

I have the following physics problem: "A worker is pushing a wooden crate across a concrete floor at a uniform speed. The coefficient of kinetic friction between the crate and the floor is 0.36. The worker applies a force at an angle of 12.74° downward with respect to the horizontal. The required force exerted is 465.64 N. The acceleration due to gravity is 9.81 m/s^2 . Find the mass of the crate in kilograms. Express your answer with two significant figures." I want to generate 10 isomorphic versions of this problem. Each isomorphic version should: 1. Involve a different scenario of an object being pulled or pushed by either a human, an animal, or a machine/vehicle across a rough surface. 2. Involve only 1 external pushing or pulling force that can point either upward or downward 3. Can ask for either F, m or μ_k as unknown variable. 4. List the numerical answer to the problem after the problem body 5. Provide a simple, student-facing solution.

Here are **10 isomorphic versions** of your physics problem, each meeting your requirements:

Problem 1

A farmer pulls a metal sled loaded with hay across a dirt path at a constant speed.

The coefficient of kinetic friction between the sled and the dirt is **0.28**.

The rope used to pull the sled makes an angle of **15.0° upward** from the horizontal.

The force required is **520 N**. The acceleration due to gravity is **9.81 m/s^2** .

Find the mass of the sled in kilograms.

Answer: 170 kg

Solution:

Since the sled moves at a constant speed, net force = 0.

Vertical forces: Normal force + vertical component of pull = weight.

Horizontal forces: Horizontal pull balances kinetic friction.

Use:

$$f_k = \mu_k N \text{ and } F \cos \theta = f_k \quad N = mg - F \sin \theta$$

Substitute into friction equation and solve for m .

Problem 2

A person pushes a refrigerator across a tiled kitchen floor with a horizontal force of **380 N**.

The coefficient of kinetic friction is **0.31**, and the person pushes **at a downward angle of 10°**.

The refrigerator moves at constant speed. $g = 9.81 \text{ m/s}^2$

What is the mass of the refrigerator?

Answer: 120 kg

Solution:

Since it's uniform speed, net force is zero.

Use same force balance setup as in Problem 1.

Normal force increases due to downward push.

Solve using:

$$F \cos \theta = \mu_k (mg + F \sin \theta)$$

Solve for m .

Problem 3

A horse pulls a wagon across a grassy field at constant speed.

The wagon's mass is **400 kg**. The coefficient of kinetic friction is **0.25**.

The horse pulls with a rope angled **18° upward from the horizontal**.

Find the magnitude of the pulling force required.

Answer: 964 N

Solution:

Calculate weight: mg .

Normal force is reduced due to upward component:

$$N = mg - F \sin \theta \quad f_k = \mu_k N$$

Set $F \cos \theta = f_k$ and solve for F .

Problem 4

A child pulls a toy wagon across a wooden deck at constant speed.

The mass of the wagon is **10 kg**, and the pulling handle makes an angle of **25° upward**.

The coefficient of kinetic friction is **0.40**.

Find the required pulling force.

Answer: 47.4 N

Solution:

Compute normal force:

$$N = m g - F \sin \theta \quad F \cos \theta = \mu_k N$$

Solve for F using known mass and $g=9.81$.

Problem 5

A person pushes a box across a rough concrete ramp with a force of **300 N**, applied at **10° downward**.

The box moves at constant speed. Its mass is **80 kg**.

Find the coefficient of kinetic friction.

Answer: 0.36

Solution:

$$F \cos \theta = \mu_k (m g + F \sin \theta)$$

Solve for μ_k .

Problem 6

A robot drags a crate along an asphalt road at constant velocity.

The force is **600 N**, applied at **20° upward**. The coefficient of kinetic friction is **0.45**.

Find the mass of the crate.

Answer: 140 kg

Solution:

$$F \cos \theta = \mu_k (m g - F \sin \theta)$$

Solve for m .

Problem 7

A sled dog pulls a loaded sled at a steady pace.
The sled has mass **150 kg**, and the coefficient of kinetic friction is **0.30**.
The harness pulls the sled **at 25° upward** from the horizontal.

What force must the dog exert?

Answer: 470 N

Solution:

$$f_k = \mu_k (mg - F \sin \theta) \quad F \cos \theta = f_k$$

Solve for F .

Problem 8

A construction worker pushes a tool chest across a concrete floor.
He applies a **downward force of 700 N** at an angle of **15°**.
The chest moves at a steady speed. The coefficient of kinetic friction is **0.40**.

What is the mass of the tool chest?

Answer: 220 kg

Solution:

$$F \cos \theta = \mu_k (mg + F \sin \theta)$$

Solve for m .

Problem 9

An ATV tows a trailer across a field at constant speed.
The trailer has mass **200 kg**, and the towing chain pulls **at 12° upward**.
The coefficient of kinetic friction is **0.35**.

Find the towing force.

Answer: 663 N

Solution:

$$f_k = \mu_k (mg - F \sin \theta) \quad F \cos \theta = f_k$$

Solve for F .

Problem 10

A delivery robot pushes a crate with a force of **350 N** at **10° downward**. The crate moves at constant speed across a tile floor. The coefficient of kinetic friction is **0.30**.

What is the mass of the crate?

Answer: 110 kg

Solution:

$$F \cos \theta = \mu_k (mg + F \sin \theta)$$

Solve for m .

Let me know if you'd like these converted into a worksheet or formatted for LaTeX or another teaching format.