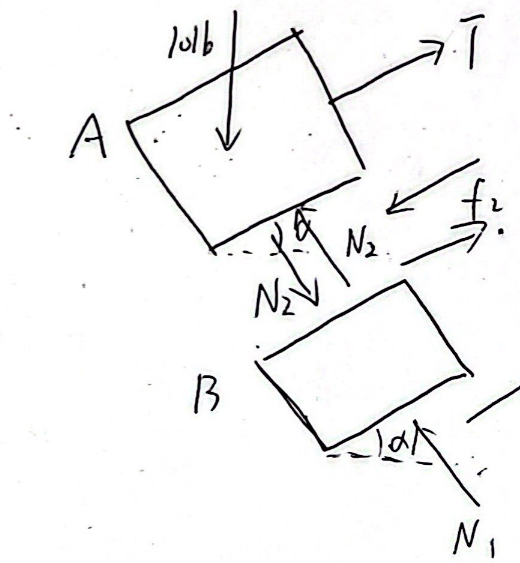
Homework 9 – Solution

Problem 9.19



$\Sigma F_A^{\nearrow} = 0: \quad T - 10\,\text{lb} \sin\alpha - f_2 = 0$

$\Sigma F_A^{\nwarrow} = 0: \quad N_2 - 10\,\text{lb} \cos\alpha = 0$

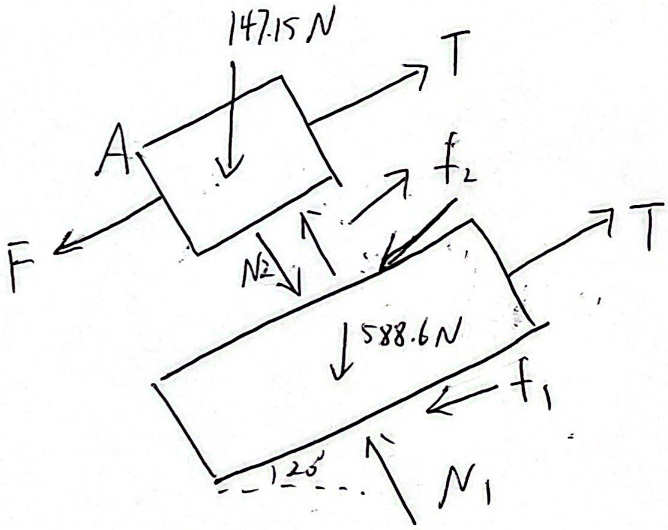
$\Sigma F_B^{\nearrow} = 0: \quad f_2 + f_1 - 10\,\text{lb} \sin\alpha = 0$

$\Sigma F_B^{\nwarrow} = 0: \quad N_1 - N_2 - 10\,\text{lb} \cos\alpha = 0$

$f_1 = 0.3 N_1 \qquad f_2 = 0.24 N_2$

Solving the six equations, we get $\boxed{\alpha = 40.0^\circ}$

Problem 9.20



$\Sigma F_A^{\nearrow}: \quad T - F - 147.15\,\text{N} \cdot \sin 20^\circ + f_2 = 0$

$\Sigma F_A^{\nwarrow}: \quad N_2 - 147.15\,\text{N} \cos 20^\circ = 0$

$\Sigma F_B^{\nearrow}: \quad T - 588.6\,\text{N} \sin 20^\circ - f_1 - f_2 = 0$

$\Sigma F_B^{\nwarrow}: \quad N_1 - N_2 - 588.6\,\text{N} \cos 20^\circ = 0$

$f_1 = 0.12 N_1 \qquad f_2 = 0.12 N_2$

Solving the six equations, we get $\boxed{F = 267\,\text{N}}$

Homework 9 – Solution

Problem 9.21

$\Sigma \vec{F_A}$: $T - F - (147.15N)\sin 20^\circ - f_2 = 0$

$\Sigma F_A^{\nwarrow}$: $N_2 - (147.15N)\cos 20^\circ = 0$

$\Sigma \vec{F_B}$: $T - (588.6N)\sin 20^\circ + f_1 + f_2 = 0$

$\Sigma F_B^{\nwarrow}$: $N_1 - N_2 - (588.6N)\cos 20^\circ = 0$

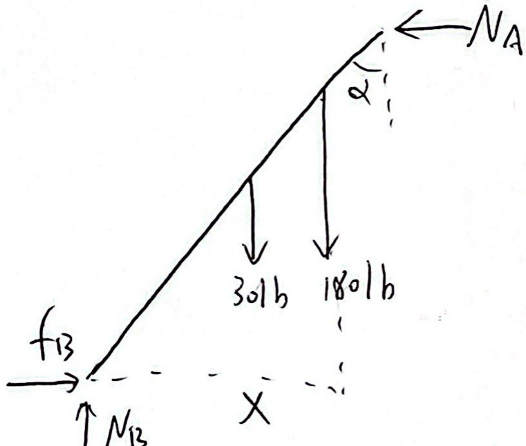
$f_1 = 0.12 N_1$ $\quad$ $f_2 = 0.12 N_2$

