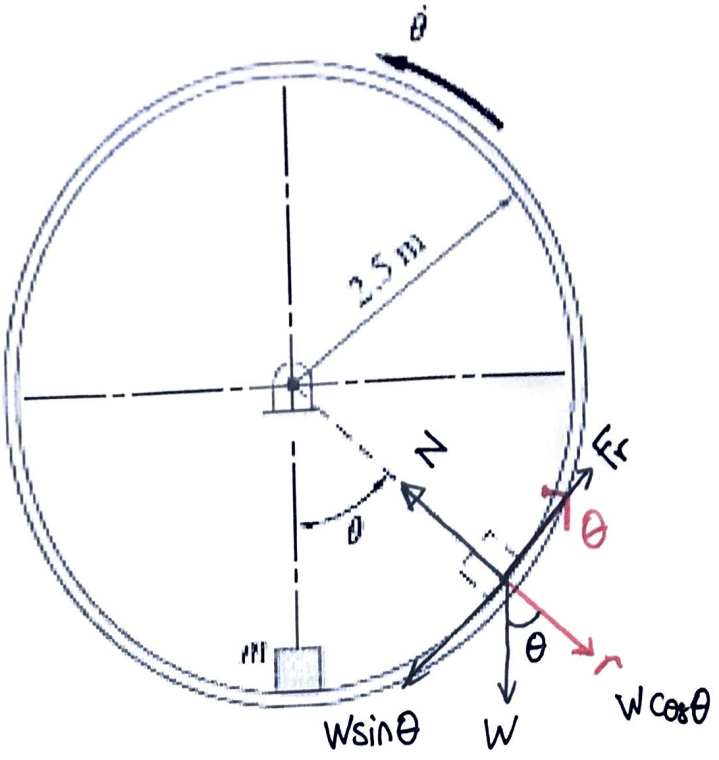
1) A package of mass m is placed inside a drum that rotates in the vertical plane at a constant angular speed of $\dot{\theta} = 1.36\ rad/s$. If the package reaches the position $\theta = 45^{o}$ before slipping, determine the static coefficient of friction between the package and the drum.
Draw the necessary free body diagram(s) and clearly label your coordinate system(s).



30 marks

$r = 2.5\ m$ (1)

$\dot{r} = 0\ m/s$ (1)

$\ddot{r} = 0\ m/s^2$ (1)

$\theta = 45^{\circ}$ (1)

$\dot{\theta} = 1.36\ rad/s$ (1)

$\ddot{\theta} = 0\ rad/s^2$ (1)

$a_r = \ddot{r} - r\dot{\theta}^2 = -4.624\ m/s^2$ (3)

$a_\theta = r\ddot{\theta} + 2\dot{r}\dot{\theta} = 0\ m/s^2$ (3)

$\Sigma F_r = W\cos\theta - N = ma_r$

$mg\cos\theta - N = m(-4.624)$ (6)

$N = 4.624m + m(6.937) = 11.561\ m$ (3)

$\Sigma F_\theta = F_r - W\sin\theta = ma_\theta$

$\mu_s N - mg\sin\theta = 0$ (6)

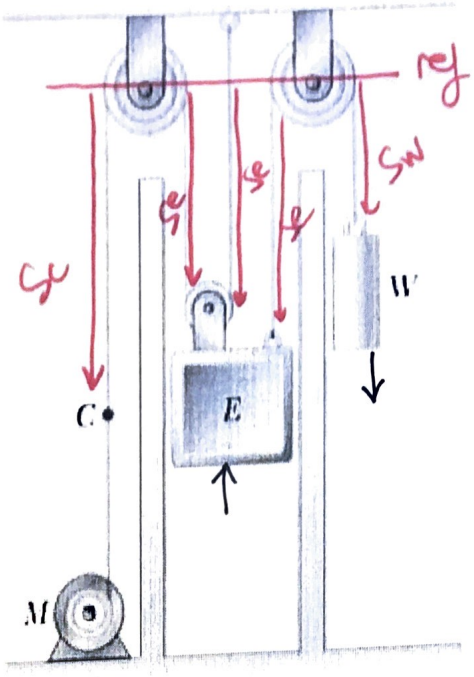
Question 1 continues on the next page...

