ECSE 2010
Electric Circuits
Exam 2
Spring 2007

Name ________________________

Section (please circle one)

MR	MR
10-12	2-4
Millard	Abouzeid

Problem No.	Pts.	Score
1	10pts	
2	25pts	
3	25pts	
4	20pts	
5	20pts	
Total	100pts	

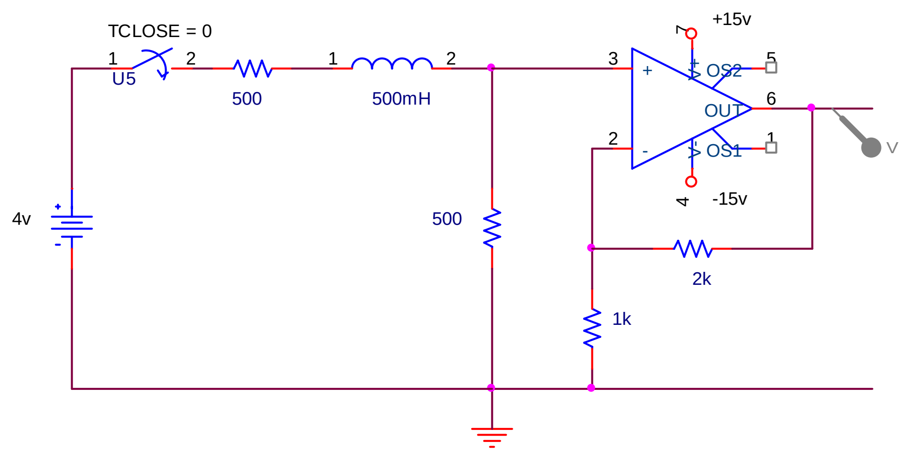
Please Note:

* Place all your answers in the spaces provided.
* You MUST show your work to receive any credit.

*** Assume ALL sources are turned ON at t=0, unless noted otherwise.**

Problem 1 (10pts)

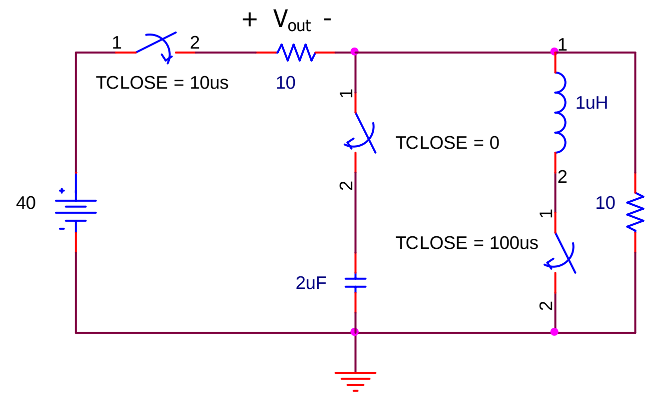
Find an expression for V(t) in the circuit shown for t ≥ 0 (at the output of the Op Amp).



V(t)	

Problem 2 (25pts)

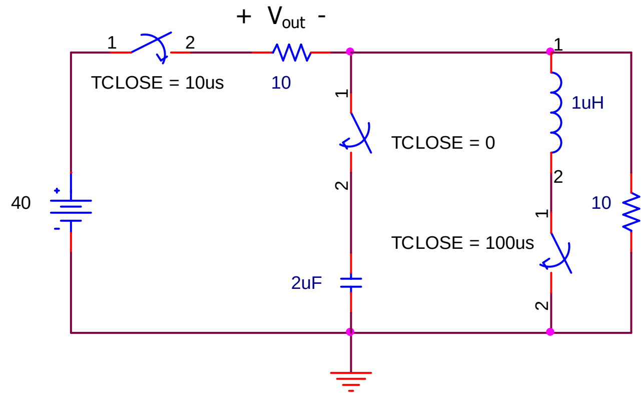
a.) Find V_{out} (across the 10 ohm resistor) at each of the times indicated for the circuit shown, assuming that no energy was stored before t=0. (15pts)

