2019/2020 SEMESTER ONE MID-SEMESTER TEST

SAS Code:
MST

Diploma in Aerospace Electronics (DASE) 2nd Year FT
Diploma in Engineering with Business (DEB) 3rd Year FT
Diploma in Electrical & Electronic Engineering (DEEE) 2nd Year FT
Diploma in Engineering Systems (DES) 2nd Year FT
Diploma in Energy Systems and Management (DESM) 2nd Year FT

CIRCUIT THEORY & ANALYSIS Time Allowed: 1.5 Hours

Instructions to Candidates

1. The Singapore Polytechnic examination rules are to be complied with.

2. This paper consists of **TWO** sections:

   Section A - 10 Multiple Choice Questions, 3 marks each.
   Section B - 4 Short Questions

3. **ALL** questions are **COMPULSORY**.

4. All questions are to be answered in the answer booklet. Start each question in Section B on a new page.

5. This paper consists of 8 pages, inclusive of the formulae sheet.

SECTION A: MULTIPLE CHOICE QUESTIONS (3 marks each)

1. Please **tick** your answers in the **MCQ box** behind the front cover of the answer booklet.
2. No marks will be deducted for incorrect answers.

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1. For the circuit shown in Figure A1, which one of the following is the correct matrix formed by inspection using Mesh Current Analysis method.

(a) $\begin{bmatrix} 12 & -6 \\ -6 & 11 \end{bmatrix}\begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} -12 \\ 24 \end{bmatrix}$

(b) $\begin{bmatrix} 12 & -6 \\ -6 & 11 \end{bmatrix}\begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} 12 \\ -24 \end{bmatrix}$

(c) $\begin{bmatrix} 12 & 6 \\ 6 & 11 \end{bmatrix}\begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} -12 \\ 24 \end{bmatrix}$

(d) $\begin{bmatrix} 12 & 6 \\ 6 & 11 \end{bmatrix}\begin{bmatrix} I_1 \\ I_2 \end{bmatrix} = \begin{bmatrix} 12 \\ -24 \end{bmatrix}$

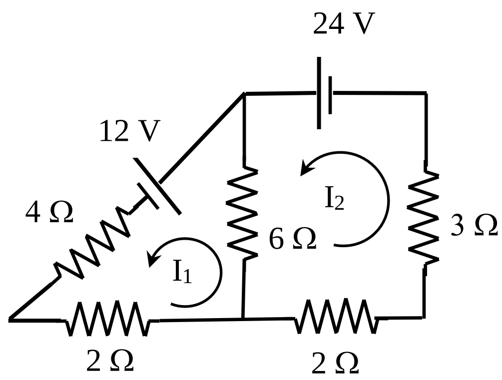

Figure A1

2. For the circuit shown in Figure A1, determine the expression for the voltage across the 6 Ω resistor.

(a) $6\ I_1$

(b) $6\ I_2$

(c) $6\ (I_1 - I_2)$

(d) $6\ (I_1 + I_2)$

3. If the 12 V supply is shorted for the circuit shown in Figure A1, determine the supply current.

(a) 2.18 A

(b) 3 A

(c) 4.8 A

(d) 6.86 A

4. Determine the Norton equivalent current source I_N across terminals A and B for the circuit given in Figure A4.

(a) 0.4 A
(b) 0.8 A
(c) 2 A
(d) 5 A

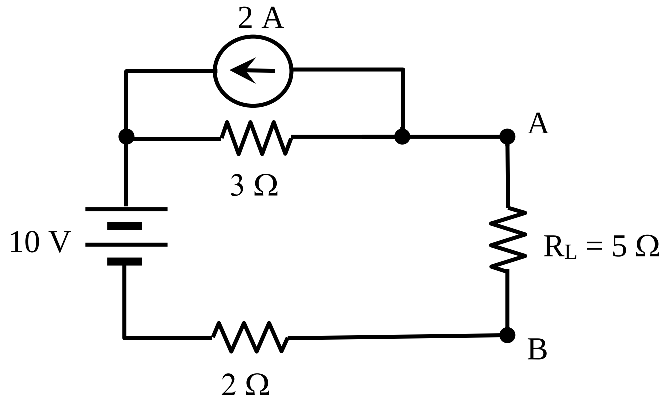

Figure A4

5. The value of the Norton equivalent resistance R_N across terminals A and B for the circuit given in Figure A4 is

(a) 2 Ω
(b) 2.5 Ω
(c) 5 Ω
(d) 10 Ω

6. For the same circuit in Figure A4, if the 10 V supply is shorted, determine the new value of the Norton equivalent current source I_N across terminals A and B.

