answered without knowing the value of the voltage.

(8) B **2.** A fully charged parallel-plate capacitor is connected to a resistor R to form a resistor-capacitor (RC) circuit. Which of the following is true?
[A] The charge on the plates increases and the voltage across the capacitor increases.
[B] The charge on the plates decreases and the voltage across the capacitor decreases.
[C] The charge on the plates remains constant, but the voltage across the capacitor increases.
[D] The charge on the plates remains constant, but the voltage across the capacitor decreases.

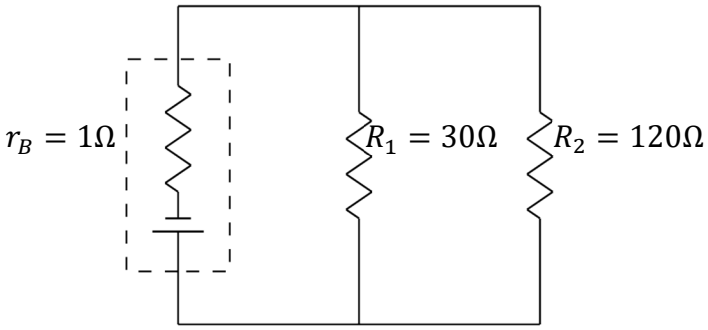
(8) C **3.** To build a circuit you need a 1.5-Ohm resistor, but you only have at your disposal a box of 1-Ohm resistors. How do you combine three 1-Ohm resistors to make a 1.5-Ohm resistor?
[A] All three resistors in series.
[B] One resistor in parallel with two resistors connected in series.
[C] One resistor in series with two resistors connected in parallel.
[D] All three resistors in parallel.

(8) D **4**. A proton and an electron enter into a region of constant magnetic field $\vec{B}$ with a velocity $\vec{v}$ oriented perpendicular to $\vec{B}$. Which of the following statements describes the circular orbits of the two particles?
[A] The two orbits have the same radius and same direction.
[B] The two orbits have the same radius, but different direction.
[C] The two orbits have different radius, but same direction.
[D] The two orbits have different radius and different direction.

(8) _____ **5** (Free). How many ears does Captain Kirk of the Star Trek Enterprise have:
[A] Two (his left ear and his right ear).
[B] One (only his left ear because a Gorn ate his right ear).
[C] One (only his right ear because a tribble nibbled his left ear).
[D] Three (his left ear, his right ear and his final front ear).

/40

6. A 10V battery with an internal resistance $r_B = 1.0\Omega$ is connected to two resistors $R_1 = 30\Omega$ and $R_2 = 120\Omega$ as illustrated.



(value) (units)

(10) (a) Determine the total resistance of the circuit including the internal resistance of the battery.

$$R_{12} = \left(\frac{1}{R_1} + \frac{1}{R_2}\right)^{-1} = \left(\frac{1}{30\Omega} + \frac{1}{120\Omega}\right)^{-1} = 24\Omega$$

$$R_T = R_{12} + r_B = 24\Omega + 1\Omega = 25\Omega$$

$R_T = 25\Omega$

(10) (b) Determine the total current through the circuit.

$$I_T = \frac{\mathcal{E}}{R_T} = \frac{10\text{V}}{25\Omega} = 0.4\text{A}$$

$I_T = 0.4\text{A}$

(10) (c) Determine the current through R_1.

$$V_1 = \mathcal{E} - V_r = \mathcal{E} - I_T r_B = 10\text{V} - (.4\text{A})(1\Omega) = 9.6\text{V}$$

$$I_1 = \frac{V_1}{R_1} = \frac{9.6\text{V}}{30\Omega} = 0.32\text{A}$$

$I_1 = 0.32\text{A}$

(10) (d) Determine the rate at which chemical energy is converted into electrical energy.

$$P_{\mathcal{E}} = I_T \mathcal{E} = (.4\text{A})(10\text{V}) = 4\text{W}$$

$P_{\mathcal{E}} = 4\text{W}$

/40

7. A light bulb is connected across a 100V source. When it is first turned on at $20℃$ it dissipates a power of 100W. After several minutes, the light bulb filament reaches its operating temperature of $3000℃$. The light bulb filament has a temperature coefficient of resistivity of $\alpha = 1/2980(℃)^{-1}$. [You may neglect thermal expansion of the filament.]

