Name ____ Mailbox __________________

ECE-205

Exam 1

Fall 2011

Calculators can only be used for simple calculations. Solving integrals, differential equations, systems of equations, etc. does not count as a simple calculation.

You must show your work to receive credit.

Problem 1 __________/20

Problem 2 __________/30

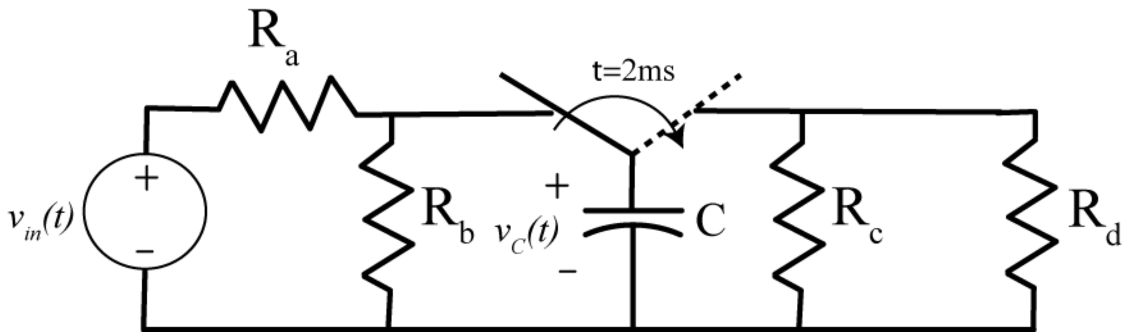
Problem 3 __________/18

Problem 4-11 __________/32

Total ______________

Name ____ Mailbox __________________

1) (20 points) Consider the circuit shown in the figure below:



a) Determine an expression for the time constant of the circuit for the time when the capacitor is charging ($t < 0.002$ seconds) and discharging ($t > 0.002$ seconds) in terms of the parameters C, R_a, R_b, R_c and R_d. (Do not use numbers).

b) Determine an expression for the static gain of the circuit for $t < 0.002$ seconds in terms of the parameters C, R_a, R_b, R_c and R_d. (Do not use numbers).

c) For $R_a = 1k\Omega, R_b = 1k\Omega, R_c = 2k\Omega, R_d = 10k\Omega, C = 2\mu F, V_{in} = 6V$ accurately *sketch* the voltage across the capacitor from 0 to 12 ms. You need to specifically lablel the voltages at $t = 0.002$ seconds and $t = 0.012$ seconds. You need to primarily determine the appropriate time constants and steady state values, and use the following table as a guide.

Time (t)	t/τ	$y(t)$
0	0	0 y_{ss}
τ	1	0.632 y_{ss}
2τ	2	0.865 y_{ss}
3τ	3	0.950 y_{ss}
4τ	4	0.982 y_{ss}
5τ	5	0.993 y_{ss}

Name ____ Mailbox __________________

2) (30 points) For the following three differential equations, assume the input is $x(t) = 4u(t)$ (the input is equal to four for time greater than zero), and the initial conditions are $y(0) = \dot{y}(0) = 0$

Determine the solution to each of the following differential equations and put your final answer in a box. Be sure to use the initial conditions to solve for all unknowns. You must show all your work to receive credit.

a) $\ddot{y}(t) + 2\dot{y}(t) + y(t) = 3x(t)$

b) $\ddot{y}(t) + 5\dot{y}(t) + 4y(t) = 2x(t)$

c) $\ddot{y}(t) + 4\dot{y}(t) + 16y(t) = 4x(t)$

Name ____ Mailbox __________________

3) (18 points) The form of the under damped ($0 < \zeta < 1$) solution to the second order differential equation

$$\ddot{y}(t) + 2\zeta\omega_n \dot{y}(t) + \omega_n^2 y(t) = \mathrm{K}\ \omega_n^2 x(t)$$

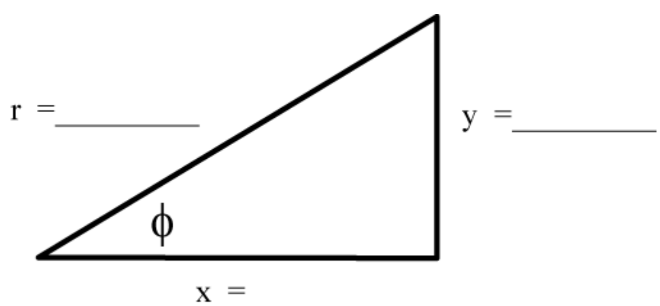
for a step input $x(t) = Au(t)$ is

$$y(t) = KA + ce^{-\zeta\omega_n t}\sin(\omega_d t + \phi)$$

where c and ϕ are constants to be determined and the damped frequency $\omega_d = \omega_n\sqrt{1-\zeta^2}$

a) Using the initial condition $\dot{y}(0) = 0$ show that $\tan(\phi) = \dfrac{\sqrt{1-\zeta^2}}{\zeta}$

b) We can express the relationship in part a using the following triangle. Fill in the blanks and then use this triangle determine an expression for $\sin(\phi)$.



