COMMUNITY COLLEGE OF CITY UNIVERSITY

Course code & title	:	AST10401 Introduction to Electrical Engineering
Session	:	Semester A 2017/18
Time allowed	:	Two hours

This paper has NINE pages (including this cover page).

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1. This paper consists of 9 questions in 2 sections.
2. Answer ALL questions in Section A and ANY THREE questions in Section B.
3. Reference formulae are provided on the last page of this exam paper.
4. Use the supplied answer book to answer all the questions.
5. Write the question numbers of the questions that you attempted on the front cover of your answer book and at the top right-hand corner of each inside page where there are written answers.
6. Start a new page for each question. If additional sheets are used, insert them properly to the corresponding questions.

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*This is a **closed-book** examination.*

Candidates are allowed to use the following materials/aids:

Approved Calculators

Materials/aids other than those stated above are not permitted. Candidates will be subject to disciplinary action if any unauthorized materials or aids are found on them.

NOT TO BE TAKEN AWAY

<u>Section A</u> (40%)

Attempt <u>ALL</u> questions from this section

1. Using mesh analysis, determine the mesh currents i_1 and i_2 and the power of the 3A current source in the circuit shown in Figure Q1. 7 marks

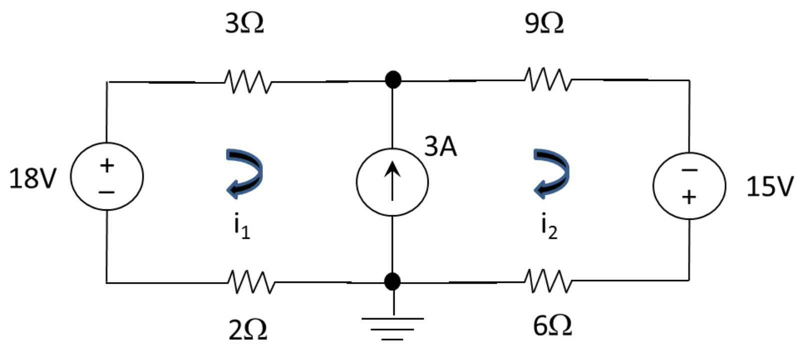

Figure Q1

2. Determine the voltage across the 10Ω resistor, V_x, in Figure Q2. 8 marks

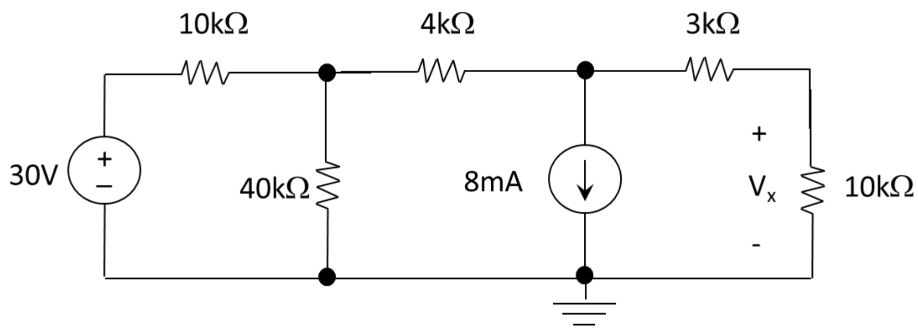

Figure Q2

3. Given the AC circuit shown in Figure Q3, the voltage of the AC voltage 8 marks

source is given by $V_g(t) = 22.36\cos(5000t)$. Find $V_{ab}(t)$.

