Physics 1. Mechanics.

Week 4 Forces and Motion 2

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Objectives

The main objectives of today's lecture are:

- Review **Newton's third law** of motion
- Practice **applying Newton's laws** to solve problems that involve the 'new' forces

Question

Today's question:

An adult person pulls on a spring scale (shown on the right) hooked to a wall and generates the force of 100 N.

A child does the same and can only pull by 30 N force.

Q: What force will the spring scale show if the adult and the child pull on it from the opposite sides?

a) 130 N

b) 100 N

c) 70 N

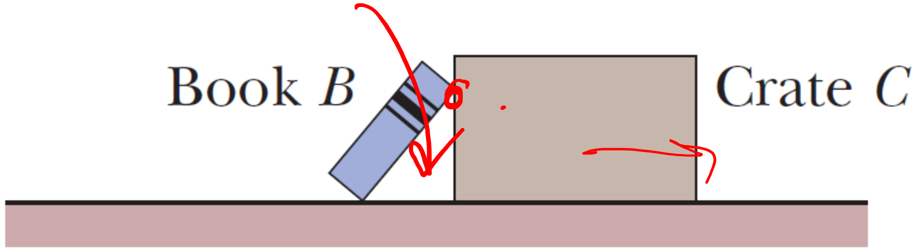
d) 30 N

Image credit: Dreamstime

Newton’s Third Law of Motion

Newton's Third Law (1)

Two bodies are said to interact when they push or pull on each other—that is, when a force acts on each body due to the other body.



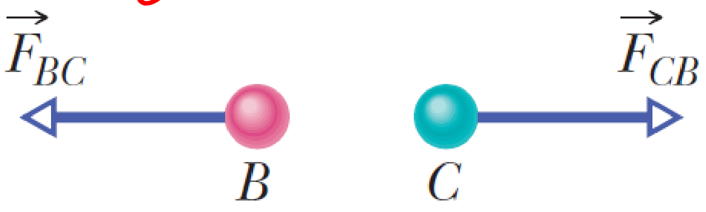
- For example, suppose you position a book B so it leans against a crate C.

Then the book and crate interact:

- There is a horizontal force $\vec{F}_{BC}$ on the book from the crate (or due to the crate) and
- a horizontal force $\vec{F}_{CB}$ on the crate from the book (or due to the book).

Newton’s Third Law (2)

Newton’s third law states that:



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- *When two bodies interact, the forces on the bodies from each other are always equal in magnitude and opposite in direction.*

- For the book and crate, we can write this law as the ~~scalar~~ vector relation

$$\vec{F}_{CB} + \vec{F}_{BC} = 0$$

$$\vec{F}_{CB} = -\vec{F}_{CB}$$

- When any two bodies interact in any situation, a third-law force pair is present.

2

Newton’s Third Law (3)

