HOMEWORK #6

Prepared by: Mümin Özsipahi
Room: C-206 **Phone:** 210 7232
E-mail: ozsipahi@metu.edu.tr

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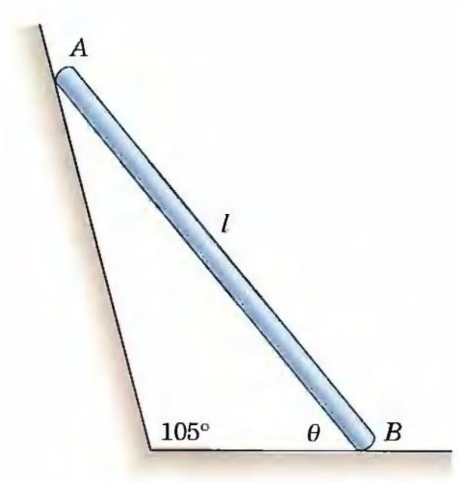
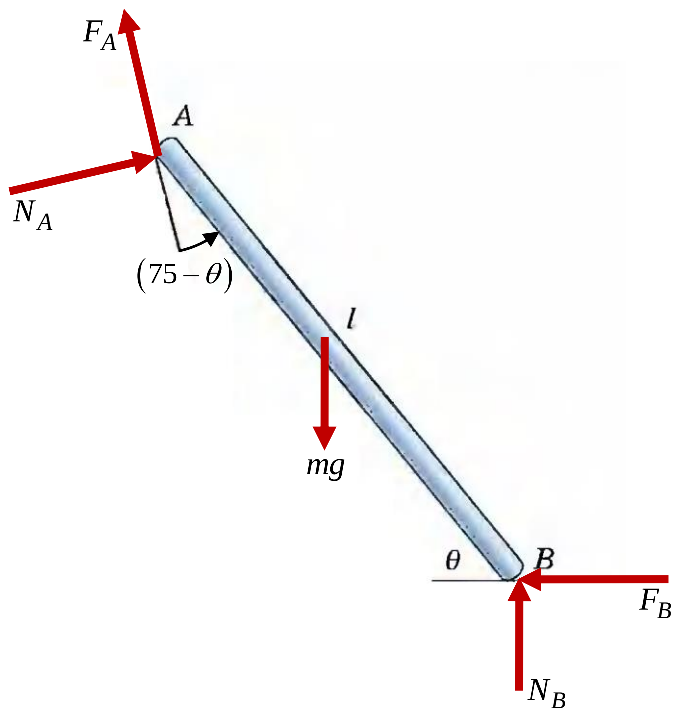
Room: C-206

Problem

The uniform rod of length *l* and mass m is placed against the supporting surfaces shown. If the coefficient of static friction is $\mu_s = 0.25$ at both *A* and *B*, determine the maximum angle θ at which the rod can be placed before it begins to slip.



SOLUTION



Using the free-body diagram,

$$\sum M_A = 0 \quad \rightarrow \quad mg\frac{l}{2}\cos(\theta) + F_B l \sin(\theta) - N_B l \cos(\theta) = 0 \tag{1.1}$$

$$\sum F_x = 0 \quad \rightarrow \quad N_A \cos\left(15^o\right) - F_A \sin\left(15^o\right) - F_B = 0 \tag{1.2}$$

$$\sum F_y = 0 \quad \rightarrow \quad N_A \sin\left(15^o\right) + F_A \cos\left(15^o\right) + N_B - mg = 0 \tag{1.3}$$

Also, since the rod is on the verge of slipping,

$$F_A = \mu_s N_A = 0.25 N_A \tag{1.4}$$

$$F_B = \mu_s N_B = 0.25 N_B \tag{1.5}$$

Use Eq. (1.4) and (1.5) in (1.2),

$$N_A \cos\left(15^o\right) - 0.25 N_A \sin\left(15^o\right) - 0.25 N_B = 0 \tag{1.6}$$

$$N_B = 3.6\, N_A \tag{1.7}$$

Use Eq. (1.4) and (1.7) in (1.3),

$$N_A \sin\left(15^o\right) + 0.25 N_A \cos\left(15^o\right) + 3.6 N_A - mg = 0 \tag{1.8}$$

$$N_A = \frac{1}{4.1} mg \tag{1.9}$$

Use Eq. (1.9) in (1.6),

$$N_B = \frac{3.6}{4.1} mg \tag{1.8}$$

Use Eq. (1.8) in (1.1),

$$mg \frac{l}{2} \cos(\theta) + 0.25 \frac{3.6}{4.1} mgl \sin(\theta) - \frac{3.6}{4.1} mgl \cos(\theta) = 0 \tag{1.9}$$

$$0.25 \frac{3.6}{4.1} \sin(\theta) = \left(\frac{3.6}{4.1} - 0.5\right) \cos(\theta) \tag{1.10}$$

$$\tan(\theta) = \frac{0.378}{0.219} \tag{1.11}$$

$$\underline{\underline{\theta = 59.9^o}} \tag{1.12}$$