(a) - 0.4 A
(b) - 0.6 A
(c) - 0.8 A
(d) -1.2 A

7. A 6 V AC source supplies a series RLC resonant circuit having a 0.22 µF capacitor and a coil whose resistance and inductance are 30 Ω and 10 mH respectively. Determine the frequency at resonance.

   (a) 0.107 Hz
   (b) 0.107 kHz
   (c) 3.39 Hz
   (d) 3.39 kHz

8. For the same circuit in question 7, calculate the current flowing through the circuit at half-power frequencies.

   (a) 0.141 A
   (b) 0.2 A
   (c) 0.707 A
   (d) 1.414 A

9. A pure parallel RLC circuit has a resonant frequency of 10 kHz and a bandwidth of 2.5 kHz. If the current through the capacitor is 2 mA at resonance, determine the total supply current.

   (a) 0.25 mA
   (b) 0.5 mA
   (c) 2 mA
   (d) 8 mA

10. Which one of the following statements is true in a parallel RLC resonant circuit?

   (a) When the resistance R decreases, the resonant frequency and bandwidth remain constant.

   (b) When the resistance R decreases, the resonant frequency remains constant and bandwidth decreases.

   (c) When the resistance R decreases, the resonant frequency remains constant and bandwidth increases.

   (d) When the resistance R decreases, the resonant frequency decreases and bandwidth increases.

SECTION B: 4 QUESTIONS

B1. (a) Using the source conversion method, simplify the circuit shown in Figure B1 to its equivalent current source across terminals A and B. (12 marks)

(b) If a load R_L of 5 Ω is connected across terminals A and B, determine the current flowing through it. (3 marks)

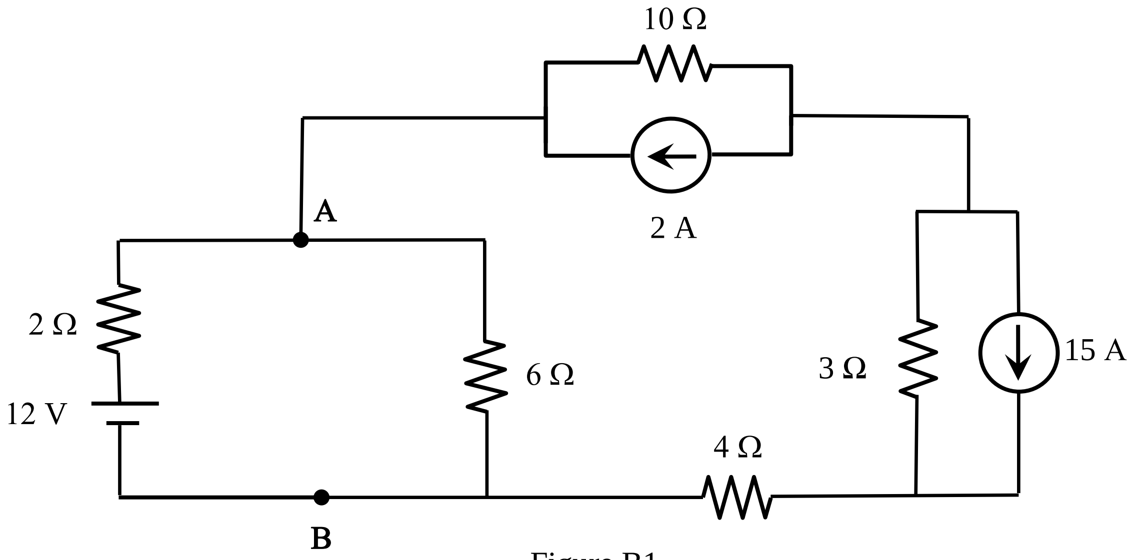

Figure B1

B2. For the circuit shown in Figure B2,

(a) convert the star-connected resistors as shown in the dotted box into an equivalent delta-connection, and hence (9 marks)

(b) calculate the total resistance between terminals X and Y. (6 marks)

