Given: A structure is made up of links AGB and CBD. Block E, having a mass of 120 kg, hangs from a cable that is attached to point G on link AGB and is hung over a pulley attached to pin D. Consider the weight of the links to be negligible, and the pulley at D to be frictionless.

Find: For this problem:
   a) complete the three free body diagrams given below.
   b) determine the reactions acting on link CBD at pin C. Write your answer as a vector.
Using FBD of member CBD:

$$\sum M_B = 2W - 2.5W - 3C_y = 0 \quad \Rightarrow$$

$$C_y = \frac{2W - 2.5W}{3} = \frac{-0.5W}{3} = \frac{-0.5(120)(9.806)}{3} = -196N$$

Using FBD of entire structure:

$$\sum M_C = -4A_x - 5.5W = 0 \quad \Rightarrow$$

$$A_x = -\frac{5.5W}{4} = -\frac{5.5(120)(9.806)}{4} = -1618N$$

$$\sum F_x = A_x + C_x = 0 \quad \Rightarrow$$

$$C_x = -A_x = 1618N$$

Answer:

$$\mathbf{C} = \mathbf{C}_x \mathbf{i} + \mathbf{C}_y \mathbf{j} = (1618 \mathbf{i} - 196 \mathbf{j})N$$
Given: A crate weighing 1500 lbs is supported by small feet on a rough, horizontal surface ($\mu_s = 0.8$). The crate supports block A (weighing 2500 lbs) with a cable that is pulled over a fixed, rough circular drum. The static coefficient of friction between the cable and drum is $\mu_s = 0.4$. Block A rests on a smooth inclined surface, as shown in figure below. A force $F$ is needed to act to the left on the crate to hold the system of the crate and block in equilibrium.

Find: You are asked to determine the smallest value of $F$ needed to maintain equilibrium. In your solution:

a) Complete the free body diagrams for the crate and block A below.

b) Clearly state all assumptions that you make and show any checks that you make on your assumptions.

c) In your final answer, state whether the crate is in a state of impending tipping or slipping.

Crate will either slide to the right or tip about point B.
From FBD of block:

\[ \sum F_x = W_A \cos 30^\circ - T_2 = 0 \quad \Rightarrow \quad T_2 = W_A \cos 30^\circ = \left(2500 \frac{\sqrt{3}}{2}\right) = 1250\sqrt{3} \]

Since impending motion of block A is DOWN the incline, then:

\[ T_2 > T_1 \quad \Rightarrow \quad \frac{T_2}{T_1} = e^{\mu \beta} \quad \Rightarrow \quad T_1 = \frac{T_2}{e^{\mu \beta}} = \frac{1250\sqrt{3}}{e^{(0.4)(60\pi/180)}} = 1424 \text{ lb} \]

From FBD of crate:

(1) \[ \sum F_x = -f_B - f_D - F + T_1 = 0 \]
(2) \[ \sum F_y = N_B + N_D - W_G = 0 \]
(3) \[ \sum M_B = -4N_D + 2W_G - 5T_1 + 8F = 0 \]

**Assume tipping** (which would be about point B): \( N_D = f_D = 0 \)

Using equation (3):

\[ F = \frac{-2W_G + 5T_1}{8} = \frac{-2(1500) + 5(1424)}{8} = 515 \text{ lb} \]

**Check:**

Equation (2) gives: \( N_B = W_G = 1500 \quad \Rightarrow \quad (f_B)_{\text{max}} = (0.8)(1500) = 1200 \text{ lb} \)

Equation (1) gives: \( f_B = -F + T_1 = -337.5 + 1140 = 1086 \text{ lb} \)

Since \( f_B < (f_B)_{\text{max}} \), tipping assumption correct. Therefore,

\[ F_{\text{min}} = 515 \text{ lb} \text{ (impending tipping)} \]

**Alternate solution:**

Assume slipping: \( f_D = \mu_S N_D \) and \( f_B = \mu_S N_B \)

Equations (1) and (2) give:

\[ F = -f_B - f_D + T_1 = -\mu_S(N_B + N_D) + T_1 \\
= -\mu_S W_G + T_1 = -(0.8)(1500) + 1424 = 224 \text{ lb} \]

To prevent BOTH tipping and slipping, need to take the **larger** of the two forces.

Therefore, \[ F_{\text{min}} = 515 \text{ lb} \text{ (impending tipping)} \]
**ME 270 - Fall 2004**

**Examination No. 2**

**PROBLEM NO. 3**

**Given:** Beam AB is built into a fixed wall at end A. A distributed line load acts on the beam as shown below. A 2000 lb force also acts at end B.

**Find:** Determine the reactions at end A due to this loading. Write your answers as vectors.

\[ R_1 = (600)(3) = 1800 \text{ lb} \]
\[ R_2 = (300)(3)/2 = 450 \text{ lb} \]
\[ R_3 = (300)(3) = 900 \text{ lb} \]

\[ \sum F_x = (2000) \sin 36.87^\circ + A_x = 0 \Rightarrow A_x = -1200 \text{ lb} \]
\[ \sum F_y = -(2000) \cos 36.87^\circ + A_y - R_1 - R_2 - R_3 = 0 \Rightarrow A_y = (2000)(0.8) + 1800 + 450 + 900 = 4750 \text{ lb} \]
\[ \sum M_A = M_A - 1.5R_1 - 4R_2 - 4.5R_3 - 6(2000) \cos 36.87^\circ \Rightarrow M_A = 1.5(1800) + 4(450) + 4.5(900) + 6(2000)(0.8) = 18,150 \text{ ft-lb} \]

**Answers:**

\[ \bar{A} = (-1200\hat{i} + 4750\hat{j}) \text{ lb} \]
\[ M_A = (18,150 \hat{k}) \text{ ft-lb} \]