

Motion

(Chapter 1)

Student Learning Outcomes: Differentiate between mass and weight, and compare and contrast the terms used to describe motion.

1. *What is inertia?*
2. *How is mass defined?*
3. *What quantities contribute to weight?*
4. *What is a force?*
5. *How are scalar and vector quantities different?*
6. *How do speed and velocity compare?*
7. *How is acceleration defined?*
8. *What causes vertical acceleration?*

What is Inertia?

❖ **Inertia is the tendency of an object to maintain its motion.**

❖ Inertia depends on mass.

more mass → more inertia → harder to change motion

Example: Smart car versus Hummer

How is mass defined?

❖ **Mass is the amount of material contained in an object.**

❖ Mass is measured in grams or kilograms

Examples:

Empty 747 Jet	160,000 kg
Average Man	73 kg
5¢ coin	0.0052 kg
Raindrop	0.000002 kg

❖ Mass does not depend on any other quantity.

Question: Mass is often defined in elementary school as “the amount of space an object takes up”. Why is this **not** correct?

What quantities contribute to weight?

- ❖ **Weight depends on mass and the force due to gravity.**
- ❖ Weight is measured in pounds or Newtons

$$1 \text{ Newton} = 0.2248 \text{ lb}$$

- ❖ 1 kg of mass weighs 9.81 Newtons on Earth.

Questions:

- 1) Do you think weight depends on volume?
- 2) If you were instantly transported to Mars, which (if any) of the following would change?
 - a. mass
 - b. weight
 - c. inertia

What is a force?

- ❖ A force is the amount of push or pull on an object.
- ❖ Forces can cause a change in motion.
- ❖ The net force on an object is the summation of all forces acting on the object.

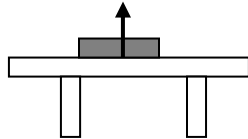
$$F_{\text{net}} = \sum F$$

- ❖ When the net force on an object is zero (when forces add to zero), the object is in mechanical equilibrium.
 - An object at rest is in mechanical equilibrium
 - An object moving at a constant speed in one direction is in mechanical equilibrium.
- ❖ **Mechanical equilibrium means there is no change in the object's motion.**

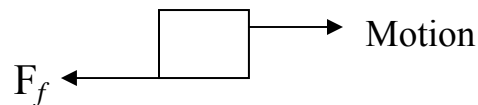
Questions:

- 1) If car engine provides 700 Newtons of push, and there is 200 Newtons of opposing friction, what is the net force on the car?
- 2) What is the net force on the car if the opposing friction force is 700 Newtons? Would this cause the car to stop?

- ❖ Objects at rest in the vertical have a **support force** acting against gravity.



- ❖ Objects in motion have a **friction force** that is opposite to the direction of motion.



How are scalar and vector quantities different?

- ❖ **Scalars are quantities that indicate the size of something.**
- ❖ **Vectors are quantities that indicate the size of something in a particular direction.**
- ❖ The **magnitude** of a vector is a scalar; it is the size of the vector.

Question: What is the magnitude of a force that is pushing with 500 N East?

How do speed and velocity compare?

- ❖ Speed and velocity are both words used to describe motion.
- ❖ The basic difference is the inclusion of direction.
- ❖ **Speed is the amount of distance covered in some amount of time.**
- ❖ **Velocity is speed in some direction.**

❖ The direction may be specified in many ways.

- Up, Down
- Left, Right
- North, South, East, West
- -, +

❖ The average speed or the magnitude of the velocity is:

$$s = \frac{d}{t}$$

❖ The standard units of speed and velocity are:

$$m/s$$

Question: A runner's average speed to run the 100 meter dash is 12 m/s. How long does it take the runner to finish the dash?

How is acceleration defined?

❖ Acceleration is the rate of change of velocity. It is a change in speed or direction.

$$a = \frac{\Delta v}{t}$$

❖ The standard units of acceleration are:

$$m/s^2$$

❖ Deceleration is a change in velocity that is in the opposite direction as compared to the motion of the car.

❖ A calculated acceleration that is negative indicates **deceleration**.

❖ A car that maintains a constant speed in a straight line has zero acceleration, but it is still moving!

Go To: <http://www.physicsclassroom.com/mmedia/kinema/avd.cfm>
<http://www.physicsclassroom.com/mmedia/kinema/pvpa.cfm>
<http://www.physicsclassroom.com/mmedia/kinema/pvna.cfm>

Questions:

- 1) On the freeway, you increase your speed from 15 mph (6.7 m/s) to 65 mph (29 m/s) which takes about 2 seconds. What is your average acceleration?
- 2) When driving through a curve at a constant rate of speed, is there acceleration?

What causes vertical acceleration?

- ❖ Objects are accelerated downward because of a downward force, gravity.
- ❖ The gravitational force of Earth pulls objects toward the center of Earth.
- ❖ **The gravitational pull from the Earth is the same on all objects, so the downward acceleration is the same on all objects, 9.81 m/s^2 .**

Go To: http://www.youtube.com/watch?v=5C5_dOEyAfk

- ❖ Any difference in the net acceleration is due to air resistance.
- ❖ When there is acceleration, the distance traveled depends on how long the object has been accelerating.

$$d = 1/2at^2$$

Questions:

- 1) I toss a ball upward and it returns to my hand. What is the ball's rate of acceleration if there is no air resistance?
 - a. Just after the ball leaves my hand?
 - b. At the top of the trajectory?
 - c. Just before the ball hits the ground?
- 2) Professional cliff divers jump from a cliff into the sea. If it takes 2.7 seconds to fall to the sea, what is the distance they fall? What would the speed of the diver be when they hit the water?