EE240: Circuits I

ASSIGNMENT 1

Due Date: 24 Sep 2019

- Submissions will only be accepted on A4 sized papers.
- Write your name and roll number clearly at the top of the assignment.
- You are required to show working where necessary; answers will not be graded if working is not shown.
- The assignment is worth **100** marks, you are advised to start early as it is long.
- Feel free to contact the instructor or teaching assistants if you have any questions.
- Any instance of plagiarism will be **severely** dealt with; such cases would be subjected to **disciplinary action** in accordance with the university rules and regulations.

Course Learning Outcomes Covered:

CLO1: Derive and apply working principle of passive components R, L,C and independent and controlled energy sources for device and circuit modeling and analysis

Problem 1 (11 marks)

(a) [**3 marks**] A 24V battery is connected to a motor. The battery provides a current of 250mA. The motor is switched on, calculate the energy it consumed in 2 hours.

(b) [**4 marks**] The current through an element is given by $i(t) = (5 - 2t)^2$A for $t \geq 0$. Give an expression for the charge in the element.

(c) [**4 marks**] The charge entering a terminal is given by the equation:

$$q(t) = 4\sin(2\pi t + \frac{\pi}{3}) - \cos(\frac{5\pi t}{2})\text{mC}$$

Calculate the current flowing through it at $t = 1$s.

Problem 2 (10 marks)

(a) [**3 marks**] A simple circuit consists of a 12V battery connected in series with a light bulb.

(i) If the battery supplies a current of 1.3 A for 2 minutes to the bulb, calculate the energy dissipated across the bulb.

(ii) If 3.7kJ of energy was dissipated across the bulb in 8 seconds, calculate the current flowing through the circuit.

(b) [**1 mark**] How much energy does a charge of -45mC require to move across a potential difference of 5V? Recall that charges can be negative too.

(c) [**6 marks**] The following current flows from the positive to the negative terminal of a device. Calculate the total charge that enters the positive terminal.

$$i(t) = \begin{cases} 4t & ; \quad 0 < t \leq 3 \\ 3t^2 + 2 & ; \quad 3 < t \leq 7 \\ -7t + 1 & ; \quad 7 < t \leq 9 \\ 5 & ; \quad 9 < t \leq 13 \\ 0 & ; \quad \text{otherwise} \end{cases}$$

Problem 3 (10 marks)

The charge entering a positive terminal of a device is given by $q(t) = -12e^{-2t}$mC, and the power is given by $p(t) = 3e^{-8t}$ W. In the time interval $0 \leq t \leq 500$ms, compute the following:

(a) [**3 marks**] The current across the device.

(b) [**3 marks**] The voltage across the device.

(c) [**4 marks**] The energy delivered to the device.

Problem 4 (10 marks)

(a) [**5 marks**] Find the equivalent capacitance across points A and B

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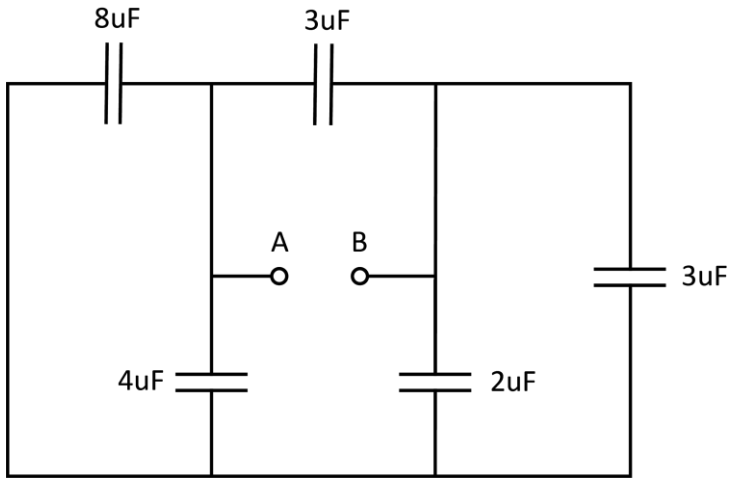

Figure 1

(b) [**5marks**] Given that L_{eq} is *2.4*mH, calculate the value of L.

