UNIVERSITY OF SASKATCHEWAN

College of Engineering

Department of Physics and Engineering Physics

Physics 155.3

Electric and Magnetic Circuits I

Instructors: J.E. Salt, R.J. Bolton, S. Koustov

MID-TERM EXAMINATION II

March 14th, 2007

7:00 PM - 8:30 PM

Indicate the Physics 155.3 Lecture Section that you are **registered** in.

☐ Section 02 (T-Th 1:00-2:30)

☐ Section 04 (T-Th 2:30-4:00)

STUDENT NAME: [redacted]

STUDENT NUMBER:

Question 1	4 / 6
Question 2	4 / 5
Question 3	6 / 7
Question 4	4 / 6
Question 5	4 / 4
Question 6	0 / 4

TOTAL	22 / 32

GENERAL INSTRUCTIONS FOR THE QUESTIONS

1) **Please place your answers in the boxes provided. Show units in all answers.**
2) Calculator allowed. One page (8½ x 11) double-sided of formulae allowed.
3) Please ensure that your name and student number are entered on every page.
4) Please show your work.
5) Hand in all of the pages of the examination. Make sure the pages are stapled together.

Physical Constants

Constant	Symbol	Value	Units
Coulomb's law constant	k	8.99×10^{9}	Nm^2/C^2
Planck's constant	h	4.14×10^{-15}	eV·s
Permittivity of free space	ε_0	8.854×10^{-12}	farad/m

QUESTION #1

MARKS: 6 (1 + 1 + 1 + 1 + 1 + 1)

Indicate the correct answer for each for the following questions in the boxes below.

a) A 10A current is maintained in a simple circuit with a total resistance of 200Ω. What net charge passes through the resistor in the circuit during a 1 minute interval?

(1) 200 C
(2) 400 C
(3) 500 C
(4) 600 C
(5) 1200 C

$I = \frac{10C}{S}\left(\frac{60s}{1min}\right)$ $\left(I = \frac{\Delta Q}{\Delta t}\right)$

$I = \frac{600C}{1min}$

b) Which one of the following combinations of units is equivalent to the ohm?

(1) V/C
(2) A/J
(3) J/s
(4) V/A
(5) W/A

$V = IR$

$R = \frac{V}{I} = \frac{J}{C/s} = \frac{Js}{C}$

c) A light bulb is connected to a battery and consumes 60W. The first light bulb is removed and another light bulb is connected to the battery and consumes 40W. What is the ratio of the resistance of the 60W bulb to the resistance of the 40W bulb?

(1) 1.5
(2) 0.67
(3) 2.3
(4) 0.44
(5) 3.0

$P = \frac{W}{\Delta t} = I^2R$ Light bulb 1: $60W = I^2R_1$ Light bulb 2: $40W = I^2R_2$

$\frac{60W}{40W} = 1.5$

d) A non-ideal 6.0V battery has an internal resistance of 0.6Ω. Determine the terminal voltage when the current drawn from the battery is 1A.

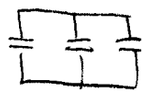
(1) 5.0 V
(2) 6.0 V
(3) 5.4 V
(4) 6.6 V
(5) 5.8 V

$V = 6.0V - (1A)(.6\Omega)$

$V = 5.4V$

e) Three parallel plate capacitors, each having a capacitance of 1μF are connected in parallel. The potential difference across the terminals of the parallel combination is 100V. What is the equivalent capacitance of this combination?

(1) 0.33μF
(2) 1μF
(3) 3μF
(4) 6μF
(5) 30μF



$Q = CV$

$C_{//} = C_1 + C_2 + C_3 \ldots$

f) The resistance of a certain heater element is found to be essentially independent of its temperature. If the current through the heater element is doubled, the amount of electrical energy converted to heat by the heater element in a given time interval will

(1) increase by a factor of two.
(2) decrease by a factor of two.
(3) increase by a factor of four.

$P = VI$

$2P = 2VI$

QUESTION #2

MARKS: 5 (2 + 1 + 2)

A engineering design company has a temperature sensor made from a certain material. The piece of material is 100cm long and has a cross sectional area of $1 \times 10^{-5} cm^2$. The sensor has a resistance of 20Ω at 20°C and a resistance of 100Ω at 100°C.

a) What is the resistivity, ρ_{20}, of the material at 20°C?
b) What is the inferred absolute zero temperature of the material?
c) What is temperature coefficient, α_{20}, of the material at 20°C?

IF NEEDED, USE THE BACK OF THIS PAGE AS A CALCULATION PAGE.

