**AES731 Electrical Technology I**

**Midterm Exam AY2016-2017 Semester 1**

# Formulas, Data and Conversions

## General

$e = -1.6 \times 10^{-19}\ C$

$1\ hp = 746\ W$

$1\ \text{rpm} = \frac{2\pi}{60} rad/s$

## Electric Fields

$F = k\frac{q_1 q_2}{d^2}; k = 9.1 \times 10^9\ Nm^2/C^2$

$E = \frac{F}{q} = \frac{V}{d}$

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

$I = \frac{Q}{t}$

## Kirchhoff's Laws

$\sum I_{node} = 0$

$\sum V_{loop} = 0$

## Y-Δ conversions

$R_a = \frac{R_1 R_3}{R_1 + R_2 + R_3}$

$R_b = \frac{R_1 R_2}{R_1 + R_2 + R_3}$

$R_c = \frac{R_2 R_3}{R_1 + R_2 + R_3}$

$R_1 = \frac{R_a R_b + R_b R_c + R_c R_a}{R_c}$

$R_2 = \frac{R_a R_b + R_b R_c + R_c R_a}{R_a}$

$R_3 = \frac{R_a R_b + R_b R_c + R_c R_a}{R_b}$

## Inductors and Capacitors

$CEMF = -L\frac{\Delta I}{\Delta t}$

$T_L = \frac{L}{R}$

$V = L\frac{\Delta I}{\Delta t}$

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

$C = k\frac{A}{d}; k = 8.85 \times 10^{-12} F/m$

## DC Generators

$E_g = k\varphi N$

## DC Motors

$T = k\varphi I_a$

$E_{CEMF} = k\varphi N$

## Batteries

$Battery\ Rating = \frac{SG_{FC} - SG_{DR}}{Normal\ Gravity\ Drop \times 0.001} \times 100\%$

## Uniformly Accelerated Rotational Motion

$\omega = \omega_0 + \alpha t$

$\omega^2 = \omega_0^2 + 2\alpha\Delta\theta$

$\Delta\theta = \omega_0 t + \frac{1}{2}\alpha t^2$

**1** Two isolated point charges $q_1 = -50\ nC$ and $q_2 = +80\ nC$ are 2.0 mm apart in air as shown in **Figure 1**.

**Figure 1**

**(a)** Sketch the electric field line in the region between and around the charges. [3]

**(b)** Determine the force acting on the negative charge due to the electric field. [3]

**(c)** State and explain whether this electric field is uniform or non-uniform. [2]

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**2** Two parallel conducting plates are held at a distance of 2.0 cm. The plates are connected to a DC power supply making the upper plate 200 V higher than the lower plate.

**(a)** Calculate the electric field strength between the plates. [2]

**(b)** Calculate the force on an electron positioned half way between the plates. [2]

**(c)** Another electron is much closer to the positive plate. Explain why the force on this second is the same as the first one. [1]

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**(d)** The plates are placed in a radiation field that ionizes the air and release a large of electrons between the plates. The plates collect the electrons at a rate of $10^{15}$ electrons per second. The collected electrons are measured as current in the external circuit. Calculate the magnitude of this current. [2]

**3** A DC power source is connected to two resistors as shown in **Figure 3**.

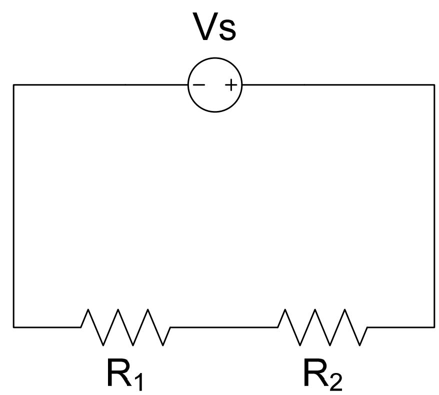


**Figure 3**

**(a)** On **Figure 3**, show the direction of the conventional current. [1]

**(b)** Explain whether resistors $R_1$ and $R_2$ are connected in series or in parallel. [2]

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**(c)** Mark the polarity of each resistor. [2]

