PHYS 1320 (Spring 2024) Sonnenfeld Online HW #6: current

Problem 1: Consider a circuit consisting of several resistors connected in series.
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Which of the following statements are true about this situation?
MultipleChoice :

1) Current flowing through each of them is the same.
2) Power dissipated on each of them is the same.
3) It is impossible to answer without knowing the actual magnitude of resistors.
4) Voltage drop on each of them is the same.

Problem 2: A power source supplies a prescribed voltage and is used to power a light bulb.
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If another light bulb is connected in parallel to the first how would it affect the current in the power source?
MultipleChoice :

1) The current would remain the same.
2) The current would decrease.
3) The current would increase.
4) Cannot be Determined.

Problem 3: Suppose you have a 9.00 V battery, a ***2.6*** µF capacitor, and a ***8.25*** µF capacitor.
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Part (a) Find the total charge stored in the system if the capacitors are connected to the battery in series in C.
Numeric : A numeric value is expected and not an expression.
Q = _____

Part (b) Find the energy stored in the system if the capacitors are connected to the battery in series in J.
Numeric : A numeric value is expected and not an expression.
U_s = _____

Part (c) Find the charge if the capacitors are connected to the battery in parallel in C.
Numeric : A numeric value is expected and not an expression.
Q = _____

Part (d) Find the energy stored if the capacitors are connected to the battery in parallel in J.
Numeric : A numeric value is expected and not an expression.
U_p = _____

Problem 4: An extension cord that has a length of $6.25\ \text{m}$ is made from wire with a resistivity of $9.34 \times 10^{-8}\ \Omega \cdot \text{m}$ and a diameter of $0.617\ \text{cm}$.
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Part (a) What is the resistance, in ohms, of the extension cord?
Numeric : A numeric value is expected and not an expression.
R = _____ Ω

Part (b) If a current of $2.21\ \text{A}$ passes through the wire, then what is the voltage, in volts, between the ends of the extension cord?
Numeric : A numeric value is expected and not an expression.
V = _____ V

Problem 5: An alkaline battery with an emf ε = ***1.6*** V has an internal resistance r = ***0.475*** Ω. A multimeter is used to measure the voltage across a R = 1.00-kΩ load resistor connected across the terminals of the battery as shown.
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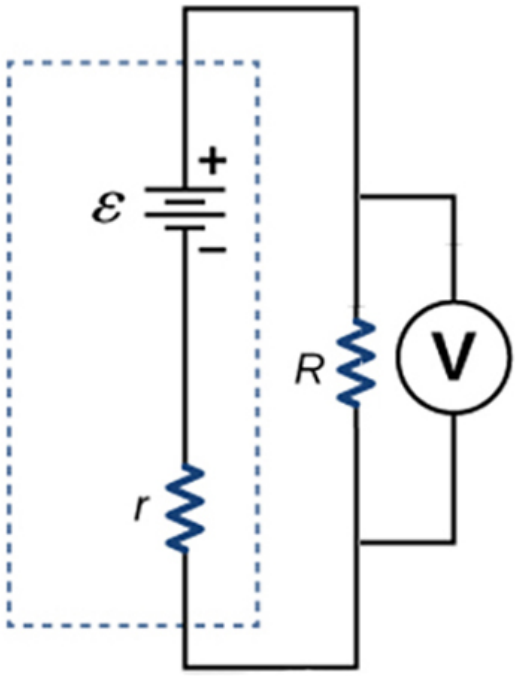

Part (a) Write an expression for the current that flows through the load resistor?
Expression :
I = _____

Select from the variables below to write your expression. Note that all variables may not be required.
β, **ε**, **γ**, **θ**, **d**, **g**, **h**, **j**, **k**, **m**, **n**, **P**, **r**, **R**, **V**

Part (b) What is the measured terminal voltage in volts?
Numeric : A numeric value is expected and not an expression.
V = _____ V

Problem 6: A man foolishly tries to fish a burning piece of bread from a toaster with a metal butter knife and creates a V = ***122.5*** V path through his body to the ground. He does not even feel it since, luckily, he is wearing rubber-soled shoes.
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If the maximum current a human can experience without feeling it is I = 1.00 mA, what is the minimum resistance in ohms of the path that the current follows though the person?
Numeric : A numeric value is expected and not an expression.
R = _____ Ω

Problem 7: A car battery has an internal resistance of r = ***0.029*** Ω. It is connected to a starter requiring I = ***93*** A and it has an internal EMF of ε = 12 V

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Part (a) Input an expression for the voltage across the terminals when the starter is operating.
Expression :
V = _____

