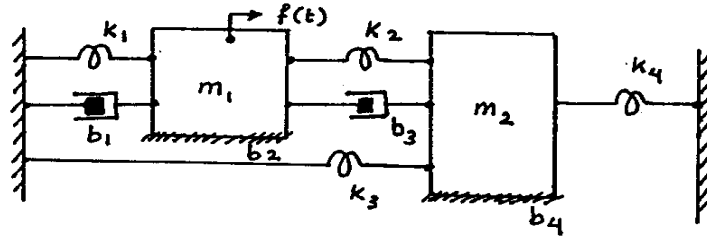
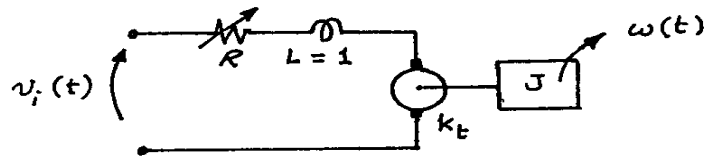


1. For the systems shown below:

- [5 Marks] (i) Find the state equations and write them in a matrix form.
- [5 Marks] (ii) Draw the simulation diagram using integrators, adders and scalars. Make sure to indicate the sign of variables at the inputs of each adder.



2. The second order electro-mechanical system shown has an input voltage, $v(t)$, and an output angular speed, $\omega(t)$. $L=1$ and the system dc-gain is 0.1
- [5 Marks] (i) Find the relation between R and J which ensures that the system is critically damped.
- [3 Marks] (ii) If we set $J=1$ and keep all other parameters unchanged, what is the value of R that makes the system resonates when the input is a sinusoidal voltage with a radian frequency $\omega_1=7.0$ rad/sec.



3. A linear system has a dc-gain $K = +10\text{dB}$ and the following poles and zeros:
- | | |
|------------------|-----------------|
| $p_1 = -0.1$ | $z_1 = -2 + j2$ |
| $p_2 = -1 + j1$ | $z_2 = -2 - j2$ |
| $p_3 = -1 - j1$ | |
| $p_4 = p_5 = -3$ | |

- [5 Marks] (i) Find the transfer function of the system, $H(s)$.
- [5 Marks] (ii) Find the impulse response of the system, $h(t)$.

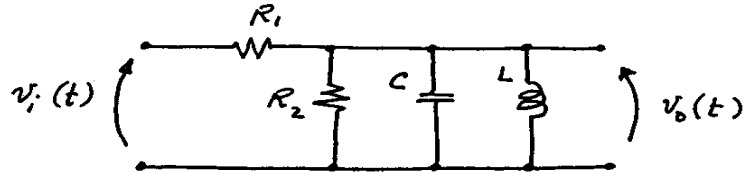
4. Consider the circuit shown in the figure. $R_1=R_2=10$ Ohms, $C=0.01$ F and $L=0.01$ H. If the input voltage, $v_i(t)$ is a unit step:

[5 Marks]

(i) What is the peak value of the output voltage, $v_o(t)$, and at what time it occurs?

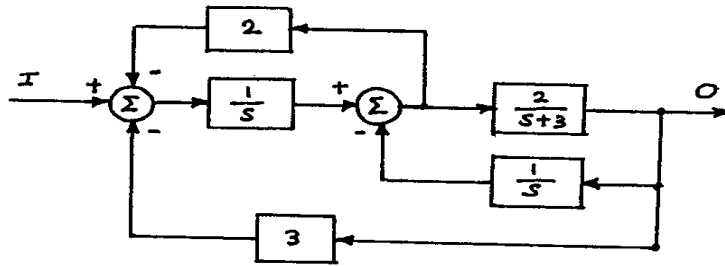
[2 Marks]

(ii) What is the maximum value of C such that the system acts as a lowpass filter rather than a bandpass filter?



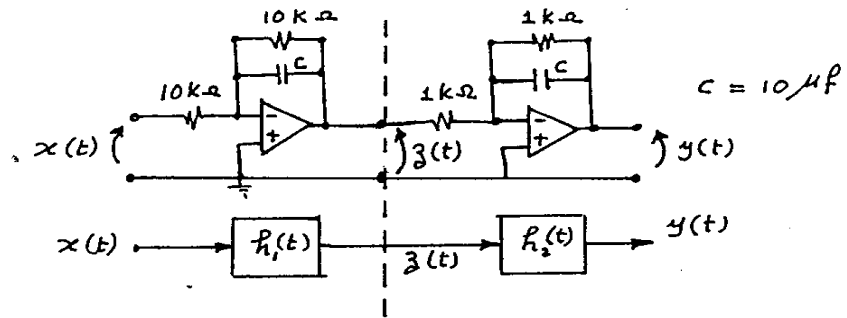
5.

[5 Marks] Find the poles and zeros and the dc-gain of the following system.



6. The operational amplifier circuit shown in the figure can be modeled as two linear systems connected in series. The impulse response of the first system is $h_1(t)$ and the impulse response of the second system is $h_2(t)$.

- [3 Marks] (i) Find $h_1(t)$ and $h_2(t)$
- [5 Marks] (ii) Use the convolution method to determine the impulse response of the overall system.



7. A linear system has the following transfer function:

$$H(s) = \frac{1}{(s+1)(s^2+10s+4)}$$

The system output is $y(t)$

- [5 Marks] Find the system natural response given that at $t=0$:
 $y(0)=1$ $dy/dt(0)=1$ and $d^2y/dt^2(0)=0$

8. A linear system has the following transfer function:

$$H(s) = \frac{(s^2 + s + 4)}{s^2 (s + 1) (s^2 + s + 100)}$$

- [5 Marks] (i) Draw the system's Bode plots (magnitude and phase) on the graph paper provided.
- [2 Marks] (ii) Calculate the exact frequency response (magnitude and phase) at each corner point.