(value) (units)

(8) (a) Calculate the initial current passing through the $20℃$ filament.

$I_0 = 1.0\text{A}$

OSE: P = IV
$I_0 = P_0 / V = 100\text{ W} / 100\text{ V} = 1.0\text{ A}$

Or OSE: V = IR, $P = V^2 / R$
$R_0 = V^2 / P_0 = 100^2 / 100 = 100$ ohm
$I_0 = V / R_0 = 100\text{ V} / 100\text{ ohm} = 1.0\text{ A}$

(8) (b) Calculate the resistance of the $20℃$ filament

$R_0 = 100\Omega$

OSE: $P = V^2 / R$, $R_0 = V^2 / P_0 = 100^2 / 100 = 100$ ohm

(8) (c) Calculate the resistance of the $3000℃$ filament

$R_f = 200\Omega$

OSE: $R_f = R_0(1 + \alpha(T_f - T_0))$

$R_f = R_0(1 + \alpha(T_f - T_0)) = 100(1 + (1/2980)(3000 - 20)) = 200$ ohm

(8) (d) Calculate the power dissipated by the $3000℃$ bulb.

$P_f = 50\text{W}$

OSE: $P = V^2 / R$, $P_f = V^2 / R_f = 100^2 / 200 = 50$ W

Or: $P = I^2R$, $I_f = V / R_f = 100 / 200 = 0.5$ A. $P_f = (0.5^2)(200) = 200/4 = 50$ W

Or: $P = P_0 / (1 + \alpha(T_f - T_0)) = 100 / (1 + (1/2980)(3000\text{-}20)) = 50$ W

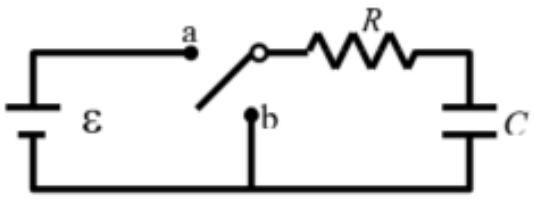
(8) (e) Calculate the current passing through the $3000℃$ filament.

$I_f = 0.5\text{A}$

OSE: P = IV, $I_f = P_f / V = 50 / 100 = 0.5$ A
or OSE: V = IR, $I_f = V / R_f = 100 / 200 = 0.5$ A

/40

8. In the circuit shown with a resistance R, capacitance C, a switch S, and a battery with an emf $\mathcal{E}$, the capacitor is initially uncharged. Ignore the internal resistance of the battery.



(8) (a) What is the initial current through the resistor immediately after the switch is set to position "*a*"?

$$\mathcal{E} - I_0 R + 0 = 0$$

$$I_0 = \frac{\mathcal{E}}{R}$$

$I_0 = \frac{\mathcal{E}}{R}$

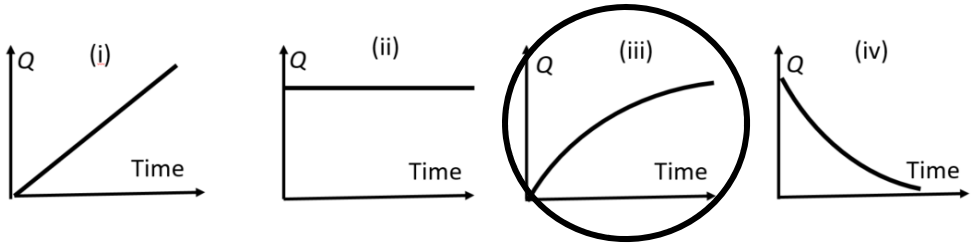
(8) (b) What will be the charge on the capacitor a long time after the switch is moved to position "*a*"?