Solving the six equations, we get [redacted] F=34.8N

Problem 9.27

a) Assume there is no slipping

$\alpha = 30^\circ$ $\quad$ $X = 4\ ft$



$\Sigma F_x = 0$: $f_B - N_A = 0$

$\Sigma F_y = 0$: $N_B - 210lb = 0$

$\Sigma M_B = 0$: $N_A(12ft\cos\alpha) - 30lb\cdot(6ft\sin\alpha)$

$- 180lb\, X = 0$

Solving equations : $\boxed{f_B = 77.9lb}$ $\boxed{N_B = 210lb}$

b) At the top of the ladder

$\alpha = 30^\circ$ $\quad$ $X = 6ft$

$\Rightarrow$ $\boxed{\mu_s = 0.536}$

$\Sigma F_x = 0$ $\quad$ $f_B - N_A = 0$

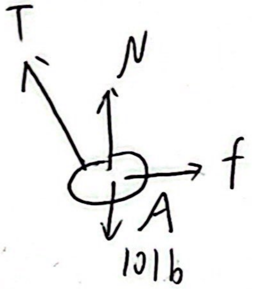
$\Sigma F_y = 0$ $\quad$ $N_B - 210lb = 0$

$\Sigma M_B = 0$ $\quad$ $N_A(12ft\cos\alpha) - 30lb(6ft\sin\alpha) - 180lb\,X = 0$

$f_B = \mu_s N_B$

Homework 9- Solution

Problem 9.62



Find the string force:

$$\vec{T} = (5\,lb)\frac{\vec{r}_{AB}}{|\vec{r}_{AB}|} = -3.08\,\vec{i} + 3.08\,\vec{j} - 2.46\,\vec{k}\ (lb)$$

The sum of the string and the weight is

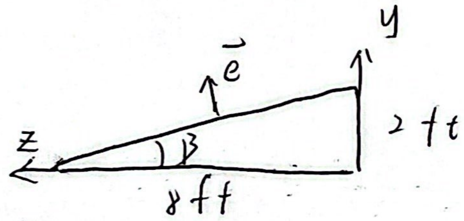
$$\vec{T} - 10\vec{j} = -3.08\,\vec{i} - 6.92\,\vec{j} - 2.46\,\vec{k}$$

The normal force and friction force are balancing this force's component that are normal and parallel to the surface.

Find the uint vector $\vec{e}$ that perpendicular to the surface.

$$\beta = \arctan\left(\frac{2}{8}\right) = 14.0^\circ.$$

$$\vec{e} = \cos\beta\,\vec{j} + \sin\beta\,\vec{k} = 0.970\,\vec{j} + 0.243\,\vec{k}$$



The component of $\vec{T} - 10\vec{j}$ normal to the surface is

$$((\vec{T} - 10\vec{j})\cdot\vec{e})\,\vec{e} = -7.09\,\vec{j} - 1.77\,\vec{k}\ (lb)$$

The magnitude of the normal force equals the magnitude of this vector

$$N = |-7.09\,\vec{j} - 1.77\,\vec{k}| = 7.31\ lb$$

The component of $\vec{T} - 10\vec{j}$ parallel to the surface is

$$(\vec{T} - 10\vec{j}) - [(\vec{T} - 10\vec{j})\cdot\vec{e}]\,\vec{e} = -3.08\,\vec{i} + 0.17\,\vec{j} - 0.69\,\vec{k}\ (lb)$$

The magnitude of friction

$$f = |-3.08\,\vec{i} + 0.17\,\vec{j} - 0.69\,\vec{k}| = 3.16\,lb$$

$$f = \mu_s N$$

$$\mu_s = \frac{f}{N} = \frac{3.16}{7.31} = 0.432$$

$$\boxed{\mu_s = 0.432}$$

Homework 9 - Solution

Problem 9.63

$\vec{N} = N_{mag}\ (0.577\vec{i} + 0.743\vec{j} + 0.371\vec{k})$

$\vec{W} = (-49.05)\vec{j}$

$\Sigma F = 0 \qquad \vec{f} + \vec{N} + \vec{W} = 0 \Rightarrow \vec{f} = -\vec{W} - \vec{N}$

We know friction is parallel to the surface

$\vec{f} \cdot (0.557\vec{i} + 0.743\vec{j} + 0.371\vec{k}) = 0 \quad \Rightarrow N_{mag} = 36.45\,N$

The friction force is

$\vec{f} = (-20.3\vec{i} + 22.0\vec{j} - 13.52\vec{k})\ N$

$\boxed{|f| = 32.83\ N}$