Desk Copy

ECE 300
Test #2
Spring Semester, 2004

wlg
AM Section

Name W. Green
Print (last, first)

This is a closed book, closed notes test. Use engineering paper for your work and work only on one side of your paper. Do not place any work on the exam sheet. Show how you obtain your answers.

(1) The switch in the circuit of Figure 1 has been closed for a very long time. Consider the circuit to be in steady state. Answer the following for $t > 0$.

20%

(a) 3
6
6

(b) 5

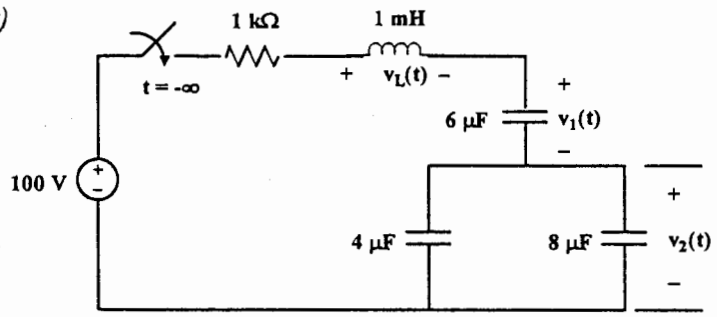


Figure 1: Circuit for problem 1.

(a) Determine the voltages $v_L(t)$, $v_1(t)$, and $v_2(t)$.
(b) How much energy is stored in the 4 μF capacitor?

(2) You are given the circuit of Figure 2.

30%

(a) 7
(b) 7
(c) 7
(d) 3
(e) 6

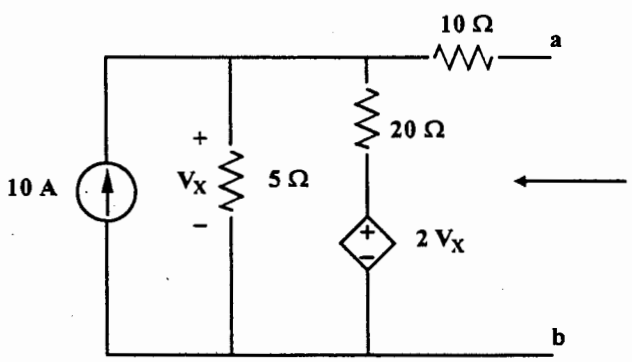


Figure 2: Circuit for problem 2.

(a) Determine the short-circuit current, that is, the current flowing through a wire with zero ohms connected between a-b.

(b) Determine the open-circuit voltage, that is, the voltage between terminals a-b with the short removed.

(c) Determine V_{TH} (Thevenin's voltage) and R_{TH} (Thevenin's resistance) looking into a-b.

(2) continued

(d) Draw the Thevenin circuit.

(e) Using your Thevenin circuit, connect a 25 Ω resistor between terminals a-b and determine the voltage, V_{ab}.

(3) You are given the circuit shown in Figure 3a. V_S is a constant voltage, but unknown.

20%

(a) 6

(b) 8

(c) 6

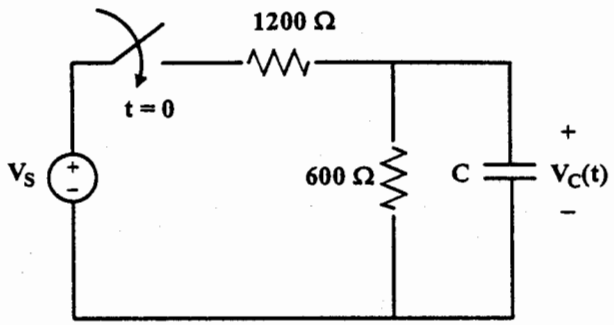


Figure 3a: Circuit for problem 3.

The step response of $V_C(t)$ is shown in Figure 3b.

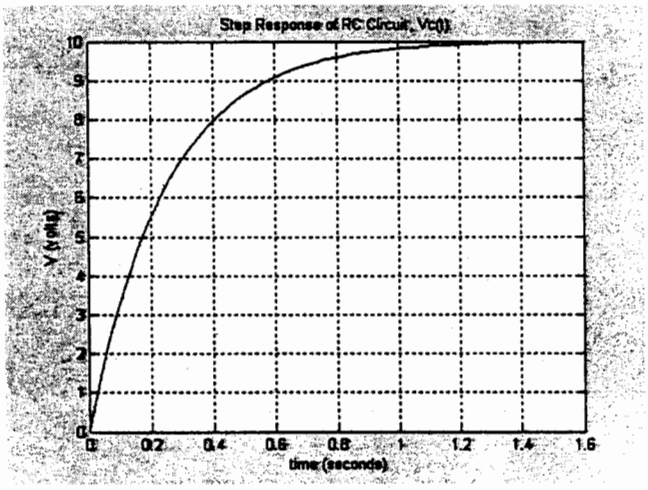


Figure 3b: Step response of circuit in Figure 3a.

