

Homework

The Unexpected:

1. Four forces act on an object that is exhibiting UNIFORM motion. One force is 5 N [E], the second force is 8 N [W], and the third is 9 N [E].

a. What must the fourth force be for the object to maintain uniform motion?

b. What is the object's acceleration?

c. If the object was initially travelling 5 m/s [E], how fast is the object travelling after 4 s?

2. You are pushing horizontally on a crate that weighs 50 N. The crate moves across the floor at constant speed. If you are pushing with 25 N,

a. what is the force of friction acting on the crate?

b. what is the coefficient of friction?

Friction and 2 Dimensional Analysis

Friction acts parallel to the surfaces

Normal force acts perpendicular to the surfaces

These two forces are already spread in 2 dimensions meaning you have to look in the direction of friction and in the direction of normal force

You look along each direction one at a time (independently).

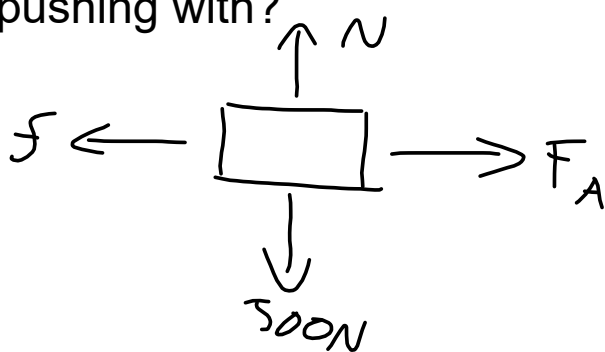
The forces along the horizontal and vertical directions are related by the "fun" equation.

$$f = \mu N$$

You already know how to do this question. I just want to make you aware that you are thinking in 2 independent directions when dealing with problems with friction.

Example

You are pushing horizontally on a chair that weighs 500 N, so it moves at a constant speed across the floor. If the coefficient of friction is 0.2, how much force are you pushing with?



$$\begin{array}{c} x \\ \hline \Sigma F = 0 \\ f = F_A \end{array}$$

$$\begin{array}{c} y \\ \hline \Sigma F = 0 \\ N = F_g \\ = 500N \end{array}$$

$$\begin{aligned} f &= \mu N \\ &= (0.2)(500N) \\ &= 100N \end{aligned}$$

Forces at an Angle

Rather than pushing horizontally, what if you were pushing/pulling at an angle.

Think of all the things you push/pull at an angle:

car door
Lawn mower
Rope

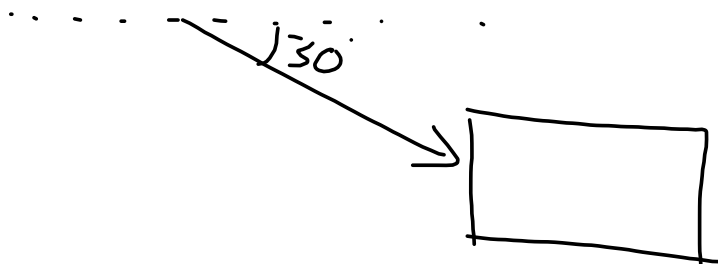
Shopping cart

When you push at an angle, what does this affect?

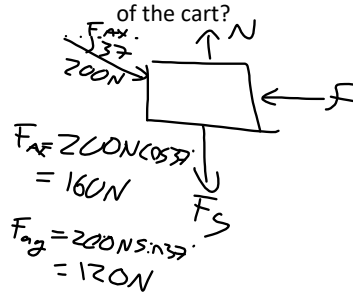


Common Language Heard in These Problems:

A force is applied 30 degrees above or below the horizontal



1. You are pushing a 50 kg shopping cart with a force of 200 N at an angle of ~~36.87°~~ downwards with respect to the horizontal.
 1. If the kinetic frictional force is 150 N, what is the acceleration of the cart?
 2. If the coefficient of kinetic friction is 0.2, what is the acceleration of the cart?



$$\begin{aligned} \sum F_x &= ma \\ F_{Ax} - f &= ma \\ 160\text{N} - 150\text{N} &= (50\text{kg})a \\ \frac{10\text{N}}{50\text{kg}} &= a \\ a &= 0.2\text{m/s}^2 \end{aligned}$$

b)

$$\begin{aligned} \sum F_x &= ma & \sum F_y &= 0 \\ F_{Ax} - f &= ma & N &= F_g + F_{Ay} \\ 160\text{N} - 150\text{N} &= (50\text{kg})a & & \end{aligned}$$

2. You are pulling a 30 kg lawn mower, with a force of 100 N upwards with an angle of 30° to the horizontal.
 1. If the kinetic frictional force is 60 N, what is the acceleration of the lawn mower?
 2. If the coefficient of kinetic friction is 0.2, what is the acceleration of the lawn mower?

3. You are moving a 150 kg refrigerator across the floor by tying a rope around the top of the refrigerator and pulling down with a force of 1000 N at an angle of 30° to the horizontal.
 1. If the kinetic frictional force is 800 N, what is the acceleration of the refrigerator?
 2. If the coefficient of kinetic friction is 0.45, what is the acceleration of the refrigerator?

4. You are pushing a 150 kg refrigerator across the floor, by pushing with a force of 600 N upwards with an angle of 36.87° to the horizontal.
 1. If the kinetic frictional force is 475 N, what is the acceleration of the refrigerator?
 2. If the coefficient of kinetic friction is 0.4, what is the acceleration of the refrigerator?

Generalization of Forces at an Angle

When pushing or pulling at an angle,

- the horizontal force that causes the object to move is reduced.
- the normal force that supports the object is either greater or smaller (depends on whether force is applied above/below horizontal)

Homework

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