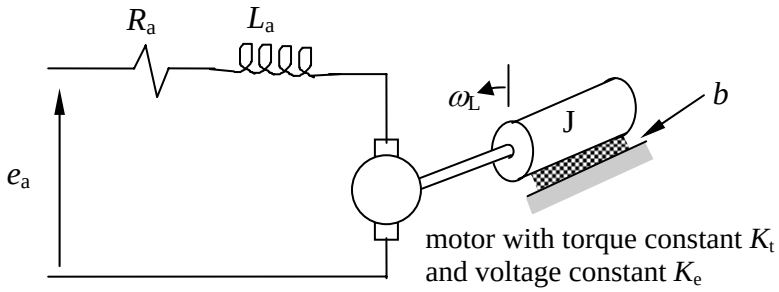
Lesson 08

Problem 8.1

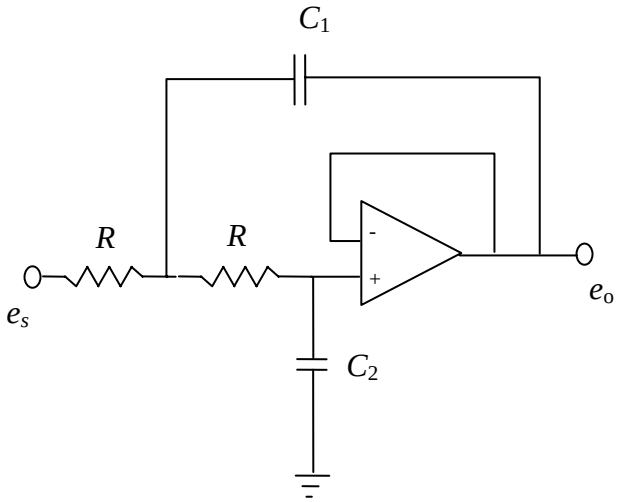
For the armature-controlled DC motor shown below,

a) Determine the necessary algebraic and differential equations to relate the known input voltage, e_a, to the angular velocity of the load, ω_L. Your solution should consist of a numbered list of equations, a list of unknowns, and a list of known or computed parameters.
b) Determine the transfer function relating the armature current to the input voltage, $I_a(s)/V_a(s)$, and the transfer function relating the angular velocity to the input voltage, $\Omega(s)/V_a(s)$.
c) For each of these two transfer functions, determine the static gain, the natural frequency, and the damping ratio.



Problem 8.2

A two pole Butterworth low-pass active filter is shown.



a) Determine the transfer function between the output e_o and the input e_s.
b) Determine an expression for the natural frequency and the damping ratio of this circuit.
c) From the given list of commonly-available resistors and capacitors, select values for R, C_1, and C_2 such that the following design criteria are met:

$$9000 \le \omega_n \le 10{,}000 \text{ rad/s}$$

$$0.7 \le \zeta \le 1.0$$

d) Substitute your design values into the transfer function and create a Simulink simulation (using the transfer-function block) for this system. Plot the output for a unit step input.

Resistors				**Capacitors**		**Inductors**
ohms		**kohms**	**kohms**	**microF**	**picoF**	**microH**
1	56	1	27	1000	5000	330
1.5	62	1.1	30	680	4700	3300
2.7	68	1.2	33	470	4560	
4.3	75	1.3	36	220	2200	**milliH**
4.7	82	1.5	39	100	1500	33
5.1	91	1.6	43	47	1000	
5.6	100	1.8	47	33	470	
6.2	110	2	51	22	330	
6.8	120	2.2	56	10	220	
7.5	130	2.4	62	4.7	100	
8.2	150	2.7	68	3.3	68	
9.1	160	3	75	2.2	47	
10	180	3.3	82	1	33	
11	200	3.6	91	0.47	27	
12	220	3.9	**Mohms**	0.33	22	
13	240	4.3	1	0.22	18	
15	270	4.7	1.1	0.1	12	
16	300	5.1	1.2	0.047	10	
18	330	5.6	1.3	0.033	7.5	
20	360	6.2	1.5	0.022	5	
22	390	6.8	1.6	0.01	2.2	
24	430	7.5	1.8		1.8	
27	470	8.2	2			
30	510	9.1	2.1			
33	560	10	2.4			
36	620	11	2.7			
39	680	12	3			
43	750	13	3.3			
47	820	15	3.9			
51	910	16	4.7			
		18	5.6			
		20	6.8			
		22	8.2			
		24	10			