Calculating Friction

Aim: How can we calculate static and kinetic friction?

- A 3.5 kilogram box is being pulled to the right with a force of 15 newtons. The box is moving at constant velocity.
  - A) Sketch a free body diagram.

Are the forces balanced or unbalanced?

  - B) Identify the net force.
  - C) Determine the frictional force.

Learning Target

I will be able to calculate the coefficient of friction.

Coefficient of Friction (μ)

- **How much materials *STICK TOGETHER***
  - ***DIMENSIONLESS (no units)***
  - **The *HIGHER* the coefficient, the *MORE* two surfaces *STICK TOGETHER***
  - ***LOWER* if surfaces are *SLIDING* past each other**

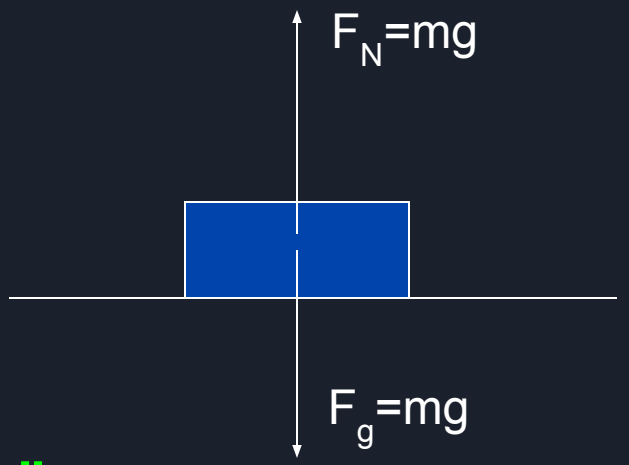
What else does frictional force depend on……

- 1. Coefficient of friction.
- 2. The normal force of the object to be moved.

Approximate Coefficients of Friction

	Kinetic	Static
Rubber on concrete (dry)	0.68	0.90
Rubber on concrete (wet)	0.58	
Rubber on asphalt (dry)	0.67	0.85
Rubber on asphalt (wet)	0.53	
Rubber on ice	0.15	
Waxed ski on snow	0.05	0.14
Wood on wood	0.30	0.42
Steel on steel	0.57	0.74
Copper on steel	0.36	0.53
Teflon on Teflon	0.04	

Only for Horizontal surfaces $F_g = F_N$



- Friction formula:
- $F_f = \mu F_N$
- F_f = force of friction
- μ = “coefficient of friction”
- F_N = “normal force” acting on the object to be moved.

Example:

- How much force must be applied to begin moving a stationary 5 kg wooden box on a wooden floor?
- $F_f = \mu F_N$

$F_N = mg = (9.8 m/s^2)(5kg) \quad = 49N$

$F_f = (0.42)(49N)$

$= 20.6$ Newtons

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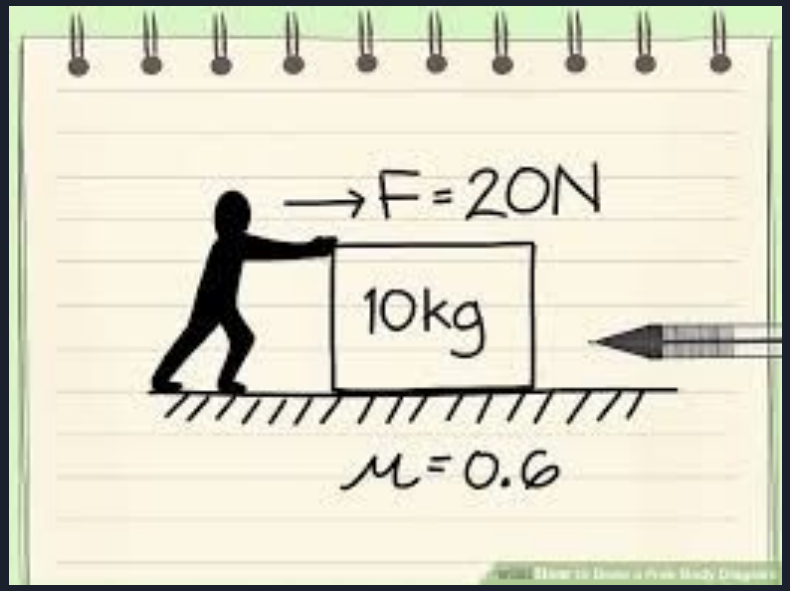