$\mu_s (11.561) m - m(9.81)(0.7081) = 0$

$\mu_s = 0.6$ ✱

3

2) The elevator shown starts from rest and moves upward with a constant acceleration. If the counterweight W moves through 30 ft in 5 s, determine (a) the acceleration of the elevator and the acceleration of point C, (b) the velocity of the elevator after 5 s. Clearly label your coordinate system(s).



35 marks

$L_1 = S_C + 2S_E$ (3)

$v_C + 2v_E = 0$ (2)

$a_C + 2a_E = 0$ (2)

$L_2 = S_E + S_W$ (3)

$v_E + v_W = 0$ (2)

$a_E + a_W = 0$ (2)

$v_{E_1} = 0 \Rightarrow v_{C_1} = v_{W_1} = 0$ (1)

For W

$y_{W_2} = y_{W_1} + v_{W_1} t + \frac{1}{2} a_W t^2$

$30 = 0 + 0 + \frac{1}{2} a_W (5)^2$ (8)

$a_W = 2.4 \text{ ft/s}^2 \downarrow$ (2)

$a_E = -2.4 \text{ ft/s}^2$ (2)

$a_C = 4.8 \text{ ft/s}^2$ (2)

For E

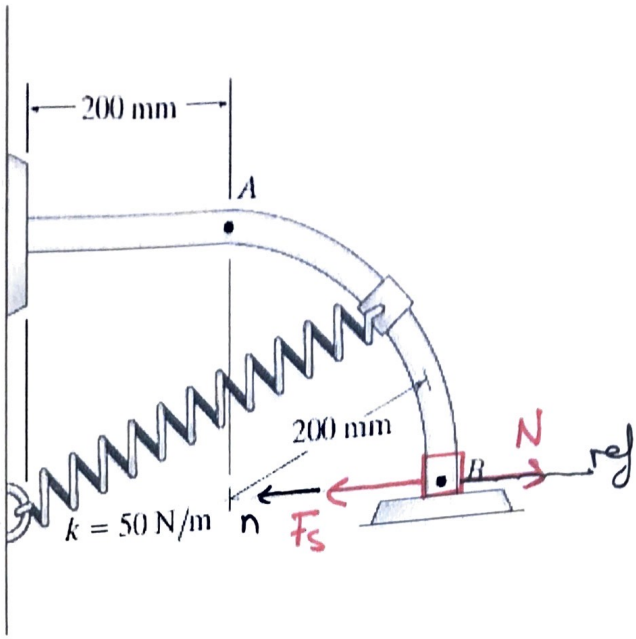
$v_{E_2} = v_{E_1} + a_E t$ (4)

$= 0 - 2.4 \times 5$

$v_{E_2} = -12 \text{ ft/s}$ (2)

Question 2 continues on the next page...

3) The 5 kg collar has a velocity of 5 m/s to the right when it is at A. It travels down along the smooth guide. Determine the speed of the collar when it reaches point B, which is located just before the end of the curved portion of the rod. The spring has an unstrtecched length of 100 mm. Also, find the normal force acting on the collar at point B. Draw the necessary free body diagram(s) and clearly label your coordinate system(s).



35 marks

$T_A = \frac{1}{2} m v_A^2 = \frac{1}{2}(5)(5)^2$

$T_A = 62.5$ J (3)

$T_B = \frac{1}{2} m v_B^2 = 2.5 v_B^2$ (3)

$V_A = V_{g_A} + V_{e_A}$ (6)

$= mgh_A + \frac{1}{2} k s_A^2$

$= 5 \times 9.81 \times 0.2 + \frac{1}{2} \times 50 (0.183)^2$

$= 10.65$ J

$s_A = \sqrt{0.2^2 + 0.2^2} - 0.1$

$= 0.183$ m (2)

$V_B = V_{g_B} + V_{e_B}$ (6)

$= 0 + \frac{1}{2}(50)(0.3)^2$

$= 2.25$ J

$s_B = 0.4 - 0.1 = 0.3$ m (2)

$\Rightarrow D \quad 62.5 + 10.65 = 2.5 v_B^2 + 2.25$

$v_B = 5.33$ m/s (5)

Question 3 continues on the next page...

at B

$$\Sigma F_n = F_s - N = m a_n \quad (6)$$

$$= k s_B - N = m \frac{v^2}{\rho}$$

$$= 50 \times 0.3 - N = 5 \times \frac{5.33^2}{0.2}$$

$$15 - N = 710.2$$

$$N = -695.2 \text{ N} \quad (2)$$