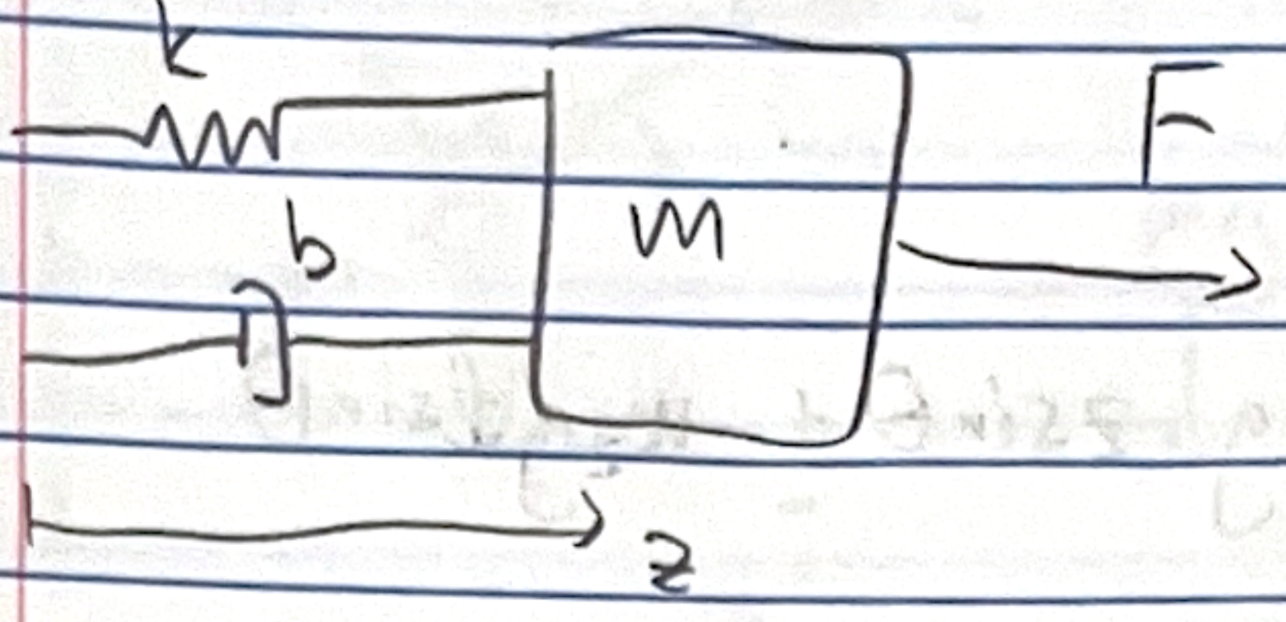
HW 3

D.3



$m = 5\,kg$

$k = 3\,N/m$

$b = .5\,Ns/m$

$U_e = \frac{1}{2} k z^2$

b. $q = (z, \theta)^T$

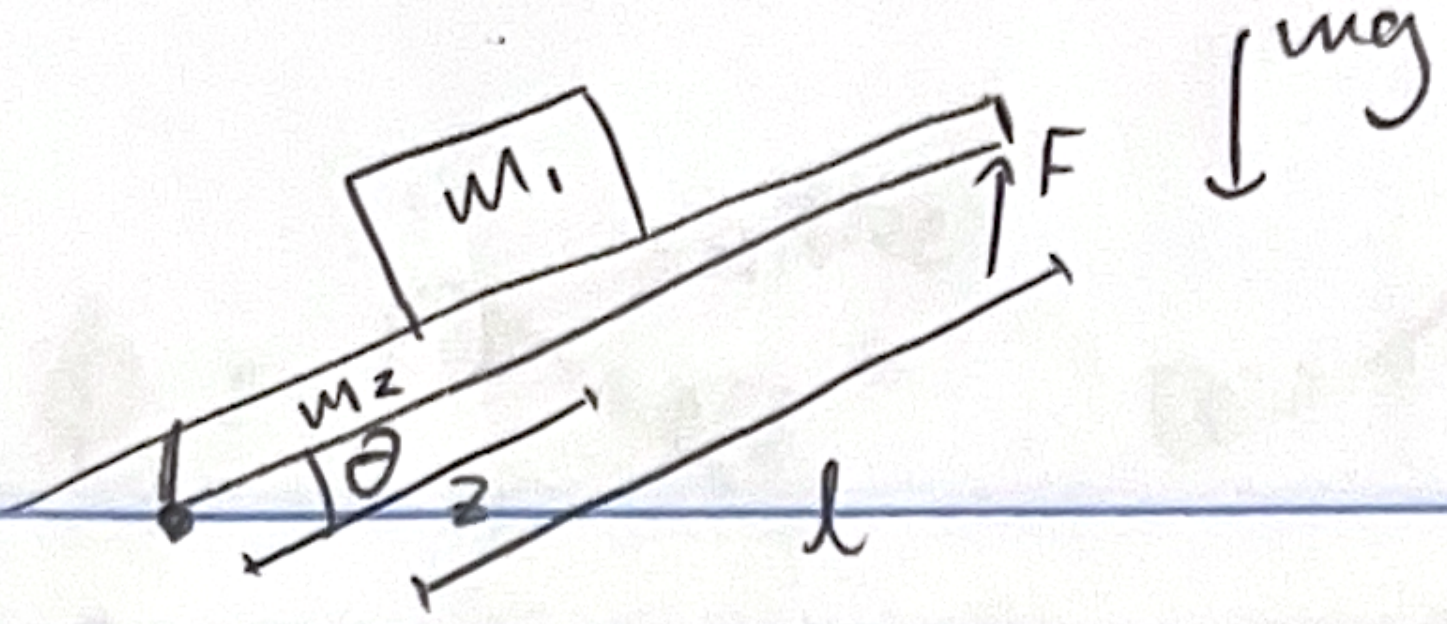
$F_b = F - b\dot{z}$

c. $\vec{\tau} - B\dot{\vec{q}}$

$\dot{q} = [$

$B_i = [$

$$[F - b\dot{z}] = [1(-k + m)\ddot{z}]$$



$m_1 = .35\,kg$
$m_2 = 2\,kg$
$l = .5\,m$
$g = 9.8\,m/s^2$

E.3

a) $U_e = mgh = m_1 g \cdot z\sin\theta + m_2 g l\sin\theta$

distances needs a force ↓ angles needs a torque ↓

b) $p(z, \theta)$

c) $\tau = (\tau, 0)^T$

$\tau = \cancel{m_2 g l^2 \sin\theta + m_1 g z l \sin\theta - F l^2 \sin\theta}$
$= \cancel{l^2 \sin\theta (m_2 g - F) + m_1 g z l \sin\theta}$