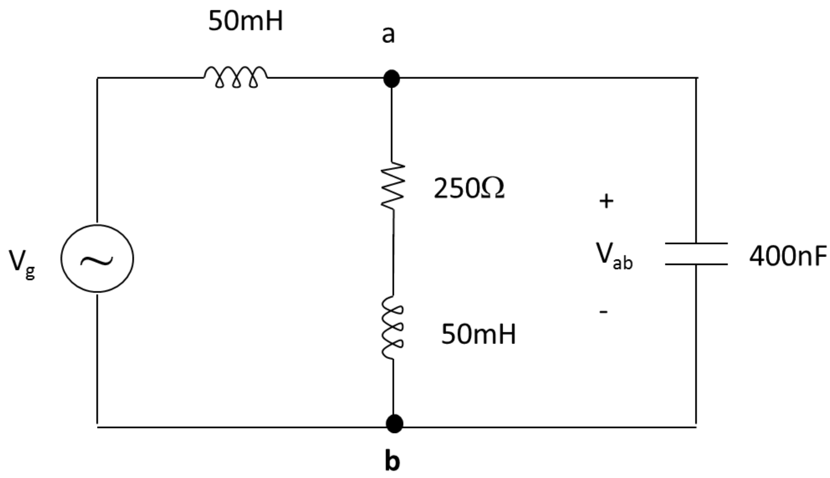

Figure Q3

4. Given a balanced three phase circuit shown in Figure Q4 with the angular frequency ω = 5000 rad/s.

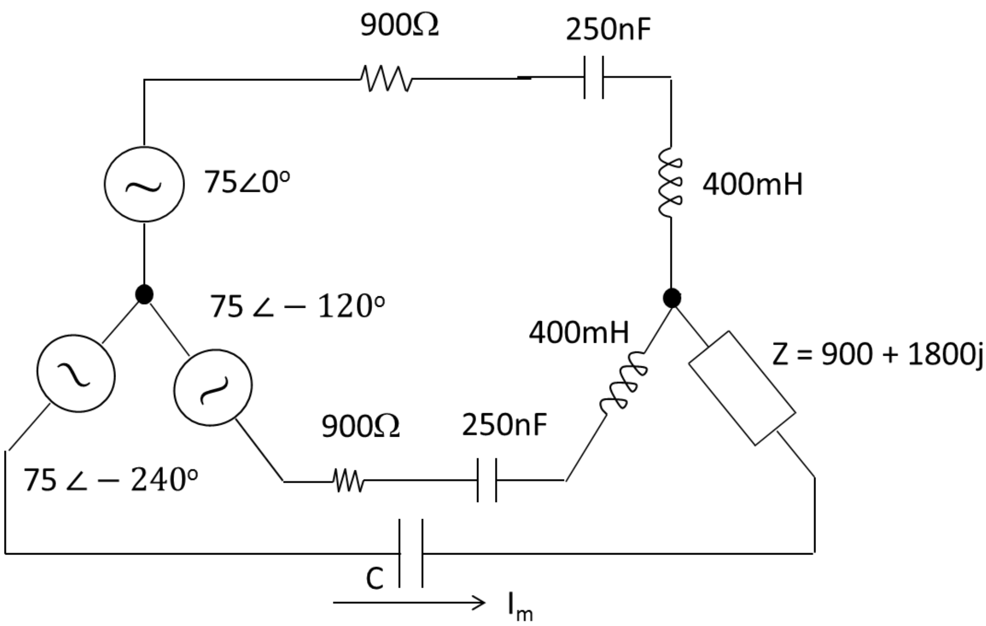

Figure Q4

(a) Determine the capacitance C of the capacitor. 4 marks

(b) Find the current I_m in the time domain form. 3 marks

5. Design a first order circuit using one current source, one two-terminal switch, one 0.1mF capacitor and resistor(s) to product the capacitor voltage response 10 marks

$$v_C(t) = 5 - 3e^{-4t} \qquad \textit{for} \qquad t \geq 0.$$

Explain and draw a circuit diagram for your design.

<u>Section B</u> (60%)