(a) Determine the circuit time constant.

(b) Determine the value of C.

(c) Determine the value of V_S, the source voltage.

(4) You are given the circuit of Figure 4.

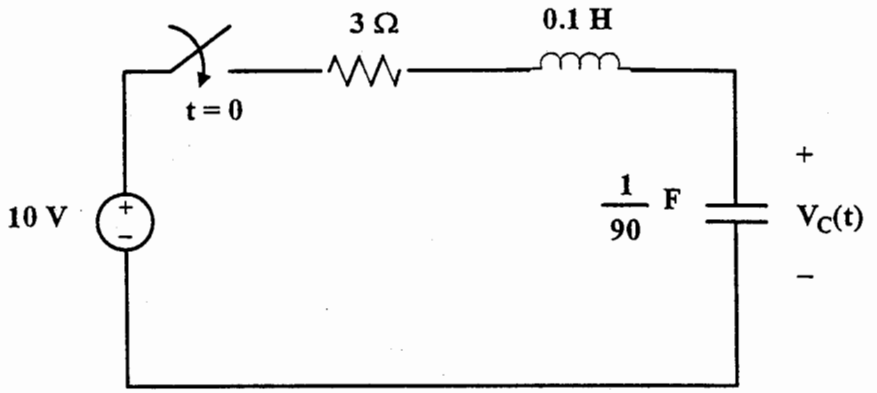


Figure 4: Circuit for problem 4.

(a) Determine the differential equation that can be used to determine the capacitor voltage, $v_C(t)$.

(b) From the differential equation of part (a), give the characteristic equation. Also, give the values of ξ (zeta) and ω_n.

(c) Solve the differential equation of part (a) for $v_C(t)$.

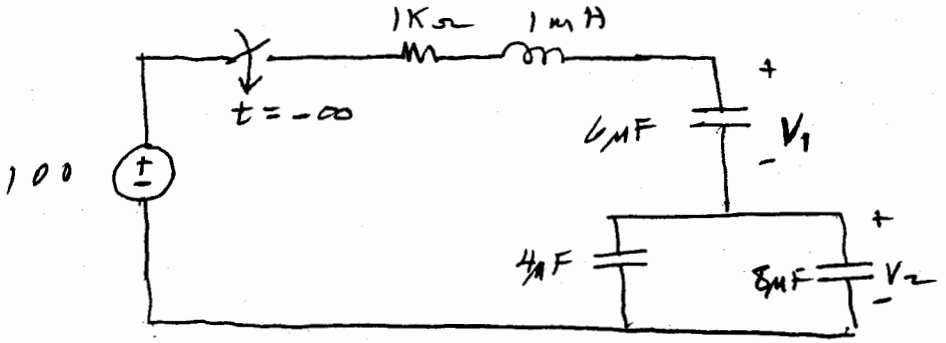
24
18
20
62

45
12
15
72

100
36
64

Test #2

(1) Find V_L, V_1 and V_2 for the following circuit, $t > 0$.



Find the equivalent C, then q.

$$C_{eq} = 6\mu F \parallel 12\mu F = 4\mu F$$

$$q = CV = 4\mu F \times 100 = 0.4 \times 10^{-3} \text{ Coulombs}$$

$$V_1 = \frac{q}{6\mu F} = \frac{4 \times 10^{-4}}{6 \times 10^{-6}} = \frac{2}{3} \times 10^{2} \text{ V}$$

$$\boxed{V_1 = 66.67 \text{ V}}$$

$$V_2 = \frac{q}{12\mu F} = \frac{4 \times 10^{-4}}{12 \times 10^{-6}} = \frac{1}{3} \times 10^{2}$$