$l = 1.00m$ $\quad A = 1 \times 10^{-5} cm^2$

$A = 1 \times 10^{-5} (cm^2) \left(\frac{1m}{100cm}\right)^2$

a) $R = \rho \frac{l}{A}$

$A = 1 \times 10^{-9} m^2$

$\rho = \frac{RA}{l}$

$= \frac{(20\Omega)(1 \times 10^{-9} m^2)}{(1.00m)}$

$\rho = 2 \times 10^{-8} \Omega \cdot m$

b) 0°C, by slope of $1°C/\Omega$

c) $R = R_{20}[1 + \alpha_{20}(T - 20°C)]$

$R = R_{20} + R_{20}\alpha_{20}(T - 20°C)$

$\alpha_{20} = \frac{R - R_{20}}{R_{20}(T - 20°C)}$

$\alpha_{20} = \frac{100\Omega - 20\Omega}{20\Omega(100°C - 20°C)}$

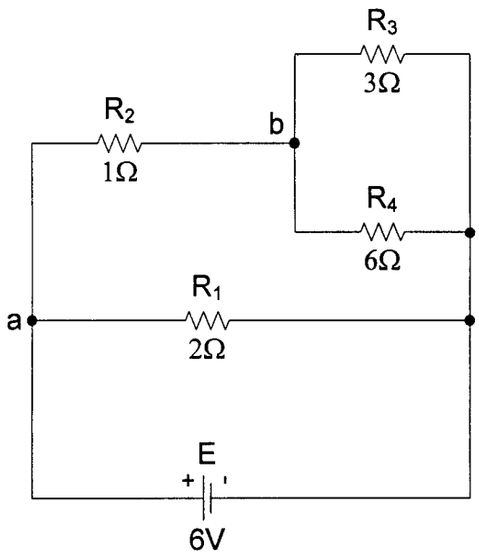
$\alpha_{20} = \frac{80\Omega}{1600\Omega \cdot °C}$

$\alpha_{20} = .005 (°C)^{-1}$

QUESTION #3

MARKS: 7 (1 + 1 + 1 + 2 + 2)

Consider the circuit shown below:



a) Are resistors R_2 and R_3 connected in series?
b) Are resistors R_3 and R_4 connected in series?
c) What resistors, if any, are in parallel in the circuit?
d) What is the equivalent resistance of the circuit as "seen" by the battery?
e) What is the voltage across the 1Ω resistor, V_{ab}?

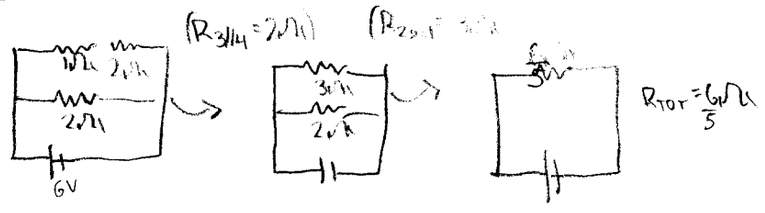
IF NEEDED, USE THE BACK OF THIS PAGE AS A CALCULATION PAGE.

a) no

b) no

c) R_3 and R_4

d)



e) VDR: $V_{R2} = 6V\left(\frac{1\Omega}{1\Omega + 2\Omega}\right)$

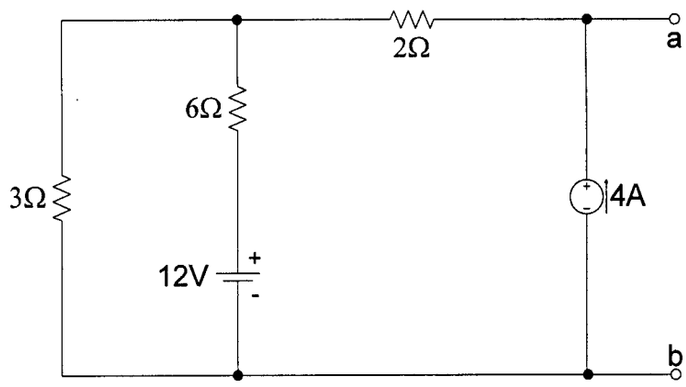
$= 2V$

QUESTION #4

MARKS: 6 (2 + 2 + 1 + 1)

This question has two parts each with a circuit. The two circuits are not related.

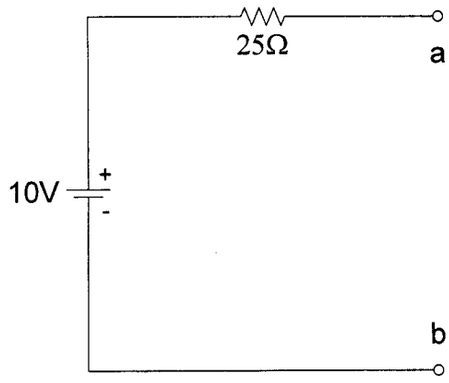
1) Consider the circuit shown below:



a) What is the Thévenin Equivalent voltage, E_{TH}, between terminals a and b?
b) What is the Thévenin Equivalent resistance, R_{TH}, between terminals a and b? } see back

IF NEEDED, USE THE BACK OF THIS PAGE AS A CALCULATION PAGE.

2) Consider the circuit shown below:



c) What is the resistance, R_{LOAD}, between terminals a and b for maximum power transfer?
d) What is the value of the maximum power transfer using the value of R_{LOAD} from part c)?

IF NEEDED, USE THE BACK OF THIS PAGE AS A CALCULATION PAGE.

