4.4

Everyday Forces
(Friction)

Objectives

- **Explain** the difference between mass and weight.
- **Find** the direction and magnitude of normal forces.
- **Describe** air resistance as a form of friction.
- **Use** coefficients of friction to calculate frictional force

Weight

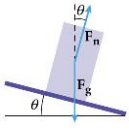
- **Weight** is the gravitational force on an object
  - Weight = F_g
- Weight depends on your location and your mass (F=mg)
- The F_g always points straight down
- Name 2 ways to change your weight

Normal Force

- **Normal force** is the force that works perpendicular to a surface
  - Regardless of surface orientation
    - What directions the normal force for these examples?
      - Book on desk
      - Apple on desk
      - Child sledding down hill
- It is NOT always opposite of gravity

Normal Force

- In the absence of other forces, the normal force is equal and opposite to the component of gravitational force that is perpendicular to the contact surface.



Practice

- Find the normal force for the following
  - A 45 kg bag sitting on a table
  - A 55 kg box sitting on a ramp
    - The ramp is at an angle of 24 degrees

Static and Kinetic Friction

- Whenever 2 objects are in contact and one object moves past the other, friction is involved
- Recall that friction is a force that opposes motion
- There are 2 types of friction:
  - Kinetic friction
  - Static friction

Static and Kinetic Friction

- **Kinetic friction** – is the friction between moving objects
- Examples are sledding down a hill, pushing a desk across the floor, or rubbing your hands together

Static and Kinetic Friction

- **Static friction** – this friction is between objects that are not moving
- Static friction is always opposite and equal to the force that is against it
- Examples are a book sitting on your desk, trying to push a heavy box across the floor (before it moves), and a sticker on a wall

Static and Kinetic Friction

- You might push harder and harder, as shown in the figure below, but if the couch still does not move, the force of friction must be getting larger.
- This is because the static friction force acts in response to other forces.

Static and Kinetic Friction

- Finally, when you push hard enough the couch will begin to move.
- So, there is a limit to how large the static friction force can be. Once your force is greater than this maximum static friction, the couch begins moving and kinetic friction begins to act on it instead of static friction.

Static and Kinetic Friction

- Frictional forces depend on the surfaces in contact
- For example, there is more friction between skis and concrete than there is between skis and snow.
- The normal force between the two objects also matters. The harder one object is pushed against the other, the greater the force of friction that results.

Static and Kinetic Friction

$$F_{f,\,kinetic} = \mu_k F_N$$

I usually like to write it as $F_k = \mu_k F_N$

- The kinetic friction force is equal to the product of the coefficient of the kinetic friction and the normal force.

Static and Kinetic Friction

$$F_{f,\,static} = \mu_s F_N$$

I usually like to write it as $F_s = \mu_s F_N$

- In the equation for the maximum static friction force, μ_s is the **coefficient of static friction** between the two surfaces, and $\mu_s F_N$ is the maximum static friction force that must be overcome before motion can begin.

Examples

Coefficients of Friction

	μ_s	μ_k		μ_s	μ_k
Steel on steel	0.74	0.57	Waxed wood on wet snow	0.14	0.1
Aluminum on steel	0.61	0.47	Waxed wood on dry snow	—	0.04
Rubber on dry concrete	1.0	0.8	Metal on metal (lubricated)	0.15	0.06
Rubber on wet concrete	—	0.5	Ice on ice	0.1	0.03
Wood on wood	0.4	0.2	Teflon on Teflon	0.04	0.04
Glass on glass	0.9	0.4	Synovial joints in humans	0.01	0.003

What do you notice when comparing kinetic with static?

Free-body Diagrams

- The force of friction is always parallel with the surface
- Practice
  - Pulling a sled across the street
  - Pulling a sled up a hill
    - Hill has an incline of 36 degrees

Air Resistance

- **Air resistance** is a form of **friction.** Whenever an object moves through a fluid medium, such as air or water, the fluid provides a resistance to the object's motion.
- For a falling object, when the upward force of air resistance balances the downward gravitational force, the net force on the object is zero. The object continues to move downward with a constant maximum speed, called the **terminal speed**

Fundamental Forces

- There are four fundamental forces**:**
  - **Electromagnetic force**
  - **Gravitational force**
  - **Strong nuclear force**
  - **Weak nuclear force**
- The four fundamental forces are all **field forces**