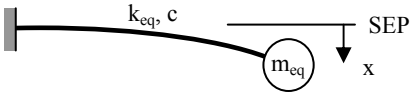
Lesson 13

Problem 13.1

You have been hired to determine the dynamic characteristics of the tail rotor of a helicopter. You have only limited equipment so you perform two tests:

1) A static deflection test where you apply a known force and measure the displacement (Figure 1)
2) A free response test where you give the rotor an initial displacement and measure the displacement of the end of the rotor as a function of time (Figure 2)

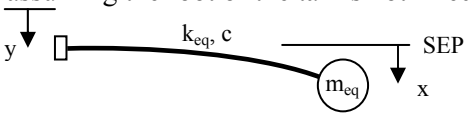
The force-deflection curve and the free response curve are shown below. For convenience, the displacement is shown along the x-axis for the force-deflection curve and the least squares curve fit is shown on the figure. Assume for parts a), b) and c) the root of the tail is fixed so that the equation of motion for a single degree of freedom model of the tail is given by



$$m_{eq}\ddot{x} + c\dot{x} + k_{eq}x = f(t)$$

Determine:

a) The spring constant, damping and equivalent mass of the tail of the helicopter.
b) Determine the equation of motion assuming the root of the tail is not fixed, but rather has a prescribed displacement of y(t).



d) Using Simulink determine the response x(t) if y(t) is given by Figure 3. Hint: Use a transfer function block. You should have terms in both the numerator and denominator.

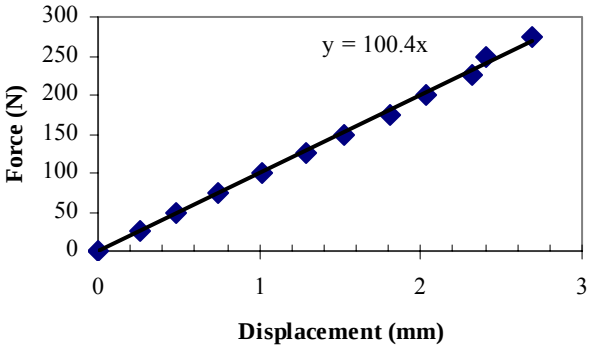


Figure 1: Results of static deflection test

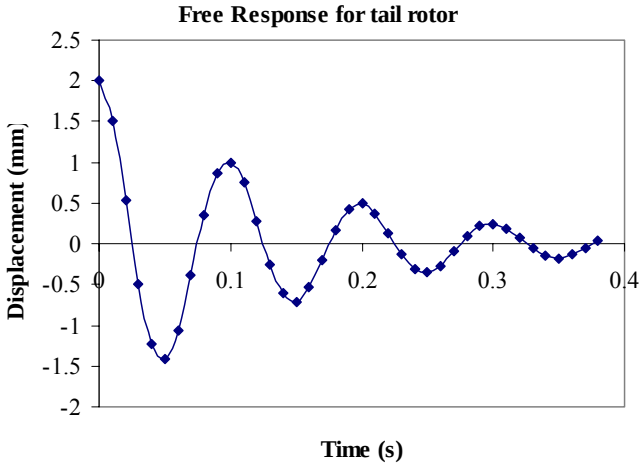


Figure 2: Results of free response test

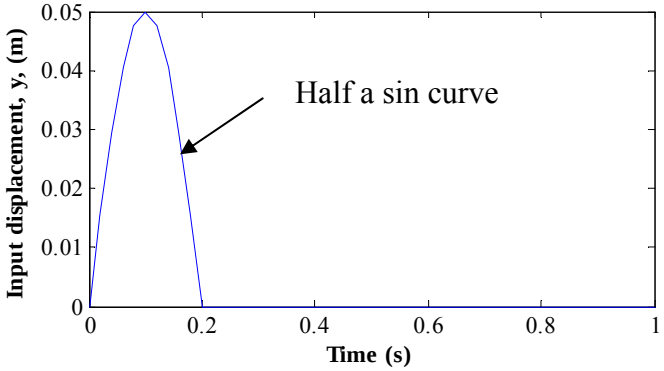
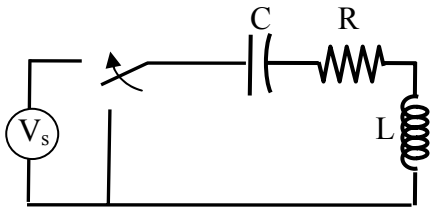


Figure 3: Input displacement for part d.

Problem 13.2

We wish to determine the parameters of a circuit by studying its transient response to a known input. For the circuit shown the source voltage is V_s and at $t = 0$, the switch closes. The voltage across the resistor ($R = 110\ \Omega$) is measured as shown below. The equation of motion is:

Circuit:



$$LC\frac{d^2i}{dt^2} + RC\frac{di}{dt} + i = 0$$

Determine approximate values for the inductance L and capacitance C, then review the list of available values for L and C using the table on the next page to determine the likely true values for L and C.

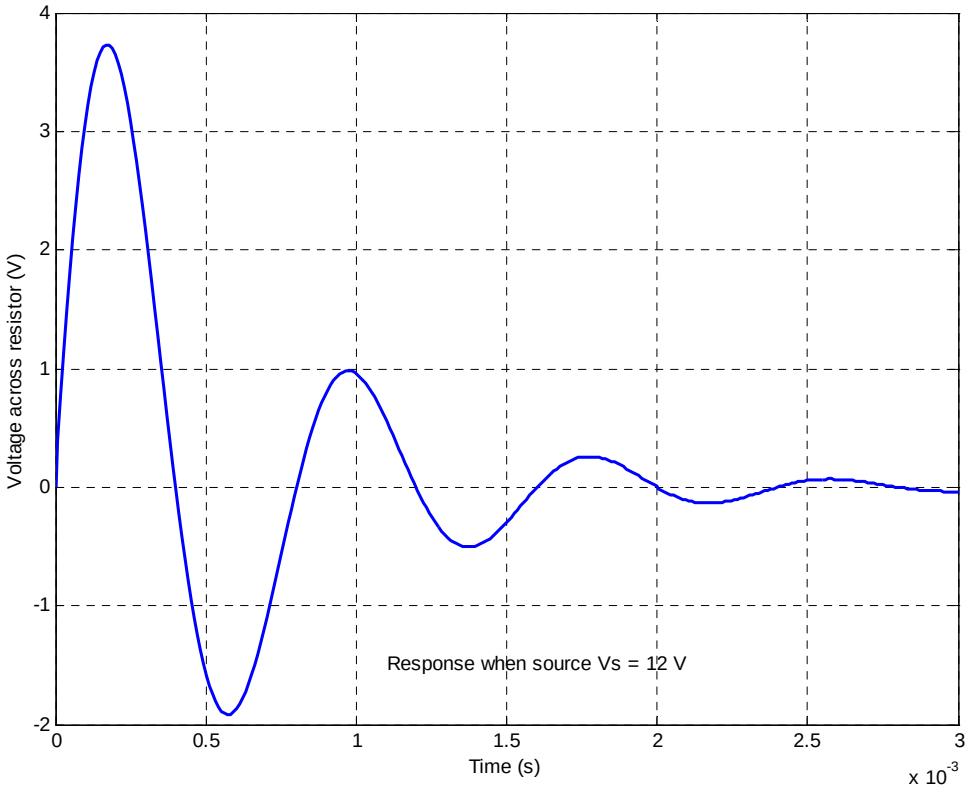


Fig. 12.1: Time response of voltage drop across resistor.

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			