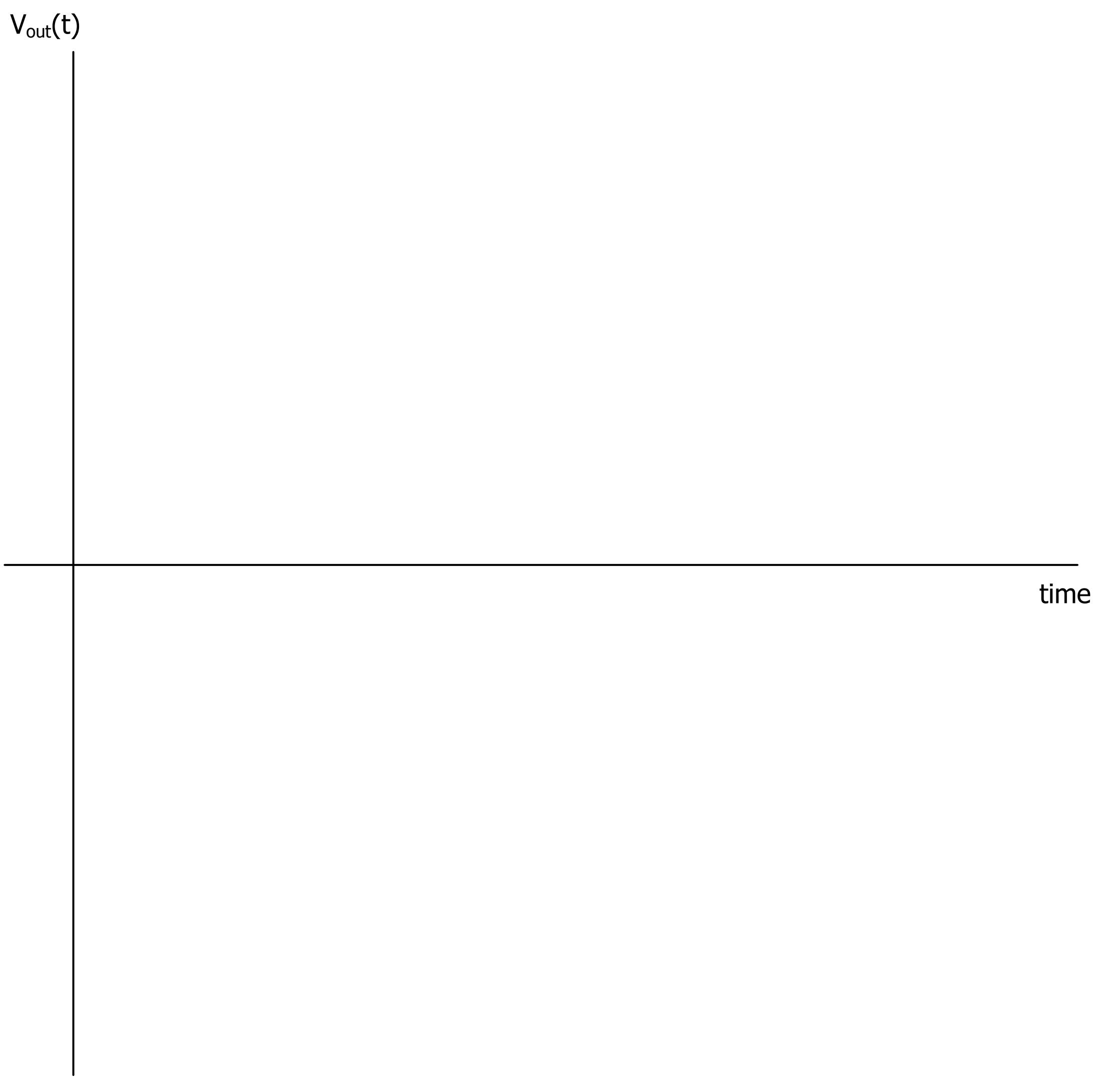


$V_{out}\,(10us^{+})$	
$V_{out}\,(100us^{+})$	
$V_{out}\,(500us^{+})$	

Problem 2 (cont)

