Fall 2018: EE-240 Circuits I
Assignment # 01
Due Date: 25 September 2018, Tuesday
Please read the following instructions:

- Submit the assignment on A-4 sheets bound together. Please note that assignments submitted from torn notebook pages will not be accepted.
- You are required to submit the assignment at the start of class on the due date. Late submissions will not be accepted.
- Please ensure that you have clearly written your name and roll numbers on the assignment.
- The assignment is long, so you are advised to start as soon as possible. Please note that no deadline extension requests will be entertained.
- You are aware of the LUMS honor code; therefore any attempts at plagiarism will be directly reported to the Disciplinary Committee. If you are facing any difficulties or have questions, ask the course staff (Instructor/TA), they are there to help you.
- The total marks for the assignment are **100.**

Q1: (17 marks)

a) The total charge entering a terminal is given by Q= 5t sin(4*pi*t) mC. Calculate the current at t= 0.5 s. [2]

b) The current flowing through an element is

$$i = \begin{cases} 2 & ; 0<t<=1 \\ 2t^2 & ; \quad t>1 \end{cases}$$

Calculate the charge entering the element from t = 0 to t = 2 s. [2]

c) Determine the total charge entering a terminal between t =1 s and t =2 s if the current passing the terminal is i= ($3t^2$ – t) Amps. [2]

d) An energy source forces a constant current of 2 A for 10 s to flow through a light bulb. If 2.3 kJ is given off in the form of light and heat energy, calculate the voltage drop across the bulb. [2]

e) To move charge *q* from point *a* to point *b* requires -30 J. Find the voltage drop if:
1) q = 2 C [2]
2) q = -6 C. [2]

f) Find the power delivered to an element at t = 3 ms if the current entering its positive terminal is:

I = 5 cos(60*pi*t) Amps

and the voltage is:
1) *v* = 3*i* [2]
2) *v* = 3 *di/dt*. [3]

Q2: (6 marks) The charge entering the positive terminal of an element is:

Q= 10 sin (4*pi*t) mC

while the voltage across the element is:

v= 2 cos (4*pi*t) V

a) Find the power delivered to the element at t = 0.3 s. [3]
b) Calculate the energy delivered to the element between 0 and 0.6 s . [3]

Q3: (9 marks) The current entering the positive terminal of a device is $i(t) = 3e^{-2t}$ Amps and the voltage across the device is $v(t) = 5\ di/dt$ Volts

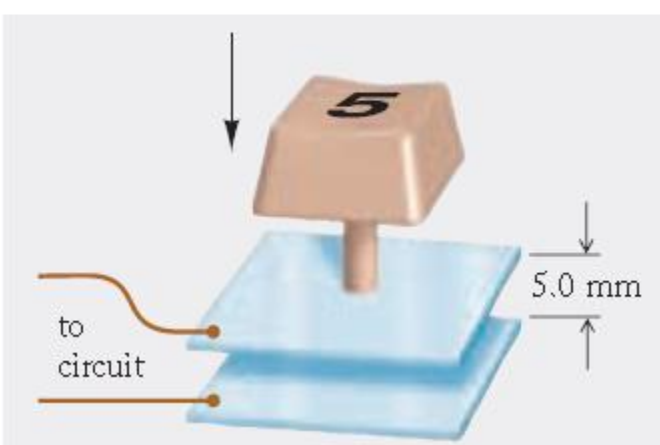
(a) Find the charge delivered to the device between t = 0 and t =2 s. [3]
(b) Calculate the power absorbed. [3]
(c) Determine the energy absorbed in 3 s. [3]

Q4: (6 marks) A capacitor with capacitance 1 F is attached in series with a 1 Ohm resistor and the switch is open. The capacitor is charged and has a voltage of 1 volt across it at $t=0^-$. The current in the circuit is of the form $i=e^{-t}$ amps for t > 0. At one instance the current in the circuit is 0.37 A. For that instance:

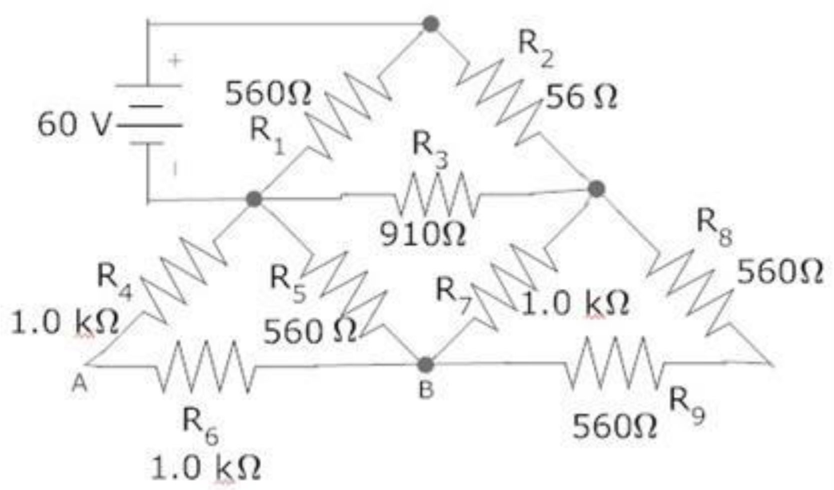
a) Calculate the rate at which the voltage across the capacitor is changing. [3]
b) Calculate the charge present on the capacitor. [3]

Q5: (6 marks) This question will use capacitors in an example which shows their use in objects from our daily lives. In many keyboards, the switches under the keys consist of small parallel-plate capacitors (see the figure below). The key is attached to the upper plate, which is movable. When you push the key down, you push the upper plate toward the lower plate, and you alter the plate separation 'd' and the capacitance. The capacitor is connected to an external circuit that maintains a constant potential difference V across the plates. The change of capacitance therefore sends a pulse of charge from the capacitor into the computer circuit. Suppose that the initial plate separation is 5.0 mm and the initial capacitance is 6.0×10^{-13} F. The final plate separation (with the key fully depressed) is 0.20 mm. The constant potential difference is 8.0 V.

a) What is the change in capacitance when you depress the key? [2]
b) What is the amount of electric charge that flows out of the capacitor into the computer circuit? [2]
c) What happens to the energy stored in the capacitor? (Give reasoning) [2]

