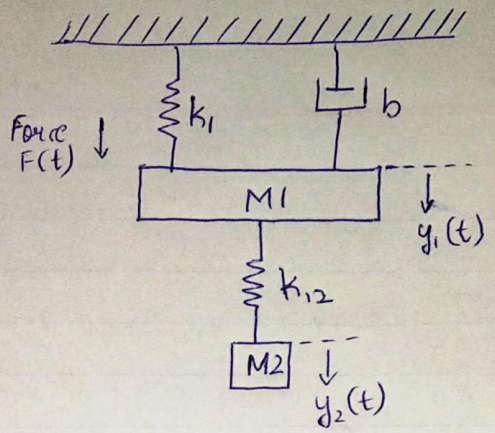
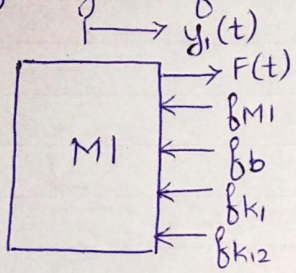
Problem 1:

Derivation :



Free-body diagram of Mass M1:



Opposing force by,

Mass M1, $f_{M1} = M_1 \frac{d^2y_1}{dt^2}$

Dashpot, $f_b = b \frac{dy_1}{dt}$

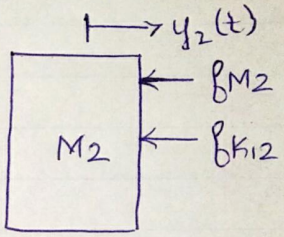
Spring 1, $f_{k_1} = k_1 y_1$

Spring 12, $f_{k_{12}} = k_{12}(y_1 - y_2)$

$\therefore F(t) = M_1 \frac{d^2y_1}{dt^2} + b \frac{dy_1}{dt} + k_1 y_1 + k_{12}(y_1 - y_2)$

$\therefore M_1 \frac{d^2y_1}{dt^2} = F(t) - b \frac{dy_1}{dt} - k_1 y_1 - k_{12}(y_1 - y_2)$

Free-body diagram of Mass M2:



Opposing force by,

Mass M2, $f_{M2} = M_2 \frac{d^2y_2}{dt^2}$

Spring 12, $f_{k_{12}} = k_{12}(y_2 - y_1)$

$\therefore 0 = M_2 \frac{d^2y_2}{dt^2} + k_{12}(y_2 - y_1)$

$\therefore M_2 \frac{d^2y_2}{dt^2} = -k_{12}(y_2 - y_1)$