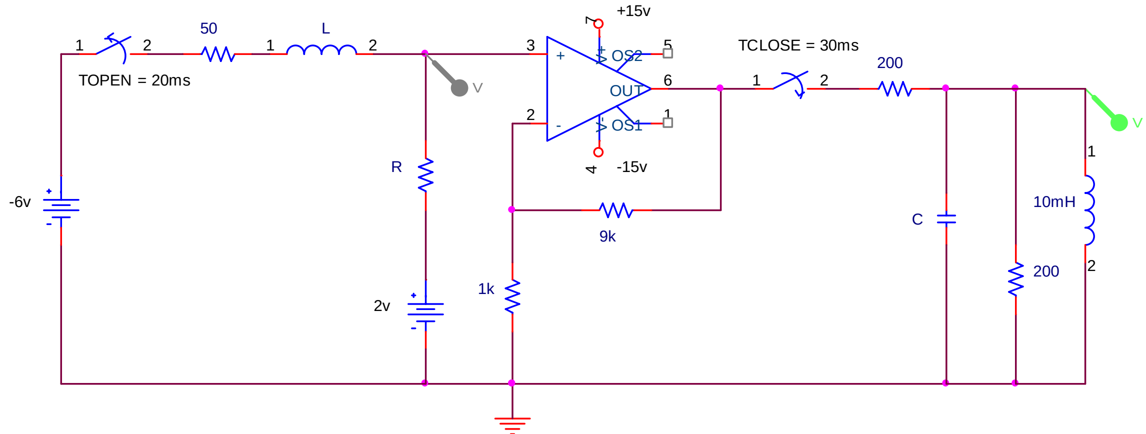
b.) Sketch $V_{out}(t)$ (across the 10ohm resistor) for $0 \leq t < 500$us; showing **ALL** pertinent values at the critical points in time (e.g. time constants). (10pts)

