Physics 1112K
Fall 2001
MIDTERM EXAM

Name/I.D._____

Closed book exam. All questions require written answers.
Answer all problems and show all working since partial credit will be given for incomplete answers. Point value for each question is shown in parenthesis.
Two 8x11 sheets can be used to record all necessary formulae and constants. No other source of information can be consulted during exam.
Duration of exam: 1 hour.
Good Luck.

1 A cigarette lighter in a car is a resistor that, when activated, is connected across a 12 V battery. Suppose the lighter dissipates 33 W of power. Find

(A) the resistance of the lighter (**3 marks**).

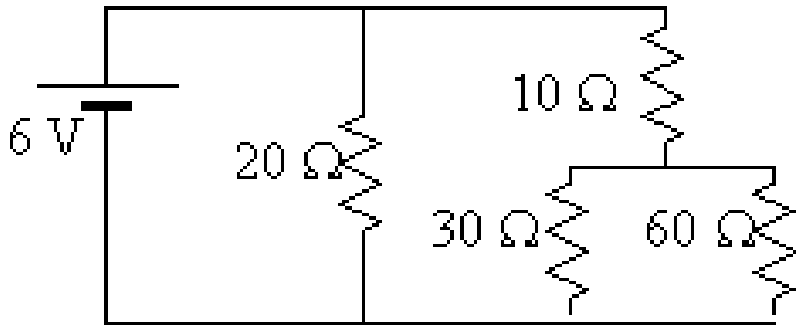
(B) the current that the battery delivers to the lighter (**3 marks**).

Solution Problem 1 Midterm. Physics 1112K Spring 2001

$$R = \frac{V^2}{P} = \frac{12V}{33W} = 4.4\Omega$$

$$I = \frac{P}{V} = \frac{33W}{12V} = 2.8A$$

2 Four resistors and a 6-V battery are arranged as shown in the circuit diagram.



A) Determine the equivalent resistance for this circuit (8 marks).
B) Calculate the potential difference across the 20 Ω resistor (2 marks).
C) Calculate the potential difference across the 60 Ω resistor (6 marks).
D) Calculate the current that passes through the 30 Ω resistor (6 marks).

Solution Problem 2 Midterm

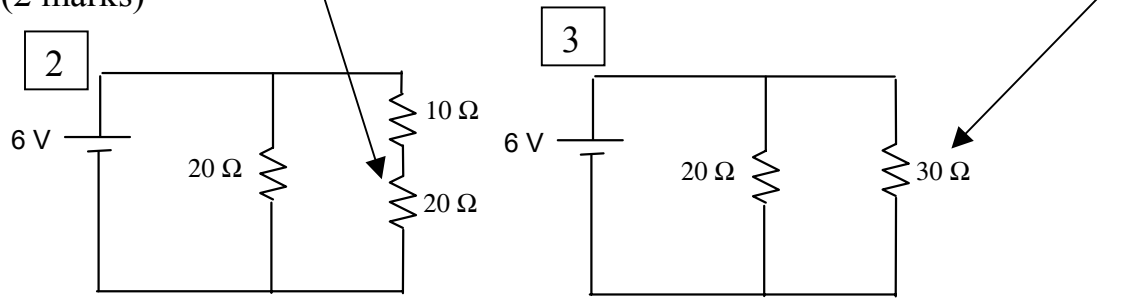
A The 60 and 30 Ω resistors are in parallel so the combined parallel resistance is

$$\frac{1}{R_P} = \frac{1}{60} + \frac{1}{30} = \frac{3}{60} = \frac{1}{20}$$

$$\Rightarrow R_P = 20\Omega$$

3 marks

The 20 and 10 Ω resistors are in series so the combined series resistance is 30 Ω (2 marks)



The 20 and 30 Ω resistors are in parallel so the combined parallel resistance is

$$\frac{1}{R_P} = \frac{1}{20} + \frac{1}{30} = \frac{5}{60} = \frac{1}{12}$$

$$\Rightarrow R_P = 12\Omega$$

(3 marks)

B The 20 Ω resistors is in parallel with the source so the voltage is the same as the source. I.e. 6 V (2 marks)