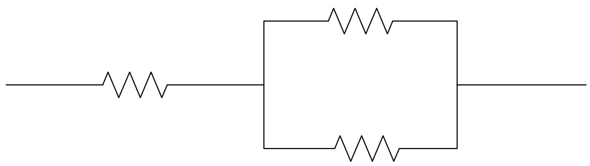
**(d)** Given that $R_1 = 20\ \Omega$ and $R_2 = 40\ \Omega$, calculate their equivalent resistance, $R_{eq}$. [1]

**(e)** Given that $V_s = 12\ V$, calculate the current in the circuit. [1]

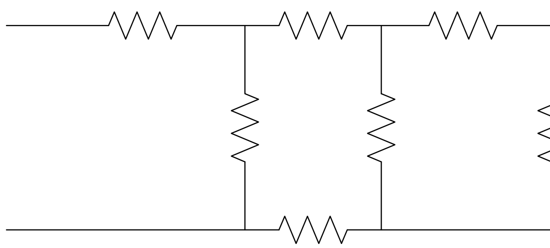
**(f)** Calculate the potential drop across each resistor. [2]

**4** Find the equivalent resistance for each of the following resistive networks. Each resistor has a value of 60 Ω.

**(a)** [2]



**(b)** [4]



**5** Given the circuit shown in **Figure 5**, follow steps **(a)** through **(f)** to solve the circuit using mesh analysis, where $V_A = 20\ V$, $V_B = 10\ V$, $R_1 = 5\ \Omega$, $R_2 = 15\ \Omega$ AND $R_3 = 10\ \Omega$.

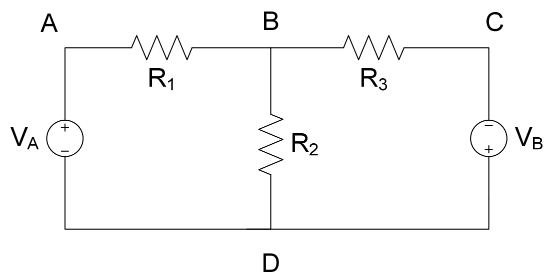



**Figure 5**

**(a)** Assuming the currents in loops ABDA (loops 1) and BCDB (loop 2) are clockwise, assign a voltage for each resistor and mark its polarity. [2]

**(b)** Write a KVL equation for each loop 1. [2]

**(c)** Use Ohm's law to rewrite the equation in **(b)** in terms of current and resistance. [2]

**(d)** Repeat steps **(b)** and **(c)** for loop 2. [2]

**(e)** Solve the current equations you obtained in **(c)** and **(d)** for loop currents. (You may do so using a calculator and not show working for this step.) [2]

**(f)** Calculate all unknown voltages in the circuit. [3]

**6** Given the circuit shown in **Figure 6**, follow steps **(a)** through **(f)** to solve the circuit using node analysis, where $V_A = 20\ V$, $V_B = 30\ V$, $R_1 = 10\ \Omega$, $R_2 = 30\ \Omega$ AND $R_3 = 15\ \Omega$.

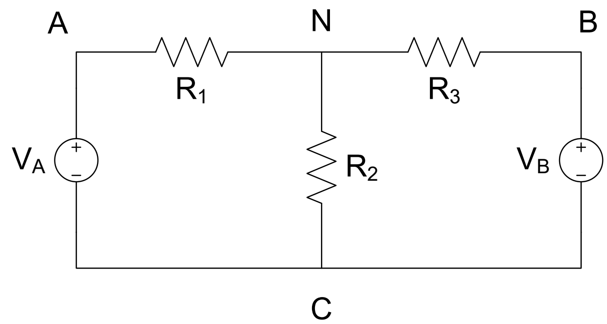



**Figure 6**

**(a)** Write a KCL equation for node N. [2]

**(b)** Rewrite your equation from **(a)** using element voltages. [2]

**(c)** Taking node C as reference node, rewrite your equation from **(b)** using node voltages. [2]

**(d)** Solve for all unknown node *and* element voltages. [3]

**(e)** Determine all branch currents. [3]