Select from the variables below to write your expression. Note that all variables may not be required.
α, **β**, **ε**, **π**, **θ**, **d**, **g**, **h**, **I**, **j**, **k**, **m**, **P**, **r**, **t**

Part (b) What is the voltage in volts?
Numeric : A numeric value is expected and not an expression.
V = _____ V

Part (c) On an especially cold day the starter requires more current, I_n = 150 A, but the metallic battery's internal resistance decreases to $r_n = 0.9r$. What is the new terminal voltage in V?
Numeric : A numeric value is expected and not an expression.
V_n = _____ V

Problem 8: The gap between the plates of a parallel-plate capacitor is filled with three equal-thickness layers of mica, paper, and a material of unknown dielectric constant. The area of each plate is ***110*** cm^2 and the capacitor's gap width is ***3.5*** mm. The values of the known dielectric constants are K_{mica} = ***6.5*** and K_{paper} = ***3.75***. The capacitance is measured and found to be ***110*** pF.

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Find the value of the dielectric constant of the unknown material.
Numeric : A numeric value is expected and not an expression.
$K_{unknown}$ = _____

Problem 9: Four identical resistors are connected to a battery in series.

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If current of 8 A flows through this battery, the current through each resistor is:
MultipleChoice :

1) It is impossible to guess without knowing of the voltage and value of resistance.
2) 2 A
3) 8 A
4) Zero
5) 4 A

Problem 10: A cell phone battery uses chemistry to create a charge separation between the terminals (anode and cathode). Such a battery is listed as having a capacity of Q = ***8500*** C.
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Part (a) If this charge separation consisted entirely of free electrons, how many free electrons would be present in the battery?
Numeric : A numeric value is expected and not an expression.
N = _____

Part (b) If the operation of the cellphone requires that ***1.2*** × 10^{18} electrons move through the circuit every second, how long will a full charge of the battery last, in seconds?
Numeric : A numeric value is expected and not an expression.
t = _____ s

Part (c) What current I, in amperes, is passing through the phone?
Numeric : A numeric value is expected and not an expression.
I = _____ A

Problem 11: A piece of ***14***-gauge copper wire has a length of ***7.25*** m. The tables provided may be a convenient source of data.

Wire diameter d for select gauges in the AWG (American Wire Gauge) system.

gauge	0	2	4	6	8	10	12	14	16	18	20
d (mm)	8.251	6.544	5.189	4.115	3.264	2.588	2.053	1.628	1.291	1.024	0.812

Conductivity (σ), resistivity (ρ), and temperature coefficient of resistivity (α) at $20^\circ\mathrm{C}$ for select materials.

material	$\sigma\ (1/(\Omega\cdot\mathrm{m}))$	$\rho\ (\Omega\cdot\mathrm{m})$	$\alpha\ (^\circ\mathrm{C}^{-1})$
conductors			
silver	6.29×10^{7}	1.59×10^{-8}	3.8×10^{-3}
copper	5.95×10^{7}	1.68×10^{-8}	3.9×10^{-3}
gold	4.10×10^{7}	2.44×10^{-8}	3.4×10^{-3}
aluminum	3.77×10^{7}	2.65×10^{-8}	3.9×10^{-3}

tungsten	1.79×10^{7}	5.60×10^{-8}	4.5×10^{-3}
iron	1.03×10^{7}	9.71×10^{-8}	6.5×10^{-3}
constantan	0.20×10^{7}	49.0×10^{-8}	0.03×10^{-3}
mercury	0.10×10^{7}	98.0×10^{-8}	0.9×10^{-3}
nichrome	0.10×10^{7}	$100. \times 10^{-8}$	0.4×10^{-3}
semiconductors	(Values for semiconductors depend strongly on type and amount of impurities.)		
carbon (pure)	2.86×10^{-6}	3.50×10^{-5}	-0.5×10^{-3}
germanium (pure)		0.60	-0.048
silicon (pure)		2300	-0.075

What is the resistance, in ohms, of the given length of wire?
Numeric : A numeric value is expected and not an expression.
R = _____ Ω

Problem 12: The charge on a capacitor in a circuit is given by

$$q(t) = q_{\max} \cos(\omega t + \phi)$$

Enter an expression for the current flowing into the capacitor as a function of time.
Expression :
$I(t)$ = _____

Select from the variables below to write your expression. Note that all variables may not be required.
cos(ωt−φ), **cos(ωt+φ)**, **$e^{-\omega t-\varphi}$**, **$e^{-\omega t+\varphi}$**, **$e^{\omega t-\varphi}$**, **$e^{\omega t+\varphi}$**, **sin(ωt−φ)**, **sin(ωt+φ)**, **ε_0**, **μ_0**, **ω**, **g**, **ln(ωt−φ)**, **ln(ωt+φ)**, **q_{max}**

Problem 13: A power source supplies a prescribed voltage and is used to power a light bulb.