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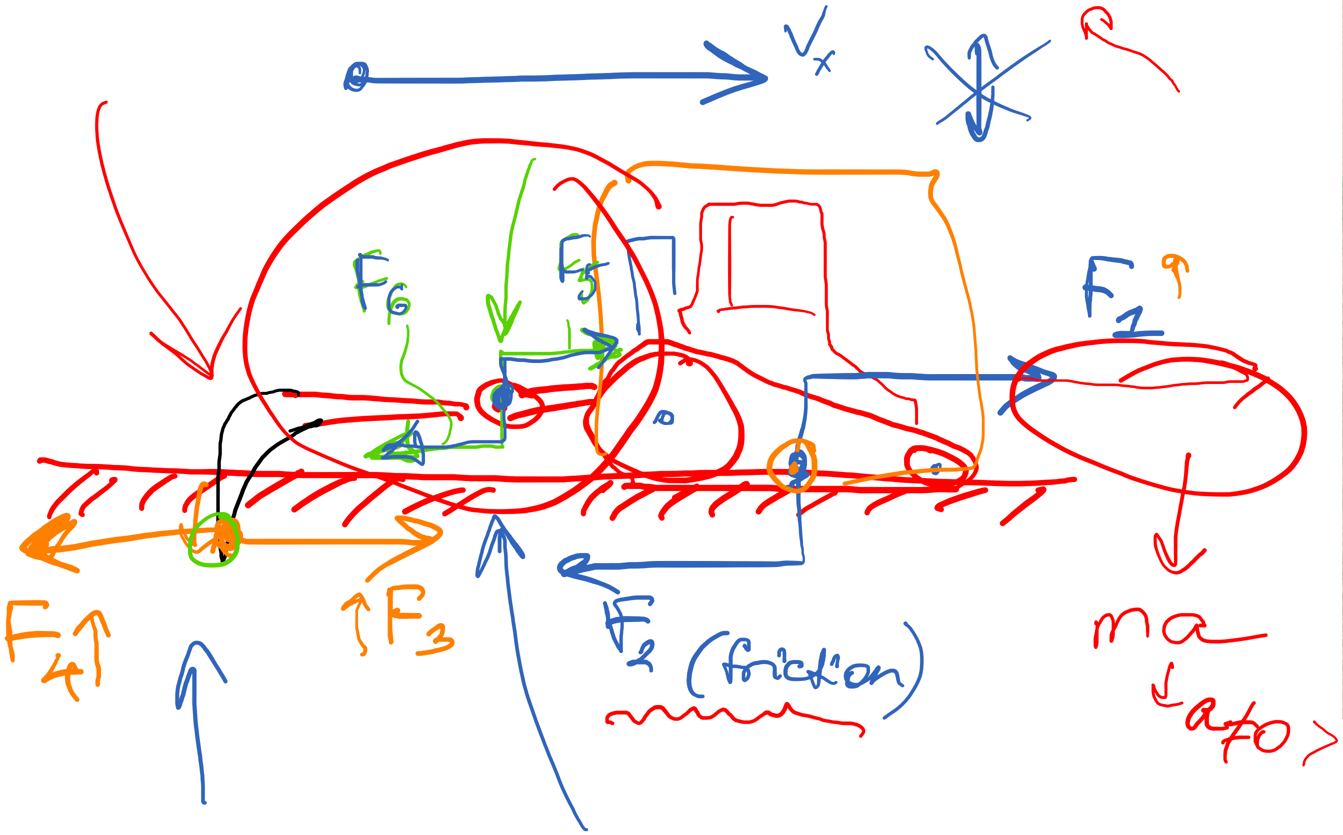
Now, how to explain using Newton’s third law how a tractor moves a plow with a constant speed?