Step 1: Calculate the Normal Force:

$F_g = mg$

$F_g = (10kg)(9.8m/s^2)$

$F_g = 98N$

Normal force = weight

Step 2: Calculate Friction

$F_f = \mu F_N$

$F_f = (0.6)(98N)$

$F_{f,} = 58.8\ N$

Example 2:

- How much force does it take to keep a 1000 kg car moving at constant speed on a dry asphalt road?
- $F_f = \mu F_N = \mu mg$

$= (0.67)\ (1000\ kg)\ (9.8\ m/s^2)$

$= 6{,}566$ Newtons

Check for Understanding

- The coefficient of kinetic friction between a 640.-newton crate and a level warehouse floor is 0.25. Calculate the magnitude of the horizontal force required to move the crate across the floor at constant speed.
    - At a constant speed - the crate will be balanced
    - therefore, the horizontal applied force will be equal to the frictional force.

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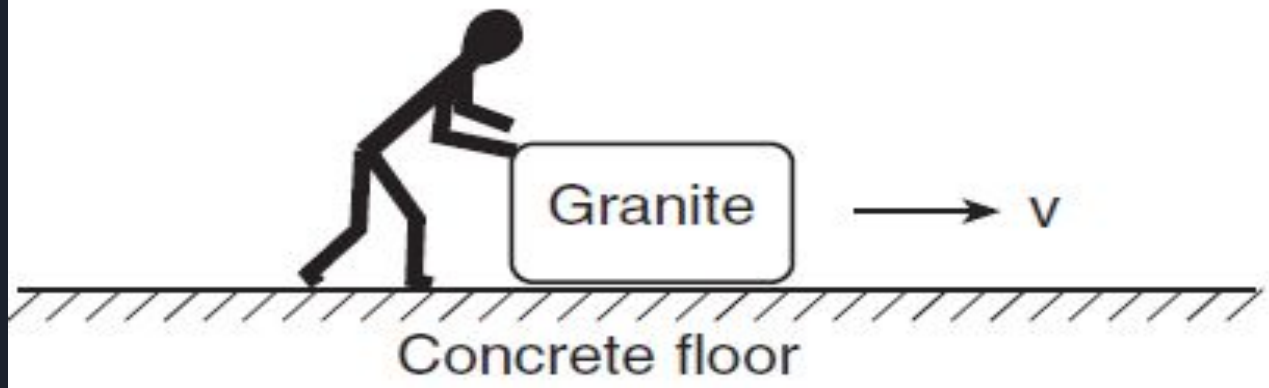
- $F_f = \mu F_N$
- $F_f = (0.25)(640N)$
- $F_f = 160N$

Example 3:

- Calculate the coefficient of friction between a 60 newton block of wood and sandpaper if it takes 12 Newtons of force to move the wood on the sandpaper?

The diagram below shows a granite block being slid at constant speed across a horizontal concrete floor by a force parallel to the floor.



Which pair of quantities could be used to determine the coefficient of friction for the granite on the concrete?

(1) mass and speed of the block
(2) mass and normal force on the block
(3) frictional force and speed of the block
(4) frictional force and normal force on the block

Answer
D

Summary

- Describe friction
- How are static and kinetic friction similar?...how are they different?
- Describe what frictional force depends on.

Aim: How can we solve for kinetic and static friction?

- 1) Explain the difference between static and kinetic friction.
- 2) A student pushes a stationary 500 newton steel box on a level steel surface. The student exerts a 15 newton horizontal force on the box.
  - A) Does the box move? What is the static frictional force?
  - B) Determine the minimum amount of force needed to move the box.

Materials	μ_s	μ_k
Steel on steel	0.74	0.57
Aluminum on steel	0.61	0.47
Copper on steel	0.53	0.36
Rubber on concrete (dry)	1.0	0.8
Rubber on concrete (wet)	0.3	0.25
Wood on wood	0.25-0.5	0.2
Glass on glass	0.94	0.4
Teflon on Teflon	0.04	0.04
Teflon on steel	0.04	0.04
Waxed wood on wet snow	0.14	0.1
Waxed wood on dry snow	0.10	0.04
Metal on metal (lubricated)	0.15	0.06
Ice on ice	0.1	0.03
Synovial joints in humans	0.01	0.003
Very rough surfaces		1.5

Practice Problem keys