Attempt <u>ANY THREE</u> questions from this section

6. Consider the circuit with nodes A and B as its two terminals shown in Figure Q6.

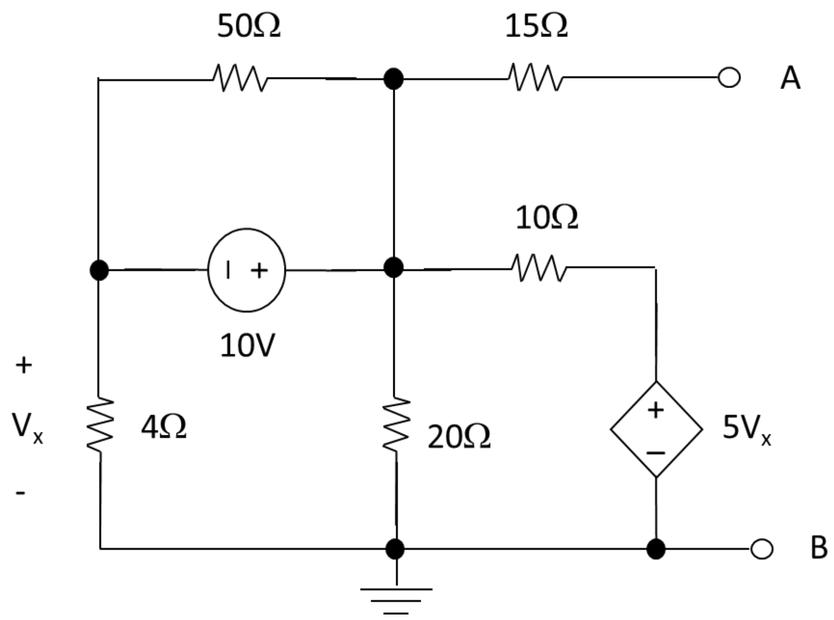

Figure Q6

(a) Find the Thevenin voltage of the circuit. 5 marks

(b) Find the Thevenin resistance of the circuit. 5 marks

(c) If we connect a resistor R_o between nodes A and B, find the resistance of R_o such that R_o will receive the maximum power transferred from the circuit. Also determine the maximum power received by R_o when it is connected to the circuit. 2 marks

(d) Now we remove the resistor R_o in (c) and connect an unknown device X between nodes A and B. Given that the power of X is +2W, determine the voltage across nodes A and B (i.e. the voltage across X). 4 marks

(e) With the same settings in (d), determine the voltage across nodes A and B (i.e. the voltage across X) if the 10V voltage source in circuit replaced by a 2.8V voltage source. 4 marks

7. The switch in Figure Q7 has been opened for a long time and the switch is then closed at $t = 0$.

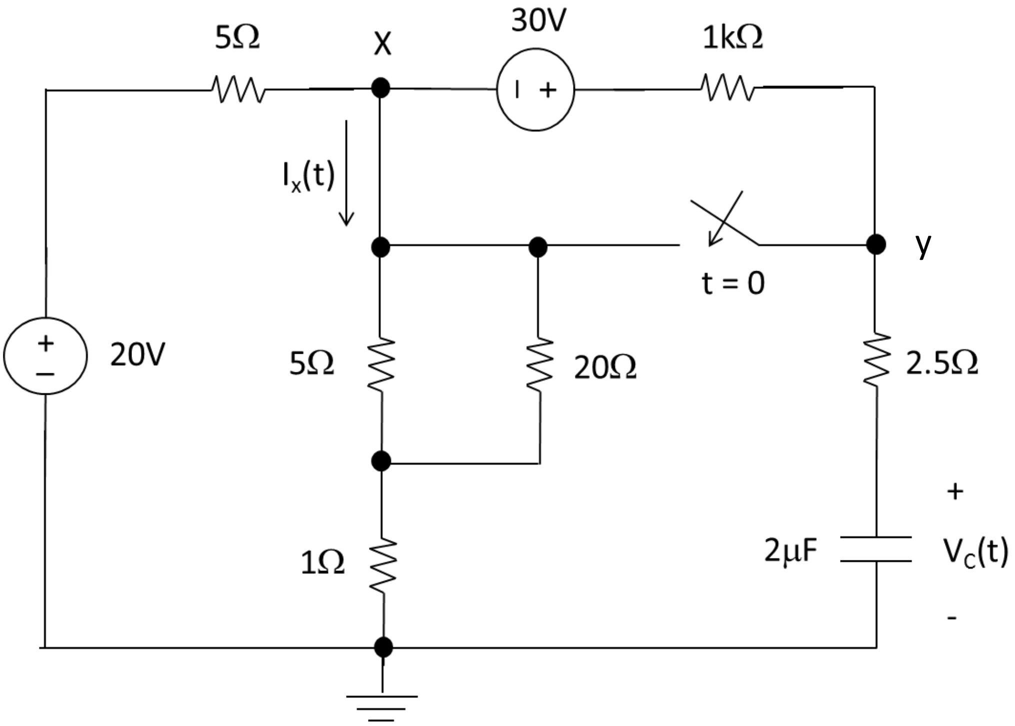

Figure Q7

(a) Determine the capacitor voltage and its energy at $t = 0$. 3 marks

(b) Draw the steady state equivalent circuit when t tends to infinity. 3 marks

(c) Determine the expression of the capacitor voltage $V_C(t)$ for $t \geq 0$. (Hint: $V_x = V_y$ for $t \geq 0$) 5 marks

(d) Without using calculus, determine the expression of the voltage at node X for $t \geq 0$. 5 marks

(e) Without using calculus, determine the expression of the current $I_x(t)$ for $t \geq 0$. 4 marks

8. There are two switches S1 and S2 in Figure Q8. S1 has been opened and S2 has been closed for a long time. At $t = 0$, S1 is closed while S2 is opened.