C In circuit 2 6 V are dropped across the 10 and 20 Ω resistors. That is 4 V across the 20 Ω resistor and 2 V across the 10 Ω resistor. (3 marks)

The 20 Ω resistor is a parallel combination of the 30 and 60 Ω resistors so 4 V are dropped across each
Voltage across 4 V are dropped across = 4 V(3 marks)

D 4 V are dropped across the 30 Ω resistor (3 marks)

so current,

$I_{30\,\Omega}$ = V / R = 4 V / 30 Ω = 0.13 A (3 marks)

3 An electric motor takes 8 A at 240 V. Determine (a) the power input and (b) the cost of operating the motor for 16 hours at $0.10 per kWh. **(6 marks)**

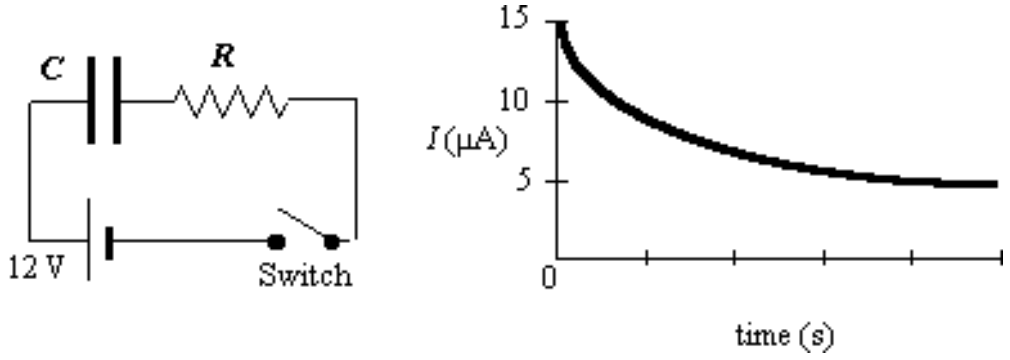
Solution

Power, P = IV = (8 A)(240 V) = 1920 W = **1.92 kW**

Energy Used in 16 hours = (1.92 kW)(16 h) = 30.72 kWh

Cost = (30.72 kWh)($ 0.1) = **$3.072**

4 An uncharged 5.0-μF capacitor and a resistor are connected in series to a 12-V battery to form a simple RC circuit as shown below at the left. The switch is closed at t = 0. The graph at the right shows the time variation of the current through the resistor. The time constant of the circuit is 4.0 s.



A Determine the value of the resistance R. (**3 marks**)

B What is the current through the resistor after one time constant has elapsed? (**3 marks**)

C Determine the maximum charge on the capacitor. (**3 marks**)

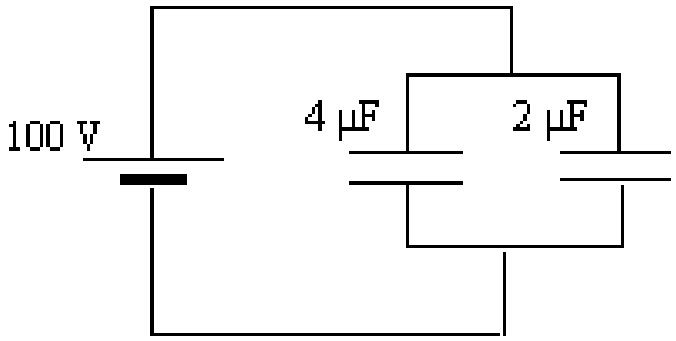
Solution

4 $\tau = RC$ so $R = \tau / C = (4\text{ s}) / (5\text{x}10^{-6}\text{ F}) = 8\text{x}10^{5}\ \Omega$