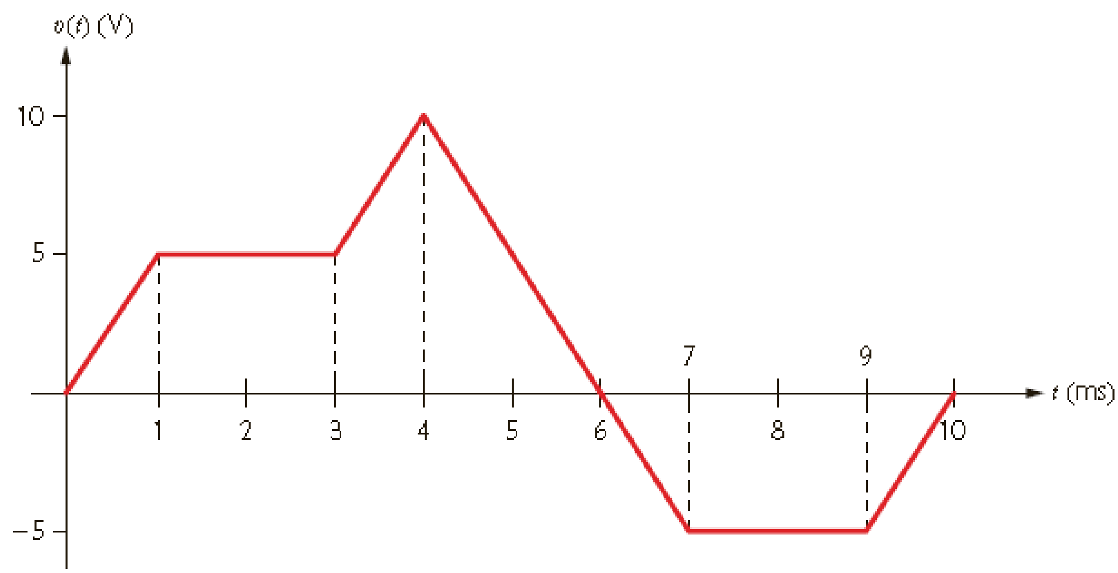


Q6: (10 marks) Calculate the equivalent resistance that is in series with the 60V source:

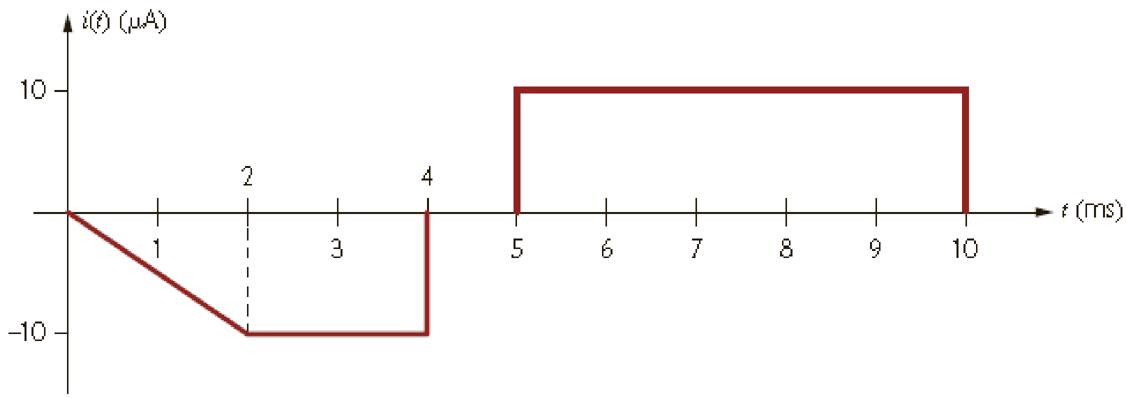


Q7: (16 marks)

a) The voltage across a 5-μF capacitor is shown in the figure below. Find the waveform for the current in the capacitor. How much energy is stored in the capacitor at t = 4 ms? [8]



b) The waveform for the current in a 1-nF capacitor is the figure below. If the capacitor has an initial voltage of −5 V, determine the waveform for the capacitor voltage. How much energy is stored in the capacitor at t = 6 ms? [8]



Q8: (6 marks) If the current flowing through an element is given by

$$i(t) = \begin{cases} 3t & ; \quad 0 <= t < 6 \text{ s} \\ 18 & ; \quad 6 <= t < 10 \text{ s} \\ -12 & ; \quad 10 <= t < 15 \text{ s} \\ 0 & ; \quad t >= 15 \text{ s} \end{cases}$$

Plot the charge stored in the element over $0 < t < 20$ s. Show your working to get full credit. [6]

Q9: (13 marks) The voltage across a 200-mH inductor is given by the expression

$$v(t) = \begin{cases} (1 - 3t)\, e^{-3t} \text{ mV} & ; \quad t \geq 0 \\ 0 & \quad t < 0 \end{cases}$$

Find the expressions and plot the waveforms (clearly labelling all important points) for:

a) Current [5]

b) Power [4]

c) Energy [4]

Q10: (11 marks) The current in a 50-mH inductor is specified as follows:

$$i(t) = \begin{cases} 0 & ; \quad t < 0 \\ 2t\, e^{-4t}\ A & ; \quad t > 0 \end{cases}$$

Find:

(a) the voltage across the inductor. [3]

(b) the time at which the current is a maximum [4]

(c) the time at which the voltage is a minimum. [4]