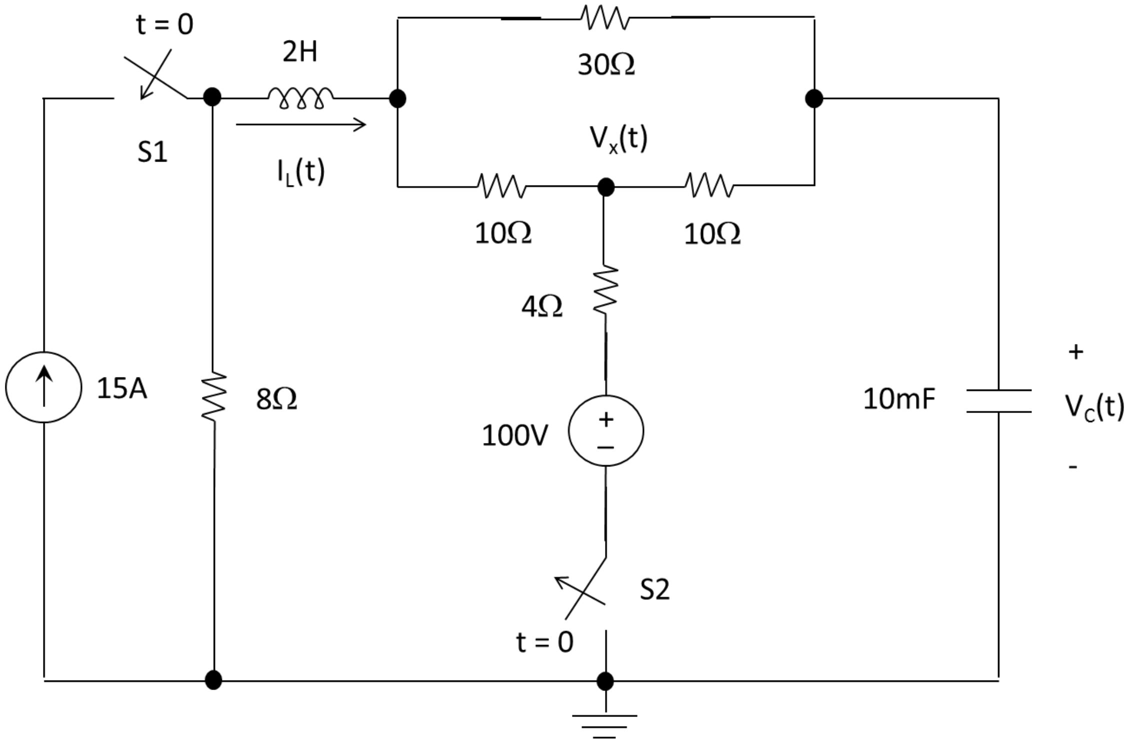

Figure Q8

(a) Draw the steady state equivalent circuit just before $t = 0$. 2 marks

(b) Determine $V_C(0)$ and $I_L(0)$. 4 marks

(c) Determine the expression of the capacitor voltage $V_C(t)$ for $t \geq 0$. 9 marks

