Answers

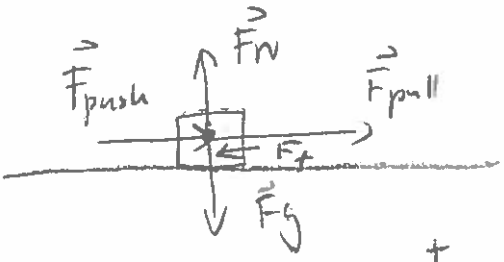
PHYSICS 11

Translational Equilibrium

Determine whether a given object is in translational equilibrium. ⇒ Is $F_{net} = 0$ N?

1. A very heavy box of books with mass of 24.0 kg is pushed on a leveled surface to the right with a force of 50.0 N. The box is also pulled with force of 80.0 N [R]. The force of friction is 6.5 N.

motion →



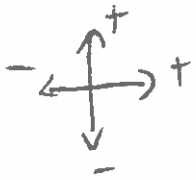
$$\vec{F}_{net} = \vec{F}_g + \vec{F}_N + \vec{F}_{push} + \vec{F}_{pull} + \vec{F}_f$$

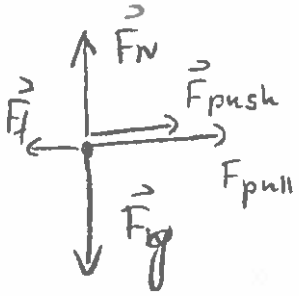
$$F_{net} = 0 + 50 + 80 - 6.5$$

$$= 123.5 \text{ N}$$

$F_{net} \neq 0$ N

FBD:





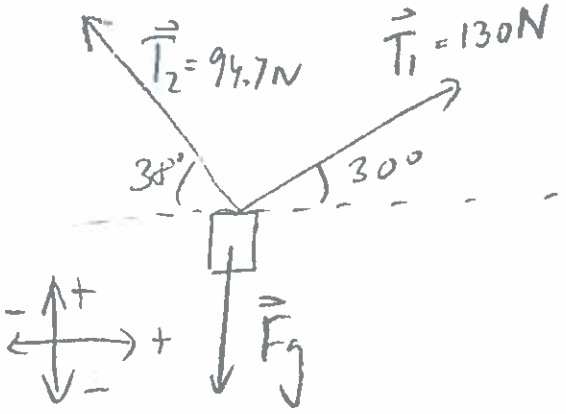
$$a = \frac{F_{net}}{m}$$

$$= \frac{123.5}{24}$$

$$\doteq 5.1 \text{ m/s}^2$$

∴ The object is not in translational equilibrium and it will accelerate 5.1 m/s^2 to the right.

2. A 0.5-kg bucket filled with 8.0 L of water is pulled by two separate ropes. One rope pulls with force of 130.0 N right at ang angle of 30° above horizontal, while the other rope pulls with force of 94.7 N left 38° above horizontal.



Express all forces in vector notation

$\vec{F}_g = [0, -mg]\ N$

$= [0, (0.5 + 8.0)(-9.8)]\ N$

$= [0, -83.3]\ N$

$\vec{T}_1 = [T_1 \cos\theta, T_1 \sin\theta]\ N$

$= [130 \cdot \cos 30°, 130 \cdot \sin 30°]\ N$

$= [112.5833, 65]\ N$

$\vec{T}_2 = [-T_2 \cos\alpha, T_2 \sin\alpha]\ N$

$= [-94.7 \cdot \cos 38°, 94.7 \sin 38°]\ N$

$= [-74.6246, 58.3031]\ N$

$\vec{F}_{net} = \vec{F}_g + \vec{T}_1 + \vec{T}_2$

$= [0, -83.3] + [112.5833, 65] + [-74.6246, 58.3031]$

$= [37.9587, 40.0031]\ N$

$F_{net} \neq 0\ N$

$a = \frac{\vec{F}_{net}}{m}$

$= \frac{[37.9587, 40.0031]}{8.5}$

$\vec{a} = \frac{1}{8.5}\vec{F}_{net}$

$\vec{a} = [4.4657, 4.7062]\ m/s^2$

∴ The object is not in translational equilibrium and it will accelerate $6.5\ m/s^2$ to R 47° U.

$\|\vec{a}\| = \sqrt{4.4657^2 + 4.7062^2}$

$\doteq 6.5\ m/s^2$

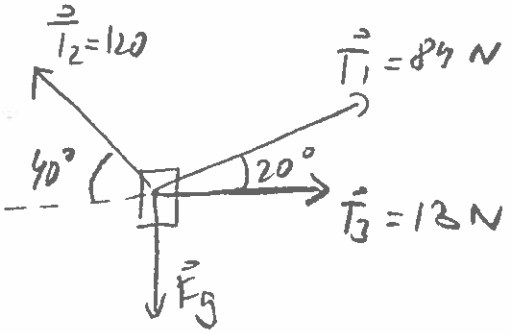
$\theta = \tan^{-1}\left(\frac{4.7062}{4.4657}\right)$

$\theta \doteq 47°$

(*) according to the rules of +/− and ×/÷ and significant digits

3. A 10.802-kg object is being pulled by three ropes. One rope pulls with 84.0 N right 20° above the horizontal, the other rope pulls with 120 N left 40° above the horizontal and the third rope pulls only 13 N right.

Express all forces in vector notation

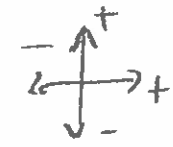


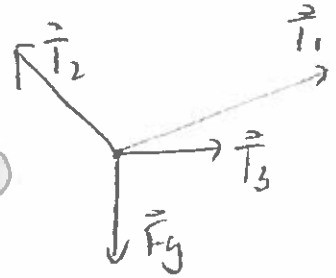
$$\vec{F}_g = [0, (10.802)(-9.8)]N$$
$$= [0, -105.8596]N$$

$$\vec{T}_3 = [13, 0]N$$

$$\vec{T}_1 = [84 \cdot \cos 20°, 84 \sin 20°]N$$
$$= [78.9342, 28.7297]N$$

$$\vec{T}_2 = [-120 \cdot \cos 40°, 120 \sin 40°]N$$
$$= [-91.9253, 77.1345]N$$





$$\vec{F}_{net} = \vec{F}_g + \vec{T}_1 + \vec{T}_2 + \vec{T}_3$$
$$= [0, -105.8596] + [78.9342, 28.7297] + [-91.9253, 77.1345] + [13, 0]$$
$$= [0.0089, 0.0046]\ N$$

(*) $\approx [0, 0]\ N$

$F_{net} = 0\ N \Rightarrow$ no $\vec{a}$

∴ The object is in translational equilibrium and it will not accelerate.

List contact forces you know:

- $\vec{F}_N$
- $\vec{T}$
- $\vec{T}_f$
- $\vec{F}_{pull}$
- $\vec{F}_{push}$
- spring force

List field forces you know:

- gravity
- electricity
- magnetism

How do contact forces differ from field forces and how are they similar?

Differences:

- contact forces require a surface/point of contact

Similarities:

- vector quantities
- measured in N
- result in $\vec{a}$ if unbalanced

Give three examples that demonstrate that friction is useful.

- matches
- winter tires
- soccer shoes' soles