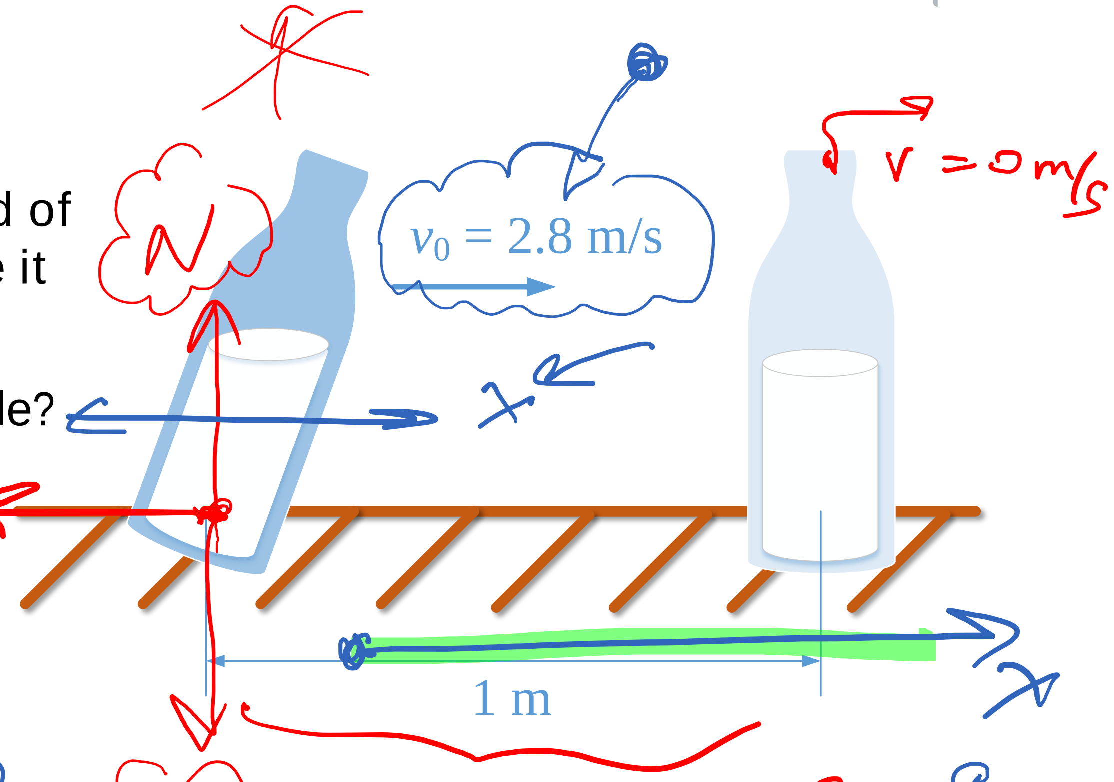
$a \neq 0 > 0 \Rightarrow V \uparrow$

Newton’s Laws: Exercise 1

$$v^2 = v_0^2 + 2\cdot a\cdot x$$

You shove a bottle of milk of mass 0.45 kg at initial speed of 2.8 m/s across a table. It travels a distance of 1 m before it stops.

Q: What is the amount of friction force acting on the bottle?



$$\boxed{x = v_0 t + \frac{1}{2} a t^2}$$

$$\boxed{F_{fr} = \mu \cdot mg}$$

$$\boxed{F_{net} = m \cdot a}$$

F_{fr}

1.75N

1 m   2.8 m/s

$$\boxed{v = v_0 + at}$$

0 m/s

$$t = -\frac{v_0}{a}$$

$$\boxed{x = -\frac{v_0^2}{a} + \frac{1}{2}\frac{v_0^2}{a} = -\frac{1}{2}\frac{v_0^2}{a}}$$