$I = I_0 e^{-1} = (15\text{x}10^{-6}\text{ A})0.36 = 5.5\ \mu\text{A}$

$Q = VC = (12\text{ V})(5\text{x}10^{-6}\text{ F}) = 6\text{x}10^{-5}\text{ C}$

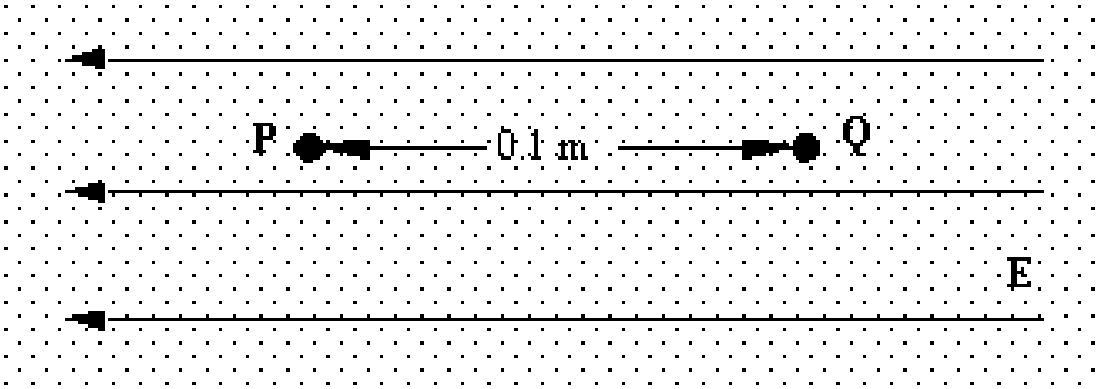
5 How much energy is stored in the combination of capacitors shown? (**5 marks**)



Solution

5 For capacitances in parallel the capacitancies add up. So the equivalent capacitance is 6 μF.
So total energy stored, $E=1/2\ CV^2 = 1/2(6x10^{-6}\ F)(100\ V) = 0.03\ J$

6 P and Q are points within a uniform electric field that are separated by a distance of 0.1 m as shown. The potential difference between P and Q is 50 V.



A Determine the magnitude of this electric field. (**3 marks**)

B How much work is required to move a +1000 μC point charge from P to Q? (**3 marks**)

Solution

$E = V / d = 50 \text{ V} / 0.1 \text{ m} = 500 \text{ V/m}$

$W = qV = (10^{-3} \text{ C})(50 \text{ V}) = 0.05 \text{ J}$

7 The characteristics of five wires are given in the following table.

Wire	Material	Length	Gauge
A	iron	2.0 m	#22
B	copper	2.0 m	#22
C	copper	2.0 m	#18
D	copper	1.0 m	#18
E	iron	2.0 m	#18

The gauge is a measure of the diameter of the wire:
#18 guage corresponds to a diameter of 1.2×10^{-3} m.
#22 guage corresponds to a diameter of 6.4×10^{-4} m.
The resistivity, ρ, of iron is: 9.7×10^{-8} Ω m.
The resistivity, ρ, of copper is: 1.72×10^{-8} Ω m.

A Which of the five wires has the largest resistance? Explain in detail. (**3 marks**)
B Of the five wires, which has the smallest resistance? Explain in detail. (**3 marks**)
C Which one of the wires carries the smallest current when they are connected to identical batteries? (**3 marks**)

Solution

7 $R = \rho L / A$

For this problem NO calculation is required.

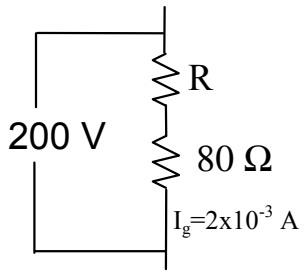
Highest resistance for thinest wires.
That is the #22 guage wire will have largest resistance.
In addition, highest resistance for longest wires.
So the 2 m long, 22 guage wires will have largest resistance.
Iron has a higher resistivity than copper.

A This means iron, 22 gauge, 2 m long will have largest resistance.
Wire A has largest resistance (3 marks).
B Copper, 18 guage, 1 m long will have lowest resistance.
Wire D has lowest resistance (3 marks)
C The lower the resistance the higher the current for a given voltage. So, wire A will carry the smallest current. (3 marks)

8 A galvanometer with a coil resistance of 80 Ω deflects full-scale when a current of 2×10^{-3} A passes through it. What series resistance is required to convert it to a voltmeter reading a full-scale deflection for 200 V. (**6 marks**)

Solution

8



$I_g(R+80) = 200$ V

$R = [\ (200V) / (2 \times 10^{-3}\ A)\ ] - 80\ \Omega$

$R = (10^5 - 80) = 99{,}920\ \Omega$