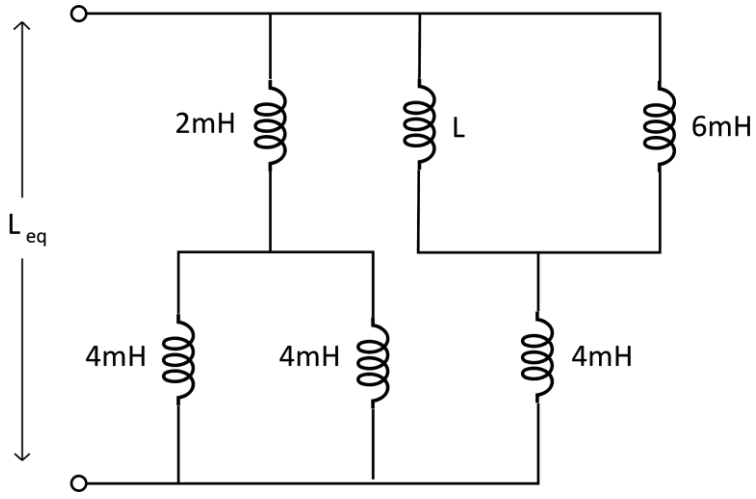

Figure 2

Problem 5 (10 marks)

(a) [**5 marks**]

(i) Find R_{eq} for the following circuit.

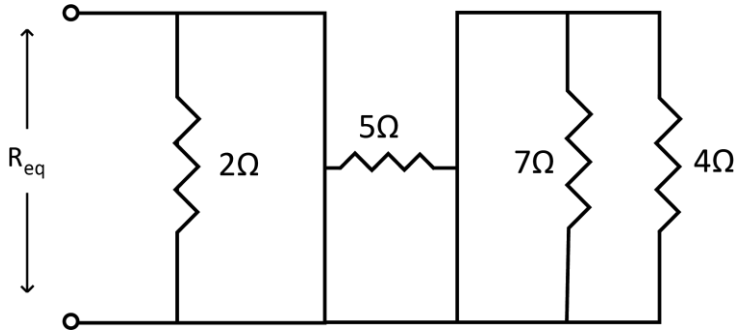

Figure 3

(ii) You are provided with 4 resistors, each rated at 1Ω. Design a circuit using **all** resistors provided, connecting in series and parallel combinations; the circuit should have an equivalent resistance of 1.33Ω. There may be more than 1 configurations, but you are only required to make one.

(b) [**5 marks**] Each resistor in the following figure is rated at 4Ω. Find the equivalent resistance across terminals A and B.

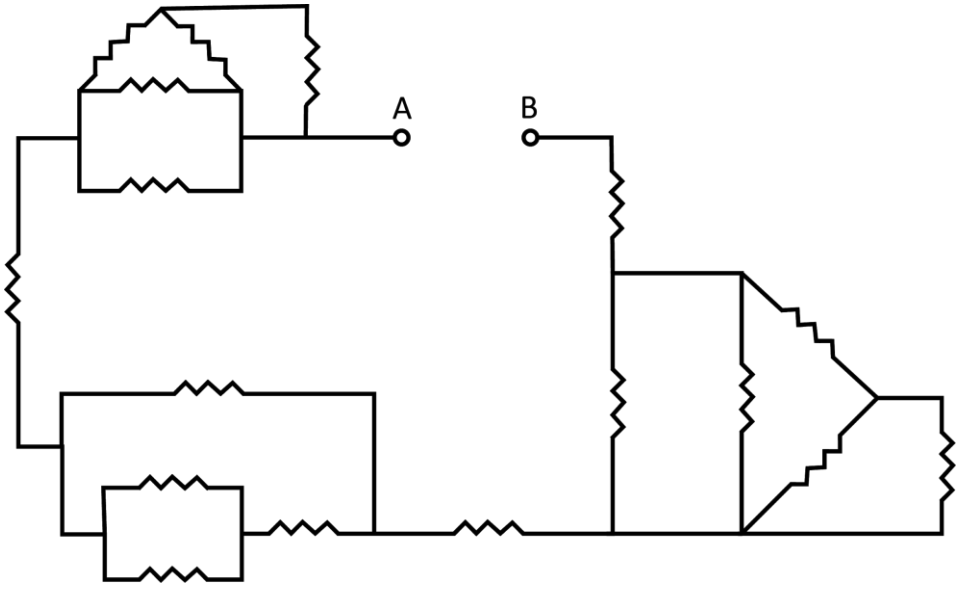

Figure 4

Problem 6 (8 marks)

A parallel-plate capacitor with capacitance *10*μF is connected to a 24V DC voltage source.

(a) [**2 marks**] What is the charge on each of its plates?

(b) [**3 marks**] Calculate the charge if the area of the plates is doubled but the separation is kept constant.

(c) [**3 marks**] Calculate the charge if the separation is quadrupled and the area is halved.

Problem 7 (6 marks)

(a) [**2 marks**] A solenoid has a radius of 10 mm and an average length of 0.5 m. If the number of turns is 200, calculate the self-inductance of the coil.