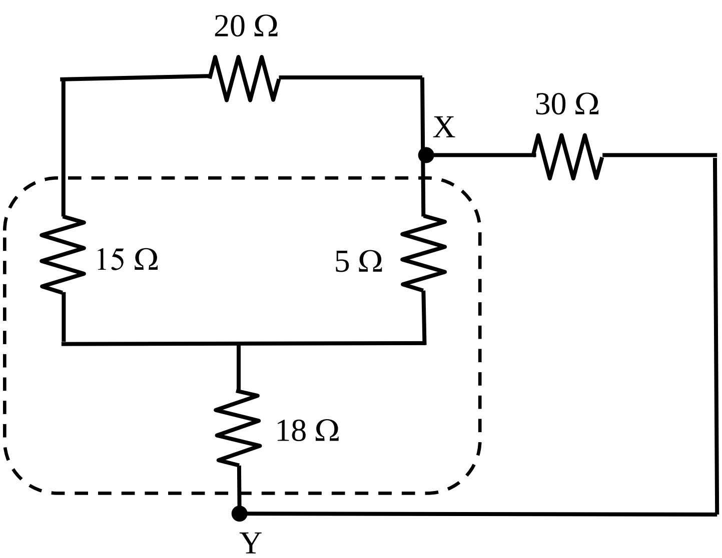

Figure B2

B3. (a) By inspection, **write** the nodal voltage equations for V_1, V_2 and V_3 in matrix form for the network shown in Figure B3. (15 marks)

(a) If the values of V_1, V_2 and V_3 are found to be 9.18 V, -7.59 V and -6.31 V respectively, determine the:

(i) current in the 4 Ω resistor, and (2 marks)

(ii) power in the 10 Ω resistor. (3 marks)

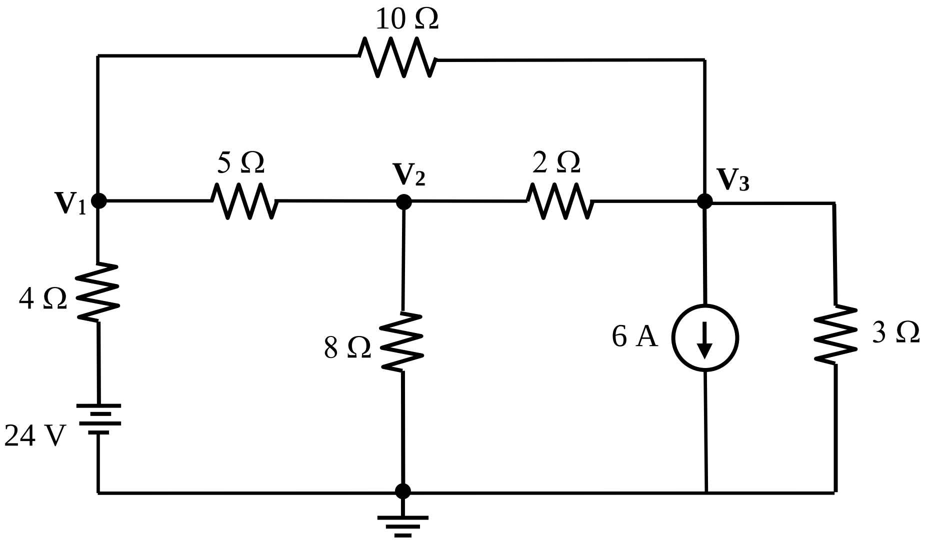

Figure B3

B4. (a) Apply Thevenin's Theorem to find the Thevenin equivalent circuit parameters V_{TH} and R_{TH} between terminals A and B for the circuit shown in Figure B4. (Include circuit diagrams for finding V_{TH} and R_{TH}) (16 marks)

(b) Draw the Thevenin equivalent circuit obtained above and hence calculate the voltage across the load R_L. (4 marks)

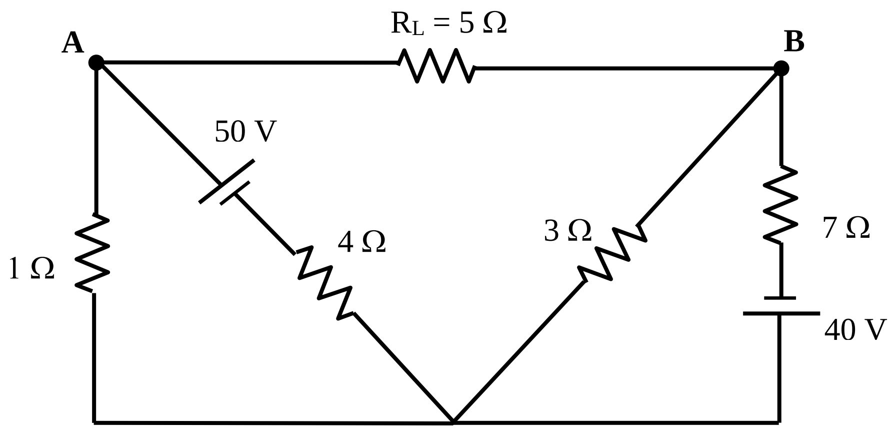

Figure B4

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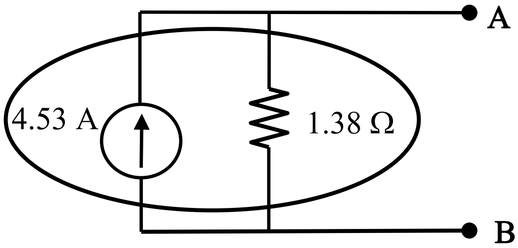
Formulae