$$\boxed{V_2 = 33.33}$$

(b) $$W = \frac{1}{2} C V^2 = \frac{1}{2} (4 \times 10^{-6}) \times (33.33)^2$$

$$W_{4\mu F} = 2.22 \times 10^{-3} \text{ J}$$

(2) For the circuit below

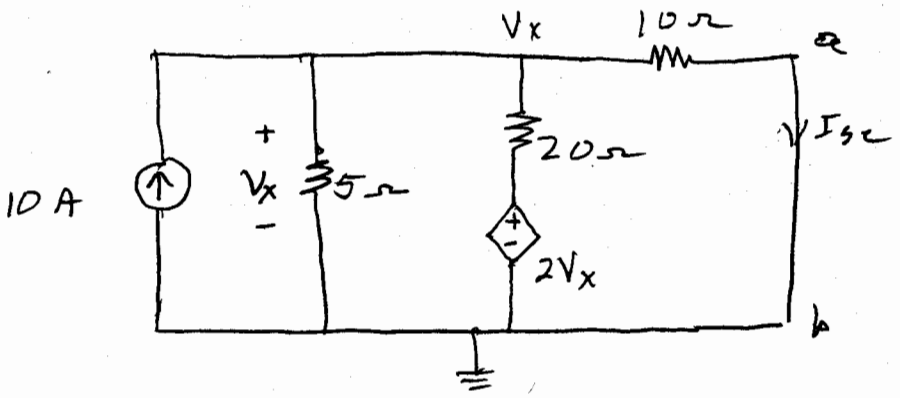
(a) Determine the short-circuit current. 4A

(b) Determine the open-circuit voltage. 66.7V

(c) Determine V_{TH} and R_{TH} 16.67Ω

(d) Draw the Thevenin circuit

(e) Using the Thevenin circuit determine the voltage across a 20Ω resistor connected between a-b. 60V



$$\frac{V_x}{5} + \frac{V_x - 2V_x}{20} + \frac{V_x}{10} = 10$$

$$4V_x - V_x + 2V_x = 200$$

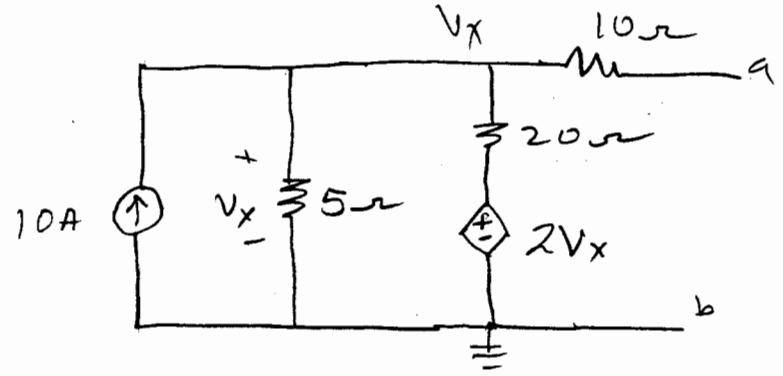
$$5V_x = 200$$

$$V_x = 40\,V$$

$$I_{sc} = \frac{V_x}{10} = \frac{40}{10} = 4\,A$$

(Continued)

(2)