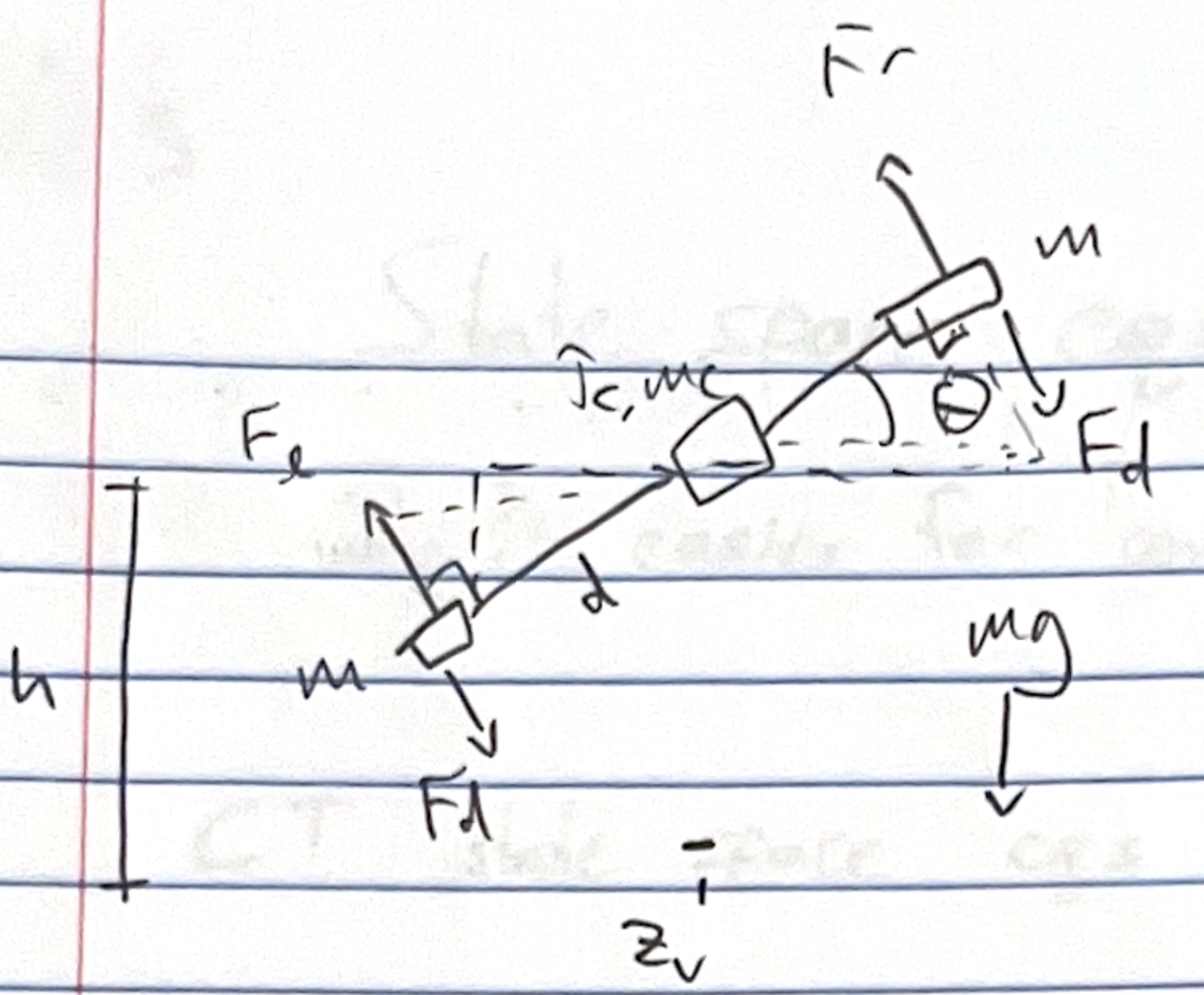
GF, no damping, gen coords

$$\begin{bmatrix} 0 \\ F l\cos\theta \end{bmatrix} - \begin{bmatrix} 0 & 0 \\ 0 & 0 \end{bmatrix}\begin{bmatrix} \dot z \\ \dot\theta \end{bmatrix}$$

$$= \begin{bmatrix} 0 \\ F l\cos\theta \end{bmatrix} = \begin{bmatrix} m_1 g\sin\theta - m_1 z\dot\theta^2 + \ddot z m_1 \\ \tfrac{1}{3} l^2 m_2 \ddot\theta + l g m_2\cos\theta + g m_1 z\cos\theta + m_1 z^2\ddot\theta + 2 m_1 z\dot\theta\dot z \end{bmatrix}$$

$$\ddot\theta = \frac{\tfrac{1}{3} l^2 m_2 \ddot\theta + m_1 z^2\ddot\theta + \left(l g m_2\cos\theta + g m_1 z\cos\theta + 2 m_1 z\dot\theta\dot z\right)}{\left(\tfrac{1}{3} l^2 m_2 + m_1 z^2\right)}$$

Fi3



a) $U_e = mg(h - d\sin\theta) + mg(h + d\sin\theta) + m_c gh$

$= 2mgh + m_c gh + P_0$

b) $F_{drag} = -\mu \dot{z}$

c) $q_c = \begin{bmatrix} z \\ h \\ \theta \end{bmatrix}$ $\qquad \overset{3\times 3}{\tau - B\dot{q}}$

$$\begin{array}{c} z \\ h \\ \theta \end{array} \underbrace{\begin{bmatrix} -F_r\sin\theta - F_l\sin\theta \\ F_r\cos\theta + F_l\cos\theta \\ F_r d - F_l d \end{bmatrix}}_{\tau} - \underbrace{\begin{bmatrix} \mu\dot{z} \\ 0 \\ 0 \end{bmatrix}}_{B\dot{q}}$$

$$\begin{bmatrix} -F_l\sin\theta - F_r\sin\theta - \mu\dot{z} \\ (F_l + F_r)\cos\theta \\ d(-F_l + F_r) \end{bmatrix} = \begin{bmatrix} (2m + m_c)\ddot{z} \\ 2gm + gm_c + 2m\ddot{h} + m_c\ddot{h} \\ -J_c\theta + 2d^2 m\ddot{\theta} \end{bmatrix}$$

$$\ddot{h} = \frac{\cos\theta(F_l + F_r) - 2gm + gm_c}{(2m + m_c)}$$

$$\ddot{\theta} = \frac{d(-F_l + F_r) + J_c\theta}{2d^2 m}$$