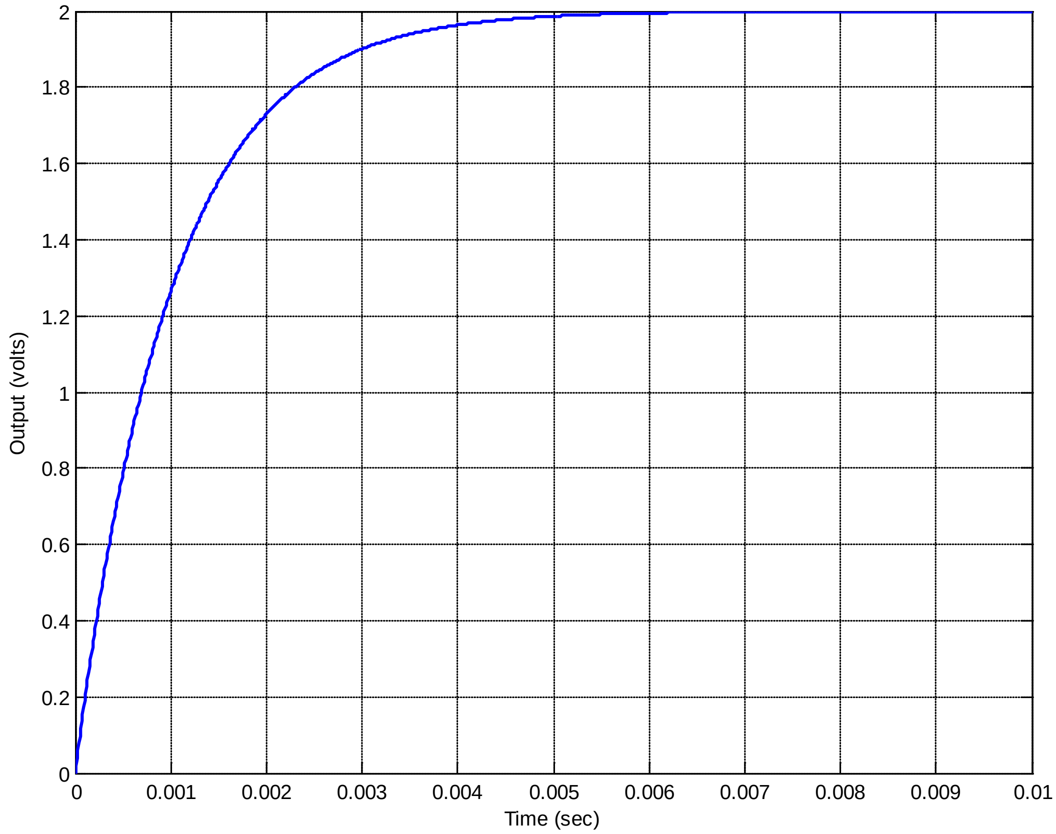
c) Use your answer to part b, and the initial condition $y(0) = 0$ to determine the remaining unknown constant, and write out the complete solution for $y(t)$.

Name ____ Mailbox __________________

Problems 4-11, 4 points each, no partial credit (32 points)

4) Consider the response of a first order circuit shown below. Of the following, which is the best estimate of the time constant?