$$\boxed{a = -3.9\ m/s^2}$$

$$\mu = ? = \frac{a}{g}$$

$$\boxed{\mu \approx 0.4}$$

$$\boxed{F_{fr} = m\cdot a \approx 1.75\ N}$$

$$\vec{F}_{fr} = -1.75N \cdot \hat{i}$$

Newton’s Laws: Exercise 2

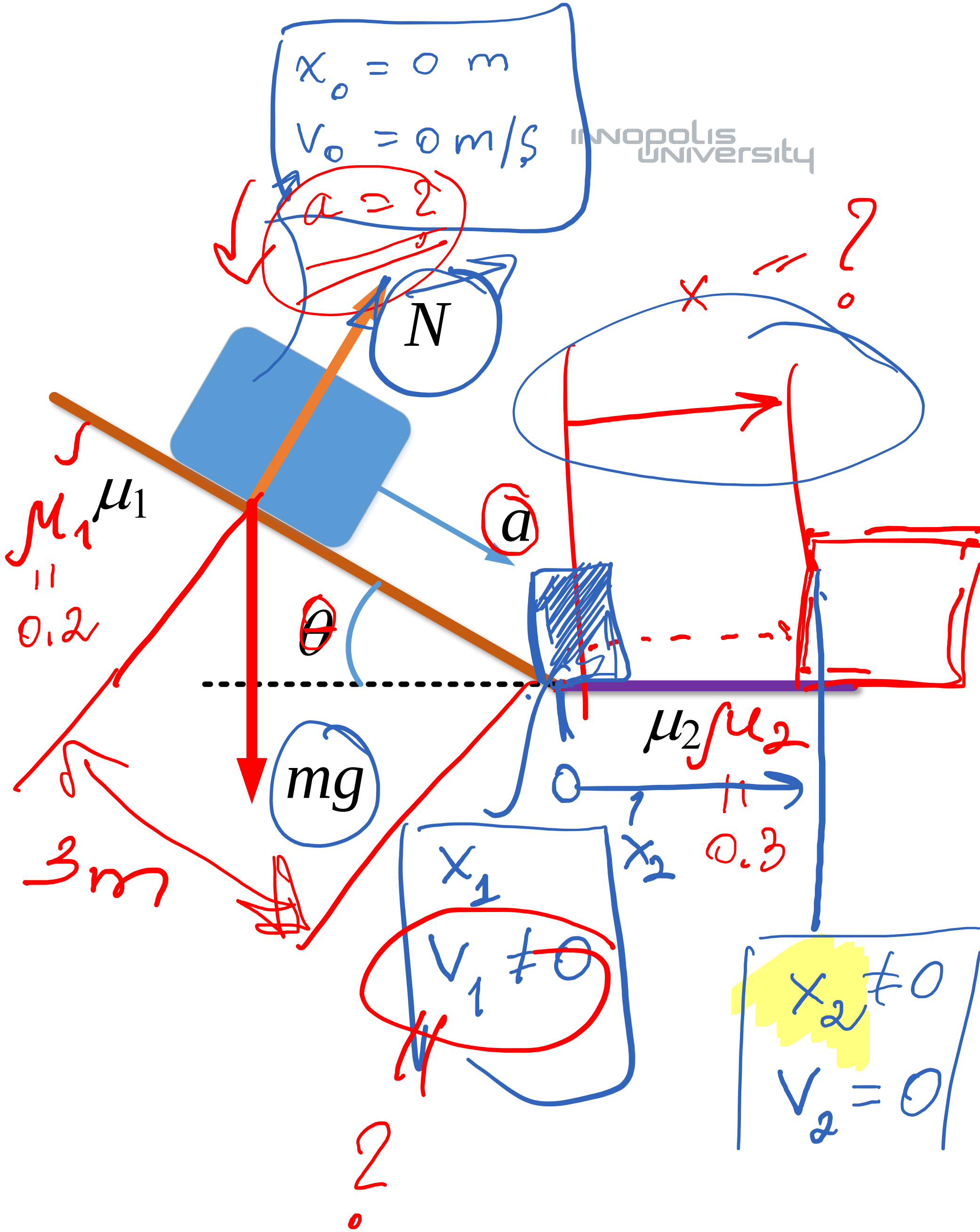
An object of mass m = 4 kg, starting from rest, slides down an inclined plane of length l = 3 m. The plane is inclined by an angle θ = 30º to the ground. The coefficient of kinetic friction is μ_1 = 0.2.

At the bottom of the plane, the mass slides along a rough surface with a coefficient of kinetic friction μ_2 = 0.3 until it comes to rest.

Q: How far will the object slide along the rough surface before stopping?

$$x = x_0 + v_0 t + \frac{1}{2} a t^2$$

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



$$-F_{fr} = \cancel{m}a = -\mu \cdot N = -\mu \cdot \cancel{m}g$$

$$\boxed{a = -\mu \cdot g = -0.3g}$$

$$V_2 = V_1 + a \cdot t_2 \Rightarrow \boxed{t_2 = \frac{4.4}{0.3g} = 1.49s}$$

$V_2 = 0$ m/s, $V_1 = 4.4$ m/s

$$X_2 = V_1 t + \frac{1}{2} a t_2^2$$

$$\boxed{X = 3.27 \, m}$$

3.3 m

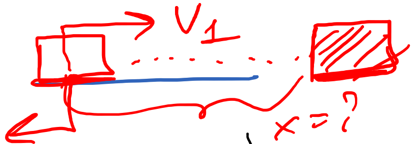
$$\boxed{F_y = m \cdot g \cdot \cos\theta}$$

$$\boxed{F_{fr} = \mu \cdot N}$$

$m \cdot g \cdot \cos\theta$, $\theta = 0$

mg

$$\boxed{X = 3.2714885}$$



$F_{fr} = \mu \cdot N$

a?