$$\mathcal{E} - IR + V_C = 0$$

$|V_C| = \mathcal{E}$ $\quad Q_f = CV = C\mathcal{E}$

$Q_f = C\mathcal{E}$

(8) (c) Which of the plots below best represents the charge on the capacitor as a function of time after the switch is moved to position "*a*"? (**circle one**)



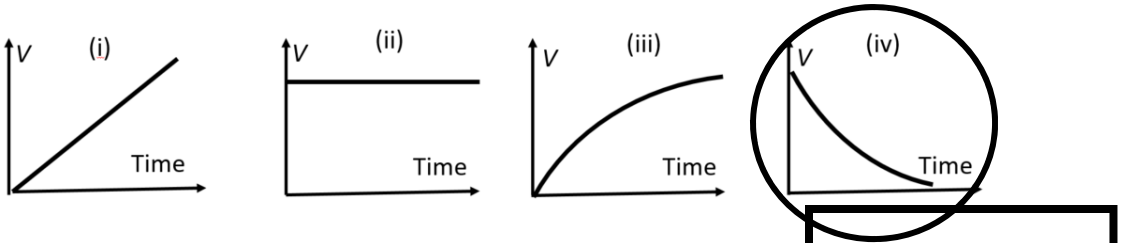
(8) (d) After the capacitor is fully charged, the switch is set to position "*b*". How much time is required for the charge on the capacitor to drop by a factor of $1/e$?

$$Q = Q_0 e^{-t/RC}$$

$\frac{Q}{Q_0} = e^{-t/RC} = \frac{1}{e}$ $\quad \frac{t}{RC} = 1$ $\quad t = RC$

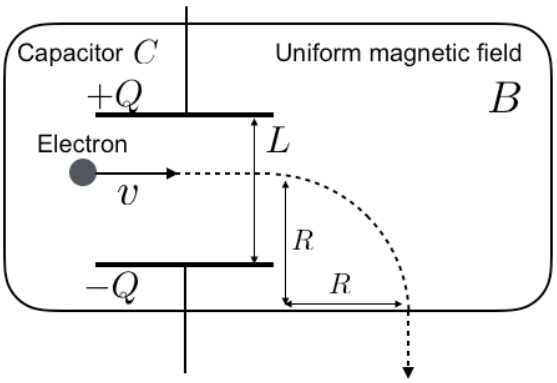
$t = RC$

(8) (e) Which of the plots below best represents the voltage across the resistor as a function of time after the switch is set to position "*b*"? (**circle one**)



/40

9. A parallel plate capacitor with a distance L and a capacitance of C is charged with Q. The capacitor is placed in a uniform magnetic field B. An electron (charge $-e$, mass m) enters into the capacitor with a speed of v, and passes undeflected as shown. Express your answers using given symbols.



(10) (a) Determine the magnitude and the direction of the electric field in the capacitor.

$V = \frac{Q}{C}$ $\Delta V = -\int \vec{E} \cdot d\vec{s}$ $V = |EL|$

$$E = \frac{V}{L} = \frac{Q}{CL}$$

$E = \frac{Q}{CL}$

Direction. Circle one: (up) (down) (left) (right)

(10) (b) Determine the magnitude and the direction of the magnetic force acting on the electron. Express your answer using *B*.

$F_B = evB$

$$\vec{F}_B = q\vec{v} \times \vec{B}$$

Direction. Circle one: (up) (down) (into the page) (out of the page)

(10) (c) Determine the magnitude and the direction of the magnetic field. Express your answer using *E*.

$B = \frac{E}{v}$

$\vec{F}_B = -\vec{F}_E = -q\vec{E}$ $eE = evB$ $B = \frac{E}{v}$

Direction. Circle one: (up) (down) (into the page) (out of the page)

(10) (d) After passing the capacitor, the electron experiences a quarter circular motion as shown. Determine the radius of the motion. Express your answer using *B*.

$r = \frac{mv}{eB}$

$\frac{mv^2}{r} = F_r = evB$ $r = \frac{mv}{eB}$

/40