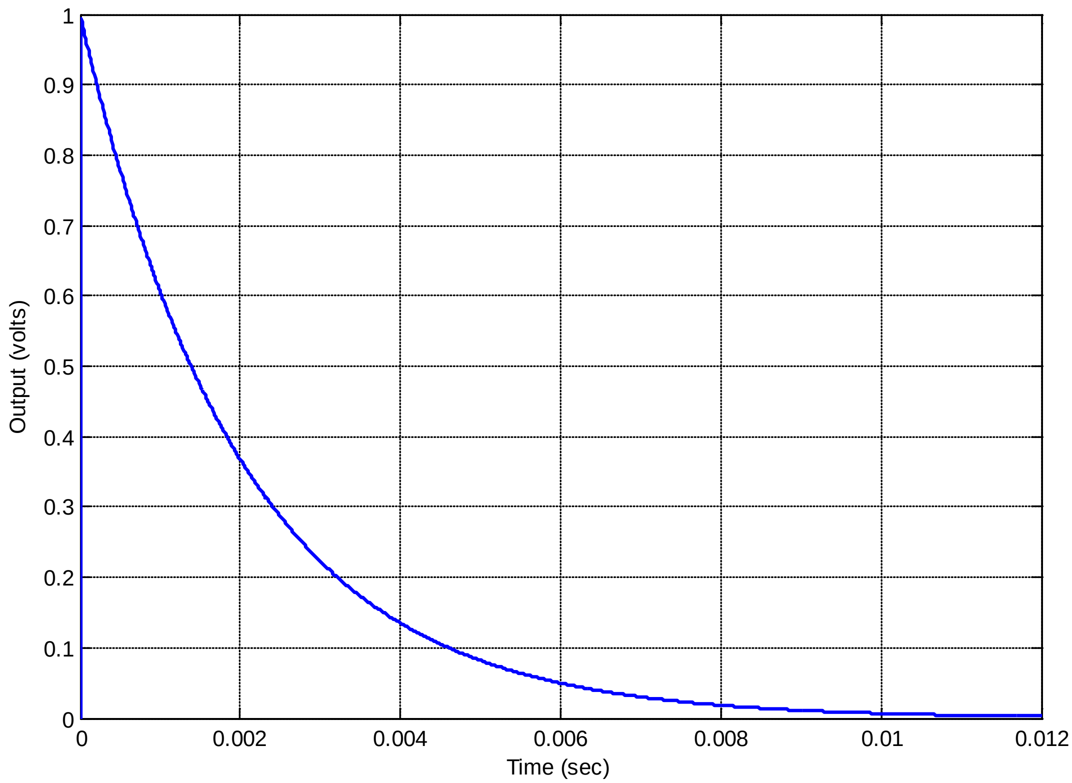
a) 0.001 sec   b) 0.002 sec   c) 0.003 sec   d) 0.004 sec e) 0.005 sec   f) 0.006 sec



Name ____ Mailbox __________________

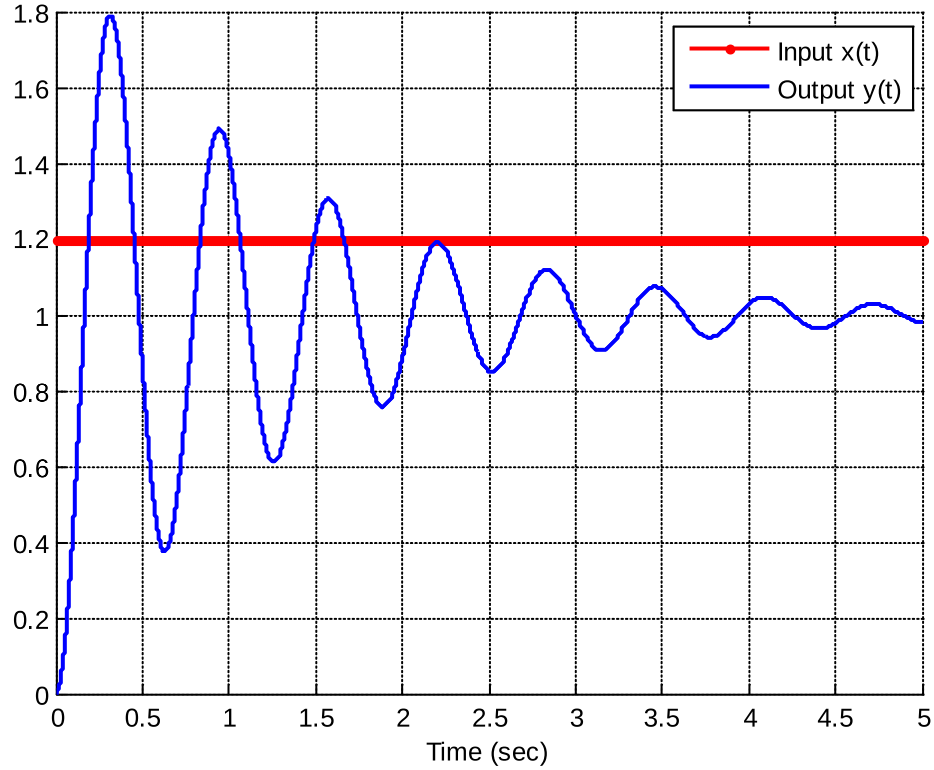
5) Consider the response of a first order circuit shown below. Of the following, which is the best estimate of the time constant?

a) 0.001 sec   b) 0.002 sec   c) 0.003 sec   d) 0.004 sec e) 0.005 sec   f) 0.006 sec



Name ____ Mailbox ________________

Problems 6 and 7 refer the following graph showing the response of a second order system to a step input.



