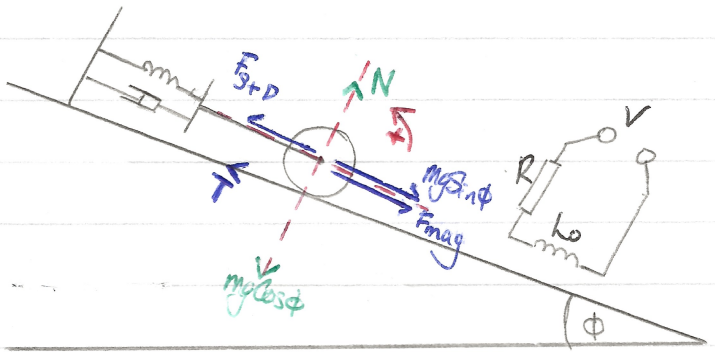
Part A

A1)



$$N - mg\,Cos\phi = 0$$

$$mgSin\phi + F_{mag} - T - F_{S+D} = m\ddot{x}$$

F_{mag}:

$$F_{mag} = \frac{c\,I^2}{y^2} \qquad y = \delta - x$$

$$= c\left(\frac{I}{\delta - x}\right)^2$$

T: Torque (M) $= -TR = I\ddot{\theta}$

$$-TR = I\ddot{\theta}$$

$$T = \frac{-I\ddot{\theta}}{R}$$

$S = -R\theta \Rightarrow S = R(-\theta)$

$\ddot{S} = -R\ddot{\theta}$

$\ddot{\theta} = \frac{-\ddot{S}}{R}$ $\quad S = x,\ \ddot{S} = \ddot{x}$

$\ddot{\theta} = \frac{-\ddot{x}}{R}$

$$T = \frac{-I}{R}\left(\frac{-\ddot{x}}{R}\right) = \frac{I\ddot{x}}{R^2} \qquad I = \frac{2}{5}mR^2$$

$$T = \frac{2mR^2\ddot{x}}{R^2} = \frac{2m\ddot{x}}{5}$$

F_{S+D}: $F_S \Rightarrow F_S = k(x - d)$

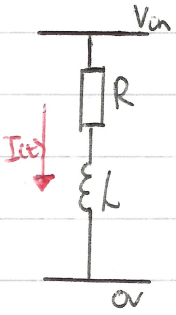
$$F_D = b\dot{x}$$

$$F_{S+D} = k(x-d) + b\dot{x}$$

$$mgSin\phi + c\left[\frac{I}{(\delta - x)}\right]^2 - \frac{2m\ddot{x}}{5} - k(x-d) - b\dot{x} = m\ddot{x}$$

$$mgSin\phi + c\left[\frac{I}{(\delta - x)}\right]^2 - k(x-d) - b\dot{x} = \frac{7m\ddot{x}}{5} \qquad (1)$$

A1)
Cont.



$V_{in} = V_R + V_L$

$V_R = RI$

$V_L = L\dot{I}$

$V_L = V_{in} - V_R$

$L\dot{I} = V - RI$

$\dot{I} = \frac{1}{L}(V - RI)$

$L = L_0 + Le^{-Ky}$

$L = L_0 + L_1 e^{-\alpha(d-x)}$

(2) $\dot{I} = \frac{1}{L_0 + L_1 e^{-\alpha(d-x)}}(V - RI)$