(b) [**4 marks**] A 50mH inductor is connected with a 12V battery and a 2Ω resistor in series. Sketch waveforms (with appropriate labels) for:

(i) the current in the circuit.

(ii) potential difference across the inductor.

(iii) potential difference across the resistor.

Problem 8 (10 marks)

The waveform given below shows the current through a1μF capacitor. Initial voltage across the capacitor is 0V, i.e. $v(0) = 0$V.

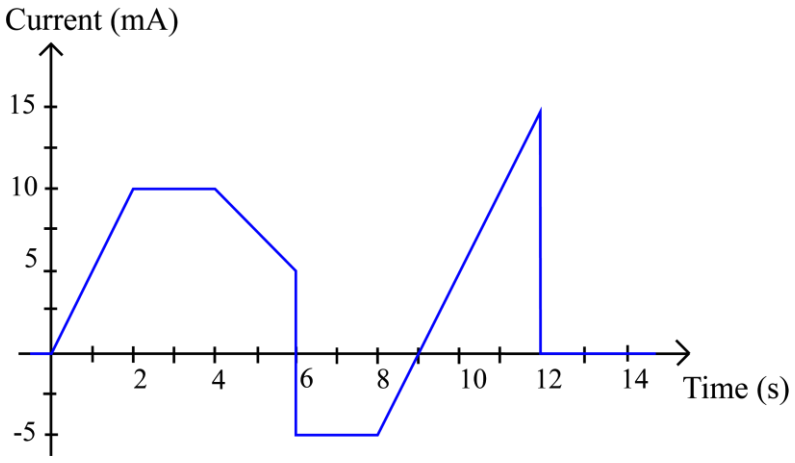

Figure 5

(a) [**5 marks**] Sketch the voltage waveform, all relevant points should be **labelled**.

(b) [**2 marks**] Calculate the instantaneous power at $t = 4s$.

(c) [**3 marks**] Compute the energy delivered to the capacitor at $t = 3$s.

Problem 9 (8 marks)

The waveform below shows the current across a 2mH inductor over time.

(a) [**5 marks**] Plot the waveform for the voltage over the same time period

(b) [**3 marks**] Find the energy stored in the inductor at t = 5ms.

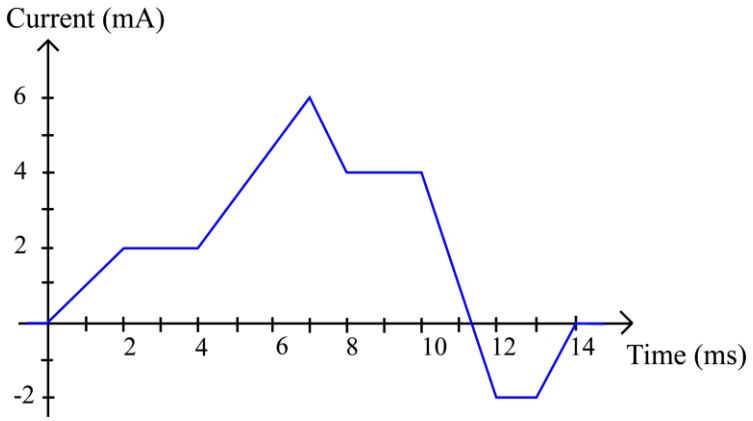

Figure 6

Problem 10 (8 marks)

The voltage and current across an element are given by:

$$v(t) = 30 - 30e^{-15t}\text{V}$$

$$i(t) = 75e^{-15t}\text{mA}$$

for $t \geq 0$,and they are zero otherwise.

(a) [**2 marks**] Give an expression for the instantaneous power across the element.

(b) [**3 marks**] At what time is maximum power delivered to the element?

(c) [**3 marks**] Calculate the total energy supplied to the element.

Problem 11 (9 marks)

The independent current source in the circuit shown generates the following current:

$$\begin{cases} i(t) = 0 & ; \quad t \leq 0 \\ 14te^{-2t}\text{A} & ; \quad t > 0. \end{cases}$$

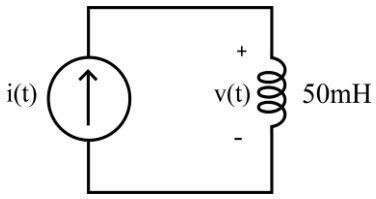

Figure 7

(a) [**2 marks**] Sketch the waveform for the current through the inductor.

(b) [**2 marks**] At what instant is the current maximum?

(c) [**3 marks**] Express the voltage across the inductor as a function of time.

(d) [**2 marks**] Plot the voltage waveform.