6) The percent overshoot for this system is best estimated as

a) 180% b) 150 % c) 100% d) 80 % e) 60% f) 50%

7) The static gain for this system is best estimated as

a) 1.8 b) 1.2 c) 1.00 d) 0.83 e) 0.5

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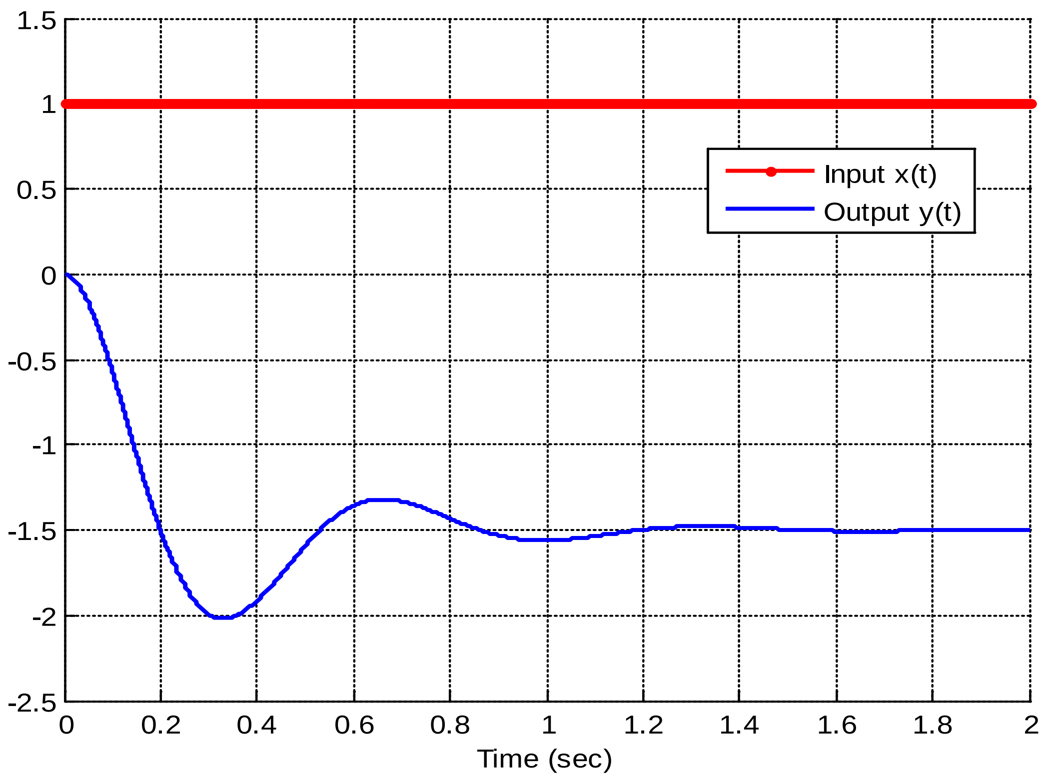
Problems 8-9 refer the following graph showing the response of a second order system to a step input.



8) The percent overshoot for this system is best estimated as

a) 300% b) -300 % c) 200% d) -200 % e) 33% f) -33%

9) The static gain for this system is best estimated as

a) -3 b) 3 c) 2.5 d) -2.5 e) 1.5 f) -1.5

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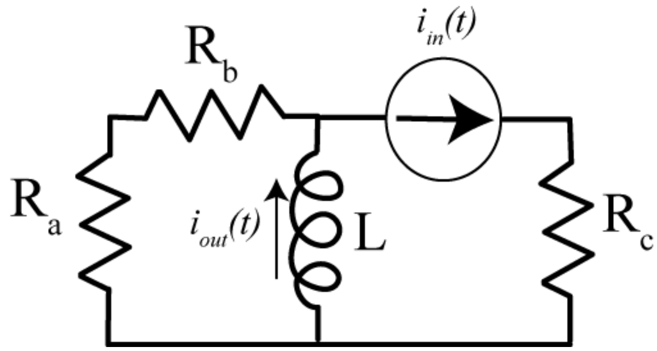
Problems 10 and 11 refer to the following circuit



10) The Thevenin resistance seen from the ports of the inductor is

a) $R_{th} = R_c \parallel (R_a + R_b)$ b) $R_{th} = R_c$ c) $R_{th} = R_a + R_b$ d) $R_{th} = R_a + R_b + R_c$ e) none of these

11) The static gain for the system is

a) $K = 1$ b) $K = \frac{R_a + R_b}{R_a + R_b + R_c}$ c) $K = \frac{R_c}{R_a + R_b + R_c}$ d) $K = \frac{R_c}{R_a + R_b}$ e) none of these

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