(d) Determine the expression of the voltage $V_x(t)$ for $t \geq 0$. 5 marks

9. Consider the balanced three phase circuit with the angular frequency $\omega = 8000$ rad/s shown in Figure Q9.

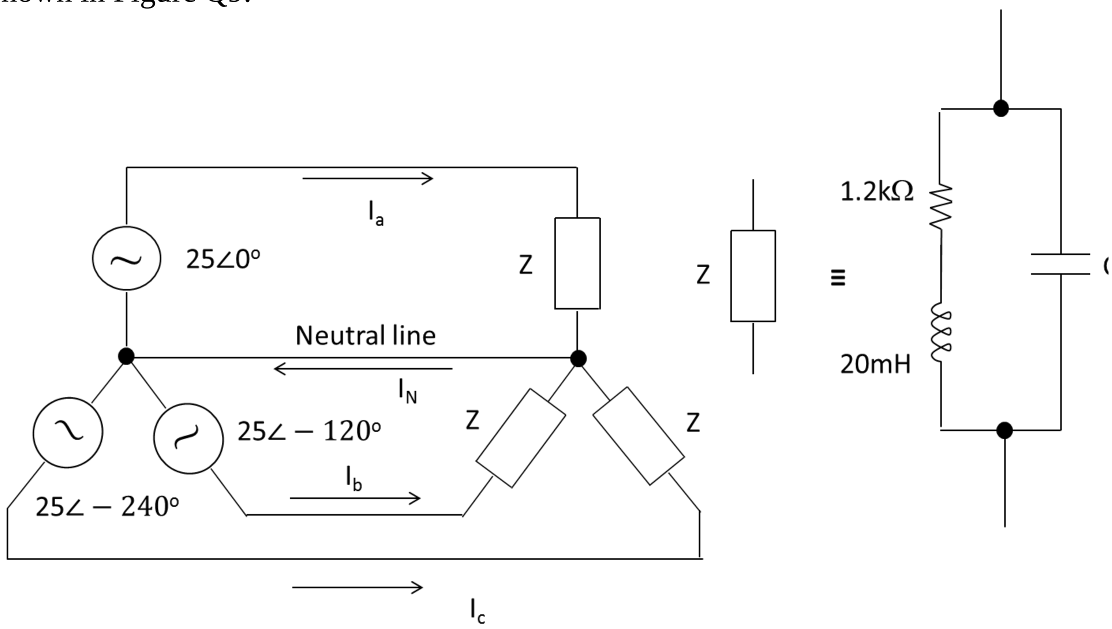

Figure Q9

(a) Show that there is no current flow in the neutral line. 6 marks

(b) Suppose the load Z is a connection shown in Figure Q9. Determine the capacitance C in the connection so that the power factor of Z is 1. (i.e. the AC current of Z is in-phase with the AC voltage of Z.) 8 marks

(c) Based on the result in (b), find the average receive power of the load of the whole three phase circuit. 4 marks

(d) If the angular frequency ω tends to 0, find the average instantaneous power of the load of the whole three phase circuit. 2 marks

Reference Formulas:

The step response of an RC circuit

$$v(t) = v(\infty) + [v(0) - v(\infty)]e^{-t/\tau}$$

$$\tau = RC$$

The step response of an RL circuit

$$i(t) = i(\infty) + [i(0) - i(\infty)]e^{-t/\tau}$$

$$\tau = L/R$$

The step response of a series RLC circuit

$$\alpha = \frac{R}{2L} \quad and \quad \omega_0 = \sqrt{\frac{1}{LC}}$$

$$s_1 = -\alpha + \sqrt{\alpha^2 - \omega_0{}^2}$$

$$s_2 = -\alpha - \sqrt{\alpha^2 - \omega_0{}^2}$$

$$\omega_d = \sqrt{\omega_0^2 - \alpha^2}$$

$$\alpha > \omega_0: \quad v(t) = V_S + A_1 e^{s_1 t} + A_2 e^{s_2 t}$$

$$\alpha = \omega_0: \quad v(t) = V_S + (A_1 + A_2 t)e^{-\alpha t}$$

$$\alpha < \omega_0: \quad v(t) = V_S + e^{-\alpha t}(A_1 \cos \omega_d t + A_2 \sin \omega_d t)$$

The step response of a parallel RLC circuit

$$\alpha = \frac{1}{2RC} \quad and \quad \omega_0 = \sqrt{\frac{1}{LC}}$$

$$s_1 = -\alpha + \sqrt{\alpha^2 - \omega_0{}^2}$$

$$s_2 = -\alpha - \sqrt{\alpha^2 - \omega_0{}^2}$$

$$\omega_d = \sqrt{\omega_0^2 - \alpha^2}$$

$$\alpha > \omega_0: \quad i(t) = I_S + A_1 e^{s_1 t} + A_2 e^{s_2 t}$$

$$\alpha = \omega_0: \quad i(t) = I_S + (A_1 + A_2 t)e^{-\alpha t}$$

$$\alpha < \omega_0: \quad i(t) = I_S + e^{-\alpha t}(A_1 \cos \omega_d t + A_2 \sin \omega_d t)$$

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