$R_{LOAD} = R_{TH}$ (max power)

$= 25\Omega$

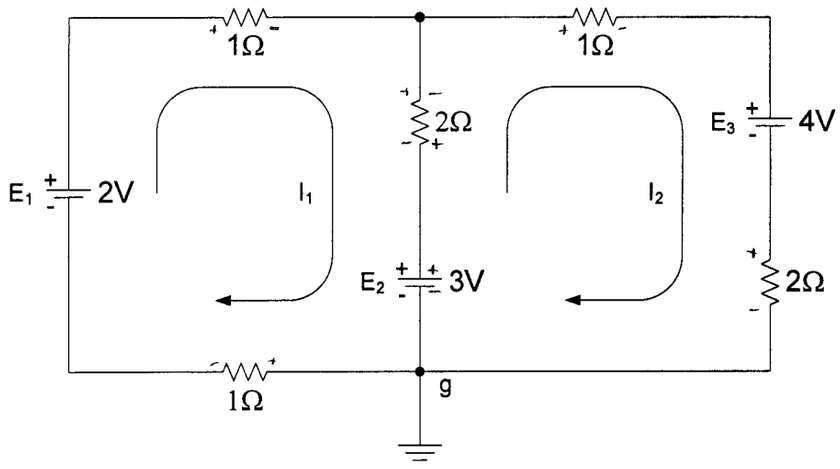
$P = \frac{V^2}{R}$

$= \frac{(10V)^2}{25\Omega}$ (1)

QUESTION #5

MARKS: 4 (2 + 2)

In doing this question you must use Kirchoff's Voltage Law (KVL). **Note: It is not required that you solve the equations in this question.**



a) Write the KVL loop equation for the current in the left hand loop. Start at point g and proceed clockwise. Do not simplify the equation.

b) Write the KVL loop equation for the current in the right hand loop. Start at point g and proceed clockwise. Do not simplify the equation.

IF NEEDED, USE THE BACK OF THIS PAGE AS A CALCULATION PAGE.

a) $-V_{1\Omega_1} + 2V - V_{1\Omega_2} - V_{2\Omega_1} - 3V = 0$

$-(1\Omega)(I_1) + 2V - (1\Omega)(I_2) - 2\Omega(I_1 - I_2) - 3V = 0$

b) $3V - V_{2\Omega_1} - V_{1\Omega_3} - 4V - V_{2\Omega_2} = 0$

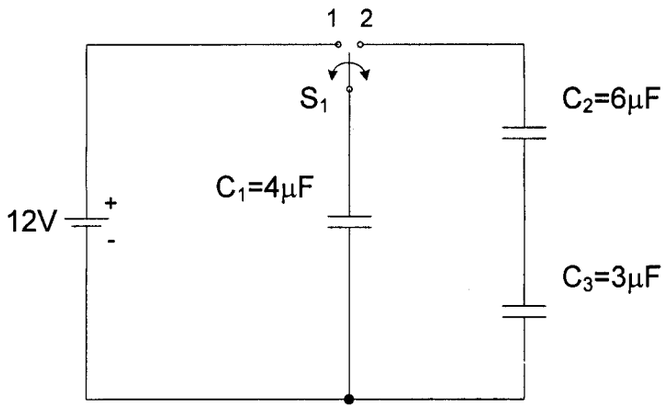
$3V - 2\Omega(I_2 - I_1) - 1\Omega(I_2) - 4V - 2\Omega(I_2) = 0$

(A)

QUESTION #6

MARKS: 4 (1 + 1 + 1 + 1)

Consider the circuit shown below. S_1 is initially open (i.e, in the center position). All of the capacitors are initially uncharged.



1) **S_1 is switched to position 1 (left side) and steady state has been reached.**
   a) Determine the charge in the plates in capacitor C_1.

2) **S_1 is switched to position 2 (right side) and steady state has been reached.**
   b) Determine the charge in the plates in capacitor C_1.
   c) Determine the charge in the plates in capacitor C_2.
   d) Determine the voltage across capacitor C_3.

IF NEEDED, USE THE BACK OF THIS PAGE AS A CALCULATION PAGE.

a) $Q_1 = C_1 V$
$= (4\times10^{-6}\,F)(12V)$
$Q_1 = 5.76\times10^{-5}\,C$

b) $C_{11} = 4\mu F + 6\mu F + 3\mu F$
$C_{11} = 13\mu F$

$Q_1 = 5.76\times10^{-5}\,C\left(\frac{4\mu F}{13\mu F}\right)$

$Q_1 = 1.77\times10^{-5}\,C$

check: $Q_1 + Q_2 + Q_3 = Q_{tot}$ ✓

c) $Q_2 = 5.76\times10^{-5}\,C\left(\frac{6\mu F}{13\mu F}\right)$

$Q_2 = 2.66\times10^{-5}\,C$

$6\mu F = C_t$

d) $Q_3 = 5.76\times10^{-5}\,C\left(\frac{3\mu F}{13\mu F}\right)$

$Q_3 = 1.33\times10^{-5}\,C$

$V = \frac{Q}{C}$

$= \frac{1.33\times10^{-5}\,C}{3\times10^{-6}\,F}$

$V = 4.43V$