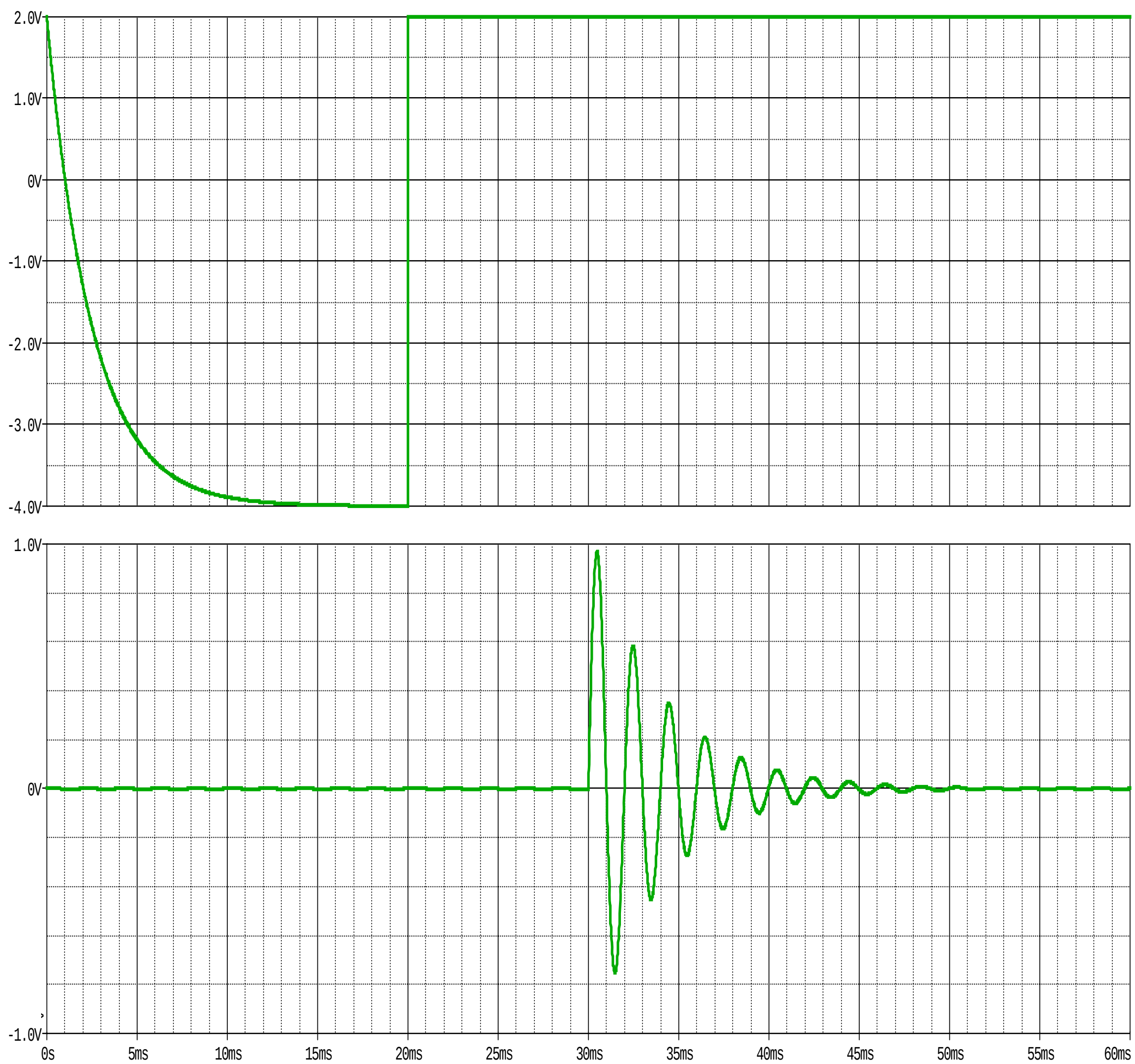




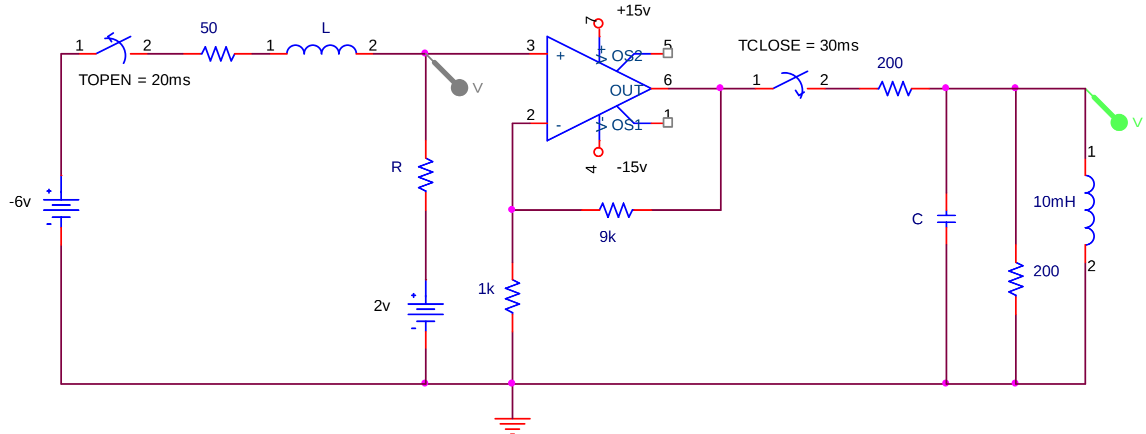
<u>Problem 3</u> (25pts)

Given the corresponding plots that result from the voltage markers in circuit shown; find the values of the circuit's components (L, R, and C).





Problem 3 (cont)