Resistors in series	$R_T = R_1 + R_2 + R_3 + ...$
Resistors in parallel	$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + ...$
Resistors in parallel (for 2 resistors)	$R_T = \frac{R_1 R_2}{R_1 + R_2}$
Voltage Divider Rule	$V_X = \frac{R_X}{R_T} V_S$
Current Divider Rule (for 2 resistors)	$I_1 = \frac{R_2}{R_1 + R_2} I_T$
Source Conversion	$E = I_S R_S$ $\qquad$ $I_S = \frac{E}{R_S}$
Mesh Current Analysis	[Z] [I] = [V]
Nodal Voltage Analysis	[Y] [V] = [I]
Delta to Star Conversion	$Z_1 = \frac{Z_A Z_C}{Z_A + Z_B + Z_C}$ $Z_2 = \frac{Z_A Z_B}{Z_A + Z_B + Z_C}$ $Z_3 = \frac{Z_B Z_C}{Z_A + Z_B + Z_C}$
Star to Delta Conversion	$Z_A = Z_1 + Z_2 + \frac{Z_1 Z_2}{Z_3}$ $Z_B = Z_2 + Z_3 + \frac{Z_2 Z_3}{Z_1}$ $Z_C = Z_1 + Z_3 + \frac{Z_1 Z_3}{Z_2}$
Inductive Reactance	$X_L = 2\pi fL$
Capacitive Reactance	$X_C = \frac{1}{2 \pi f C}$

Series RLC Resonant Circuit	Z = R I = V/R $f_o = \frac{1}{2\pi\sqrt{LC}}$ $Q_0 = \frac{X_L}{R} = \frac{X_C}{R}$ $= \frac{V_L}{V} = \frac{V_C}{V}$ $\text{Bandwidth (BW)} = \frac{f_o}{Q_o} = f_2 - f_1$ $f_1 = f_o - \frac{BW}{2}$ $f_2 = f_o + \frac{BW}{2}$
Parallel RLC Resonant Circuit	Z = R I = V/R $f_o = \frac{1}{2\pi\sqrt{LC}}$ $Q_0 = \frac{R}{X_L} = \frac{R}{X_C}$ $= \frac{I_L}{I} = \frac{I_C}{I}$ $\text{Bandwidth (BW)} = \frac{f_o}{Q_o} = f_2 - f_1$ $f_1 = f_o - \frac{BW}{2}$ $f_2 = f_o + \frac{BW}{2}$

A	
1	A
2	C
3	B
4	B
5	C
6	D
7	D
8	A
9	B
10	C

B1 (a)



B1(b) I_{RL} = 0.98 A

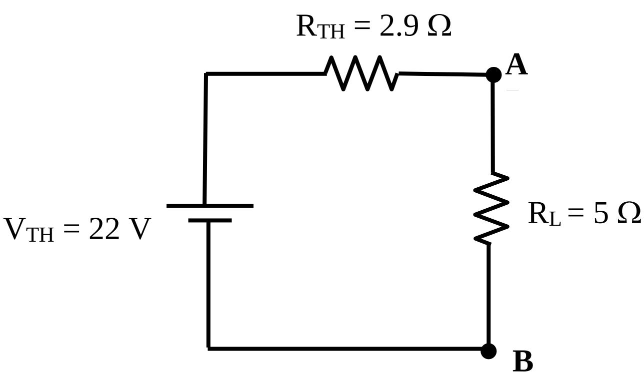
B2(a) R_1 = 24.17 Ω; R_2 = 87 Ω; R_3 = 29 Ω

B2(b) R_T = 12.82 Ω

B3(a)
$$\begin{bmatrix} \frac{1}{4}+\frac{1}{5}+\frac{1}{10} & -\frac{1}{5} & -\frac{1}{10} \\ -\frac{1}{5} & \frac{1}{2}+\frac{1}{5}+\frac{1}{8} & -\frac{1}{2} \\ -\frac{1}{10} & -\frac{1}{2} & \frac{1}{2}+\frac{1}{3}+\frac{1}{10} \end{bmatrix} \begin{bmatrix} V_1 \\ V_2 \\ V_3 \end{bmatrix} = \begin{bmatrix} \frac{24}{4} \\ 0 \\ -6 \end{bmatrix}$$

B3(b) $I_{4\Omega}$ = 3.71 A ; $P_{10\Omega}$ = 23.99 W

B4



V_{RL} = 13.92 V