$V_{ab} = V_{os} = V_x$

$$\frac{V_x}{5} + \frac{V_x - 2V_x}{20} = 10$$

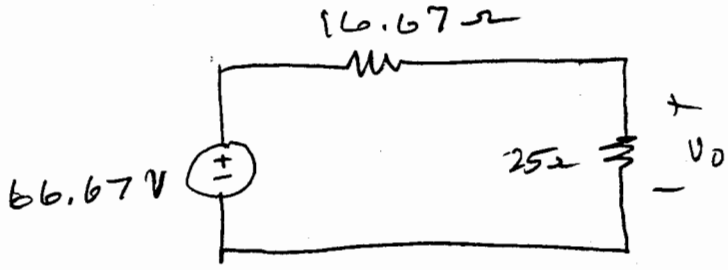
$$4V_x - V_x = 200$$

$$V_x = \frac{200}{3} = V_{oc} = 66.7\ V$$

$$R_{TH} = \frac{V_{os}}{I_{sc}} = \frac{200/3}{4} = \frac{50}{3}\ \Omega$$

$R_{TH} = 16.67\ \Omega$

$V_{TH} = \frac{200}{3} = 66.67\ V$



$$V_o = \frac{66.7 \times 25}{25 + 16.67} = 60\ V$$

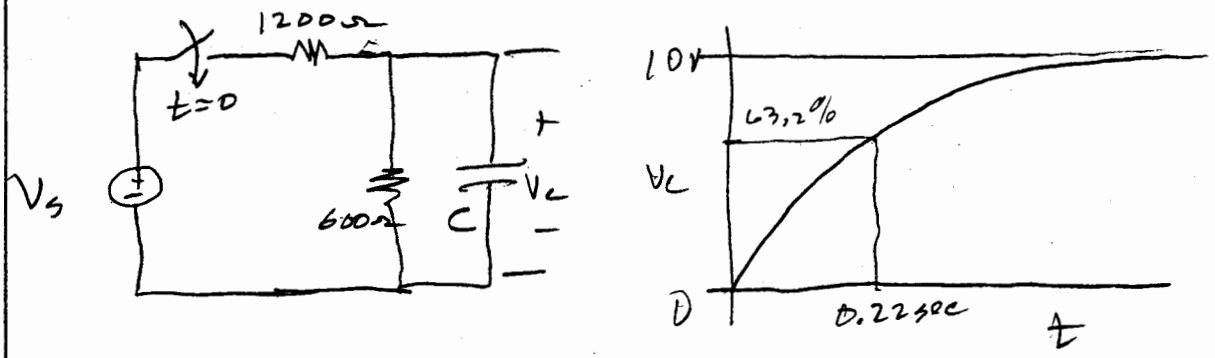
$V_o = 40\ V$

(3) For the circuit below, with the given step response, determine:

(a) τ, time constant. $\tau = 0.22$ sec

(b) the value of C. $C = 0.55 \times 10^{-3}$ F

(c) the value of V_s. $V_s = 30$ V



(a) Using the graphical step response,

$\tau = 0.22$ sec.

(b) $\tau = RC$

$R = 600 \| 1200 = 400\Omega$

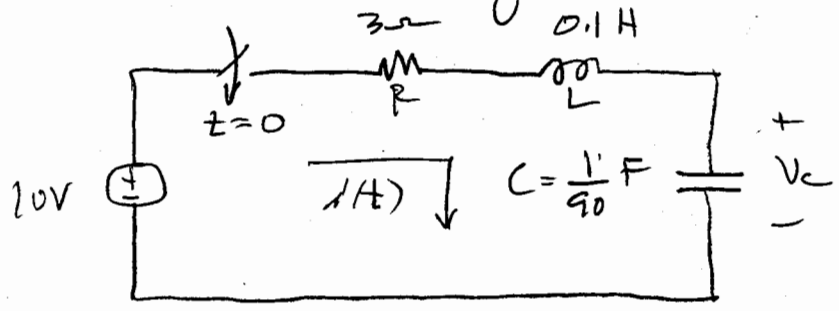
$$C = \frac{\tau}{R} = \frac{0.22}{400} = 0.55 \times 10^{-3} \text{ F}$$

$C = 0.55 \times 10^{-3}$ F

(c) $$V_c = 10 = \frac{V_s \times 600}{1800} = \frac{V_s}{3}$$

$V_s = 30$ volts

(4) For the following circuit determine



(a) the diff. that can be solved to determine $V_c(t)$.

(b) the characteristic equation and ζ, ω_n.

(c) the solution to the diff. eq.

1a)

$$Ri + L\frac{di}{dt} + V_c(t) = 10 \qquad (1)$$

Using $$i(t) = C\frac{dV_c}{dt} \qquad (2)$$

$$RC\frac{dV_c}{dt} + LC\frac{d^2V_c}{dt^2} + V_c(t) = 0$$

$$\frac{d^2V_c}{dt^2} + \frac{R}{L}\frac{dV_c}{dt} + \frac{V_c(t)}{LC} = 0 \qquad (3)$$

(b) $$\ddot{V}_c(t) + \frac{3}{0.1}\dot{V}_c(t) + \frac{90}{0.1} = 0$$

$$\ddot{V}_c + 30\dot{V}_c + 900V_c = 0$$

Char. Eq.

$$\boxed{s^2 + 30s + 900 = 0} \qquad (4)$$

(4) continued

$$s^2 + 30s + 900 = 0$$

compare with

$$s^2 + 2\zeta\omega_n s + \omega_n^2 = 0$$

$$\boxed{\omega_n = 30}$$

$$2\zeta\omega_n = 30$$

$$2\zeta = 1$$

$$\zeta = 0.5$$

$$(s^2 + 30s + 900) = 0$$

$$s_1 = -15 + j26, \quad s_2 = -15 - j26$$

$$v_c(t) = 10 + e^{-15t}\left[A_1 \cos(26t) + A_2 \sin(26t)\right]$$

$$\boxed{v_c(0) = 0}$$

From (2), with $i(0^+) = 0$

$$\boxed{\dot{v}_c(0) = 0}$$

$$A_1 = -10$$

$$\dot{v}_c(0) = 0 = e^{-15t}\left[-26A_1 \sin(26t) + 26A_2 \cos 26t\right.$$

$$\left. -15e^{-15t}\left[A_1 \cos 26t + A_2 \sin 26t\right]\right.$$

$$\boxed{0 = 26A_2 - 15A_1} = 26A_2 - 150$$

$$\boxed{A_1 = -10, \quad A_2 = 5.77}$$

$$v_c(t) = 10 - e^{-15t}\left[10\cos(26t) - 5.77 \sin(26t)\right]$$