$$-F_{fr} = ma \Rightarrow a =$$

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$$F_{net,x} = m \cdot a_x$$

$$\Rightarrow \boxed{N = F_y}$$

$$+F_x - F_{fr} = m \cdot a_x$$

$$\boxed{\cancel{m} \cdot g \cdot \sin\theta - \mu \cdot \cancel{m} \cdot g \cdot \cos\theta = \cancel{m} \cdot a_x}$$

$$a_x = a = g(\sin\theta - \mu \cdot \cos\theta) = 3.2 \, m/s^2$$

$$\boxed{X = \cancel{X_0} + \cancel{V_0 t} + \frac{1}{2} a t^2}$$

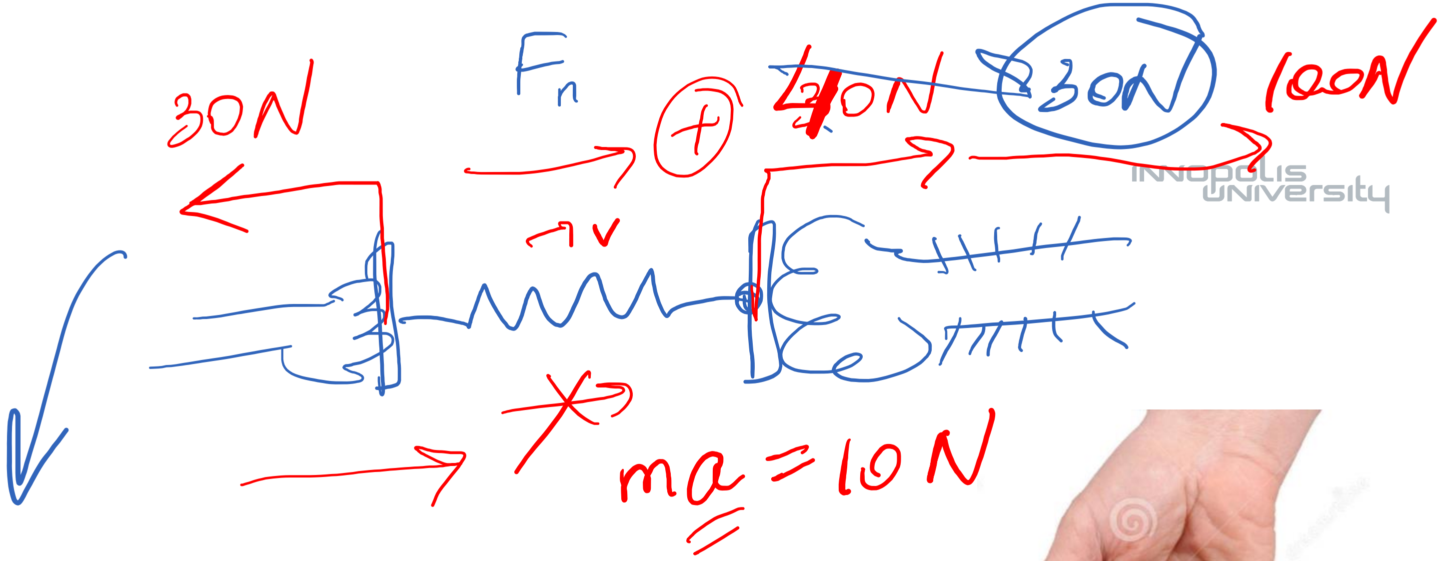
3 m

3.2 m/s²

$$\boxed{t = \sqrt{\frac{2x}{a}} = 1.37s}$$

$$\boxed{V_1 = at = 4.4 \, m/s}$$

Question



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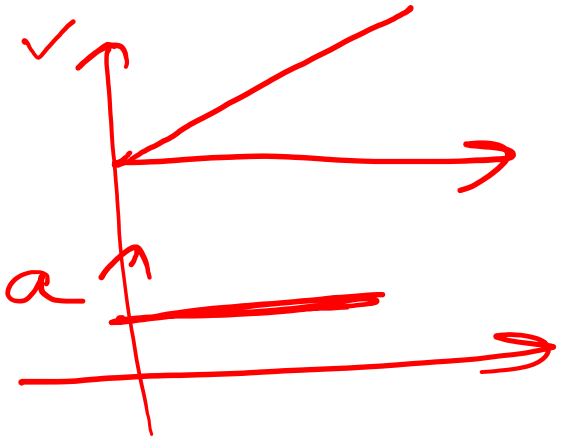

Image credit: Dreamstime

Thank you for your attention!

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