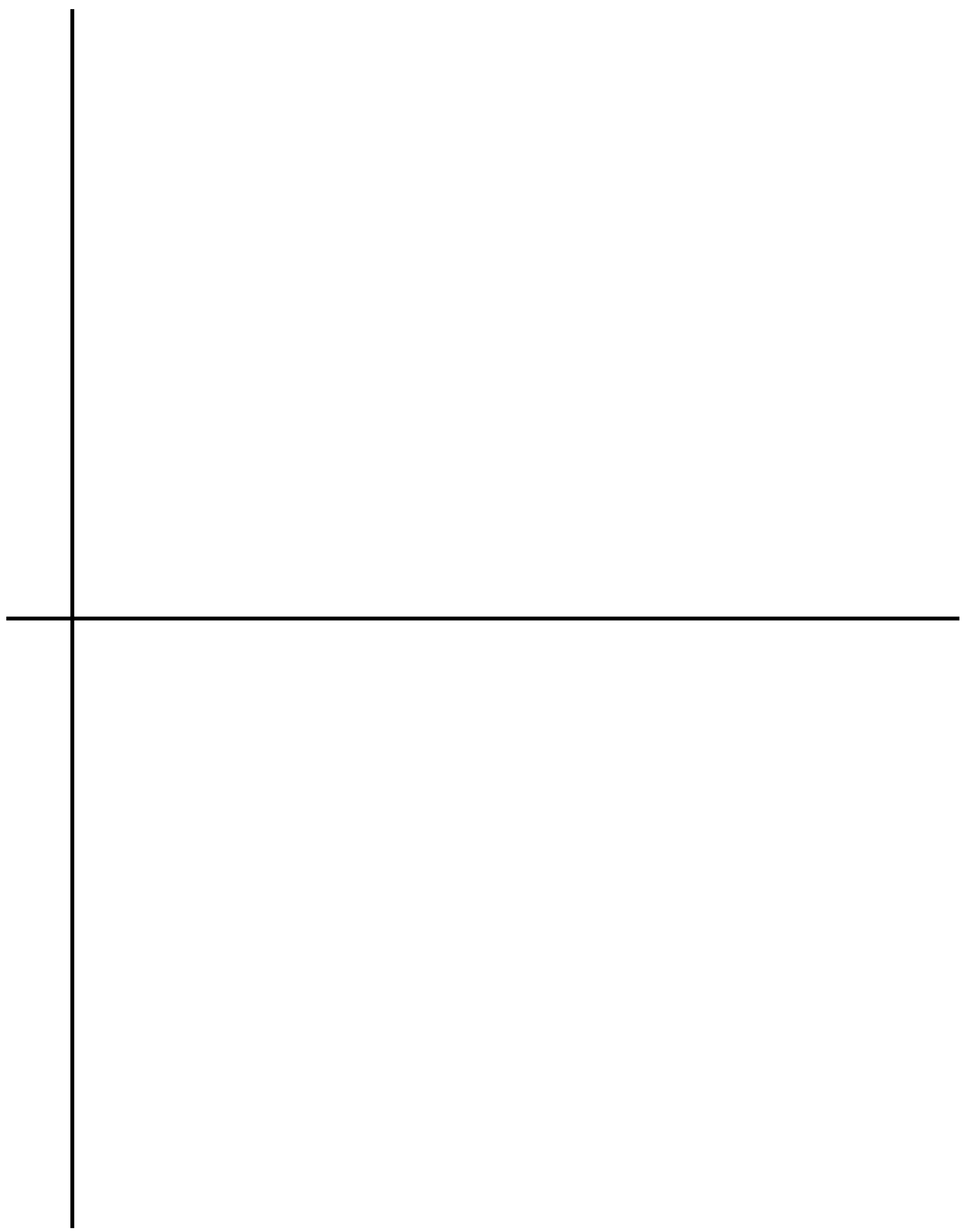
R (5pts)	
L (10pts)	
C (10pts)	

Problem 4 (20pts) Name ________________________

A circuit has an output voltage whose Laplace transform is:

$$V_O(s) = \frac{200s}{(s^2 + 12s + 20)(s + 20)}$$

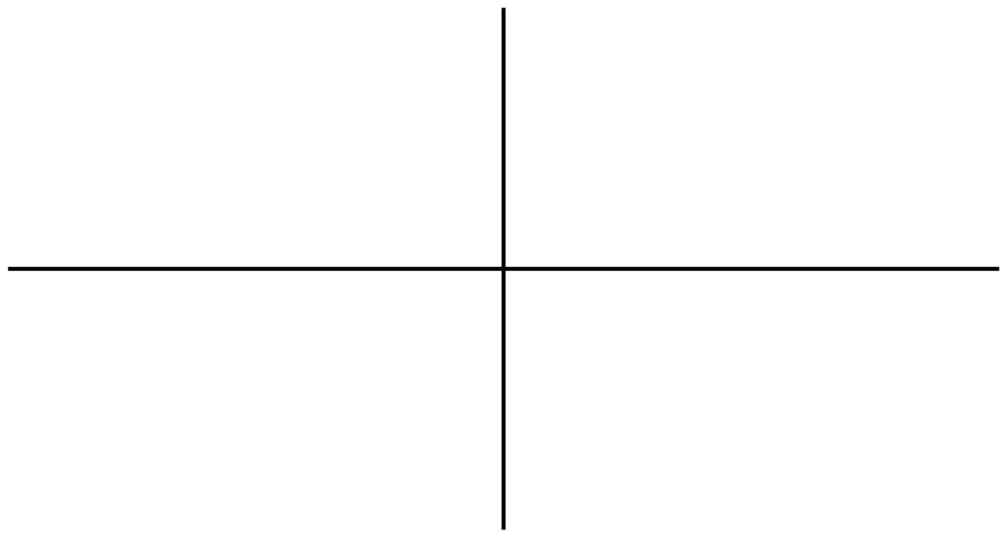
a.) Sketch $V_o(t)$ for the circuit. (10pts)



Problem 4 (cont) Name ________________________

Given: $$V_O(s) = \frac{200s}{(s^2 + 12s + 20)(s + 20)}$$

b.) Sketch the pole/zero diagram of $V_o(s)$. (5pts)

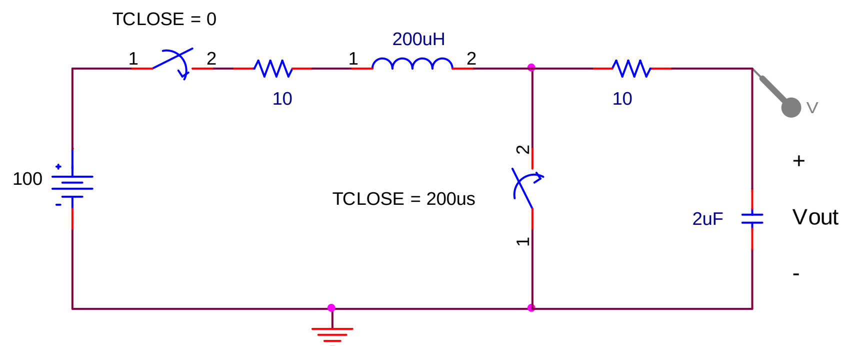


c.) Find the initial value of $V_o(t)$ as $t \rightarrow 0$. (5pts)

$V_o(t)$	

Problem 5 (20pts)

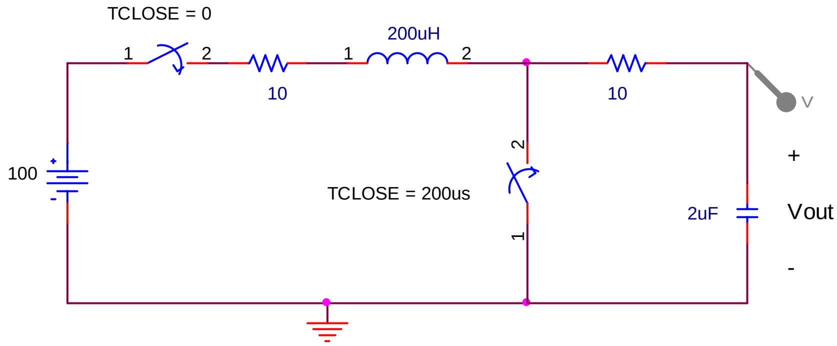
a.) Assume there is no stored energy in the L or C prior to t=0. Find $V_{out}(t)$ (across the capacitor) in the circuit shown for t > 200us. (5pts)



$V_{out}(t)$	

Problem 5 (cont)

b.) Find the response type (over, critically, or under) and $V_{out}(t)$ (across the capacitor) in the circuit shown for t < 200us. (15pts)