If another light bulb is connected in series to the first how would it affect the current in the power source?
MultipleChoice :

1) The current would increase.
2) The current would remain the same.
3) The current would decrease.
4) Cannot be Determined.

Problem 14: You take two electric bulbs. Bulb #1 is marked 20W and bulb #2 is 50W. They are designed to be used with usual household voltage.
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If you connect these bulbs in series to an outlet, which of the following is true?
MultipleChoice :

1) Bulb #2 produces greater illumination.
2) It is impossible to answer without knowing what is the voltage of battery.
3) Both bulbs produce the same illumination.
4) Bulb #1 produces greater illumination.

Problem 15: Suppose the operating resistance of a flashlight bulb is ***2.3*** Ω, and it is powered by a ***1.55*** V alkaline cell having a ***0.095*** Ω internal resistance.
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Part (a) What is the current, *I*, in amperes?
Numeric : A numeric value is expected and not an expression.
I = _____

Part (b) How much power, *P*, in watts, is being supplied to the bulb?
Numeric : A numeric value is expected and not an expression.
P = _____

Problem 16: Consider the three resistors R_1 = *17* Ω, R_2 = *54* Ω, and R_3 = *75* Ω in the configuration shown in the figure. A potential difference ΔV = *4.5* V is applied between A and B.

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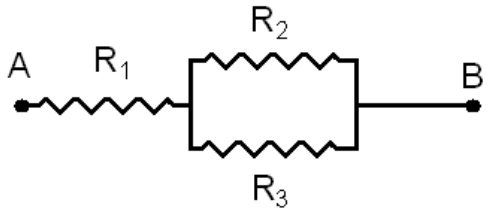

Part (a) Calculate the numerical value of the total resistance R of this circuit, in ohms.
Numeric : A numeric value is expected and not an expression.
R = _____

Part (b) Calculate the numerical value of the current I traveling from A to B, in amperes.
Numeric : A numeric value is expected and not an expression.
I = _____

Part (c) Calculate the numerical value of I_2 traveling through the resistor R_2, in amperes.
Numeric : A numeric value is expected and not an expression.
$\boldsymbol{I_2}$ = _____

Part (d) Calculate the numerical value of I_3 traveling through the resistor R_3, in amperes.
Numeric : A numeric value is expected and not an expression.
$\boldsymbol{I_3}$ = _____

Problem 17: Pictured in the circuit is a battery with emf ε and resistors R_1, R_2, and R_3, which all have the same resistance.

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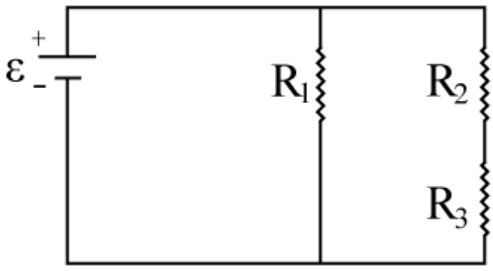

Part (a) Which resistor(s) draw(s) the most current? Choose the best answer below.
MultipleChoice :

1) R_1
2) Not enough information.
3) R_2
4) R_2 and R_3
5) All three draw the same current.
6) R_3

Part (b) Compare the current through the battery i_{batt} to the current i_1 through resistor R_1.
MultipleChoice :

1) $i_{batt} > i_1$
2) Not enough information.
3) $i_{batt} = i_1$
4) $i_{batt} \leq i_1$
5) $i_{batt} < i_1$
6) $i_{batt} \geq i_1$

Part (c) If the resistance of R_1 were increased by a factor of 2, what would happen to the current through R_2?
MultipleChoice :

1) Stay the same.
2) Not enough information.
3) Increase by a factor of 2.
4) Decrease by a factor of 2.
5) Decrease by a factor of 4.
6) Increase by a factor of 4.

Problem 18: Consider 3 resistors with resistances ***1.1*** $\times 10^2$ Ω, ***2.6*** kΩ, and ***3.8*** kΩ.
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Part (a) What would be their resistance, R_s, in kilohms, if they were connected in series?
Numeric : A numeric value is expected and not an expression.
$\boldsymbol{R_s}$ = _____

Part (b) What would be their resistance, R_p, in ohms, if they were connected in parallel?
Numeric : A numeric value is expected and not an expression.
$\boldsymbol{R_p}$ = _____