Type	
$V_{out}(t)$	

Extra space (if needed) Name ________________________

Extra space (if needed) Name ________________________

Laplace Transform Theorems

1. Definition $L[f(t)] = F(s) = \int_{0-}^{\infty} f(t)e^{-st}dt$

2. Linearity $L[k_1 f(t_1) + k_2 f(t_2)] = k_1 F_1(s) + k_2 F_2(s)$

3. Time shift $L[f(t-\tau)] = e^{-\tau s}F(s)$

4. Frequency Shift $L\left[e^{-at} f(t)\right] = F(s+a)$

5. Scaling Theorem $L[f(at)] = \frac{1}{a}F\left(\frac{s}{a}\right)$

6. Differentiation Theorem $L\left[\frac{df}{dt}\right] = sF(s) - f(0)$

7. Differentiation Theorem $L\left[\frac{d^2 f}{dt^2}\right] = s^2 F(s) - sf(0) - \dot{f}(0)$

8. Differentiation Theorem $L\left[\frac{d^n f}{dt^n}\right] = s^n F(s) - \sum_{k=1}^{n} s^{n-k} f^{k-1}(0)$

9. Integration Theorem $L\left[\int f(\tau)d\tau\right] = \frac{F(s)}{s} + \frac{\int^{0+} f(\tau)d\tau}{s}$

10. Final value theorem* $f(\infty) = \lim_{s\to 0} sF(s)$

11. Initial value theorem** $f(0^+) = \lim_{s\to\infty} sF(s)$

* Provided all poles of $F(s)$ have negative real parts with the exception of possibly one pole at the origin.

** Provided $f(t)$ is continuous or has a step discontinuity at $t = 0$.

Laplace Transform of Time Functions

1.	$\delta(t)$	1
2.	$u(t)$	$1/s$
3.	$tu(t)$	$1/s^2$
4.	$\frac{1}{2!}t^2u(t)$	$1/s^3$
5.	$\frac{1}{(m-1)!}t^{m-1}u(t)$	$1/\left(s^m\right)$
6.	$e^{-at}u(t)$	$1/(s+a)$
7.	$te^{-at}u(t)$	$1/(s+a)^2$
8.	$\frac{1}{(m\text{-}1)!}t^{m-1}e^{-at}u(t)$	$1/(s+a)^m$
9.	$(1-e^{-at})u(t)$	$a/[s(s+a)]$
10.	$\frac{1}{a}\ (at-1+e^{-at})u(t)$	$a/[s^2(s+a)]$
11.	$(1-at)e^{-at}u(t)$	$s/(s+a)^2$
12.	$\sin(\omega t)u(t)$	$\omega/(\mathrm{s}^2+\omega^2)$
13.	$\cos(\omega t)u(t)$	$s/(\mathrm{s}^2+\omega^2)$
14.	$e^{-at}\cos(\omega t)u(t)$	$(s+a)/[(s+a)^2+\omega^2]$
15.	$e^{-at}\sin(\omega t)u(t)$	$\omega/[(s+a)^2+\omega^2]$
16.	$\left\{1-\frac{1}{\sqrt{1-\zeta^2}}e^{-\zeta\omega_n t}\left[\sin(\omega_d t+\theta)\right]\right\}u(t)$	
	$\omega_\mathrm{d}=\omega_n\sqrt{1-\zeta^2}\ ;\quad \theta=\cos^{-1}(\zeta)$	
OR	$\left\{1\text{-}e^{-\zeta\omega_n t}\left[\cos(\omega_d t)+\frac{\zeta}{\sqrt{1-\zeta^2}}\sin(\omega_d t)\right]\right\}$	$\frac{\omega_n^2}{s(s^2+2\zeta\omega_n s+\omega_n^2)}$

17.

$$F(s) = \frac{Bs + C}{s^2 + 2\alpha s + \omega_0^2}$$

$$L^{-1}\left[F(s)\right] = f(t)$$

$$f(t) = Ae^{-\alpha t}\cos(\omega_d t + \phi), \text{ where}$$

$$\omega_d = \sqrt{\omega_o^2 - \alpha^2}\ , \quad \phi = \tan^{-1}\left(\frac{\alpha B - C}{\omega_d B}\right) \text{ and}$$

$$A = \sqrt{B^2 + \left(\frac{(\alpha B - C)}{\omega_d}\right)^2} = \frac{\sqrt{B^2\omega_o^2 - 2\alpha BC + C^2}}{\omega_d}$$