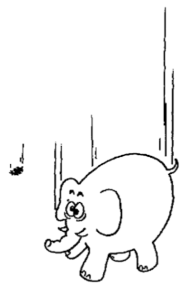
More on forces and motion



In the previous lecture

- Objects interact with other objects through forces.
- What is a force? Simply speaking, an external force is a push or pull on an object.
- There is a consequence of this push. For the cart initially sitting still on the track, the cart started to move---its *velocity* went from zero to non-zero---- the cart *accelerated*----- until…..

Displacement, velocity and acceleration

Displacement ($\vec{X}$ is position of object): $$\Delta\vec{x} = \vec{x}_f - \vec{x}_i$$

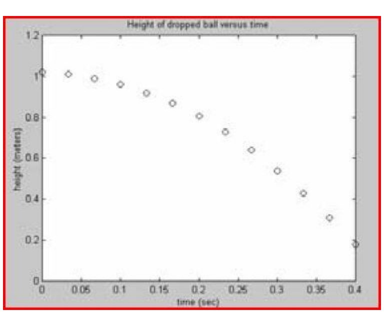
Average velocity: $$\vec{v}_{av} = \frac{\Delta\vec{x}}{\Delta t}$$

Average acceleration: $$\vec{a}_{av} = \frac{\Delta\vec{v}}{\Delta t}$$

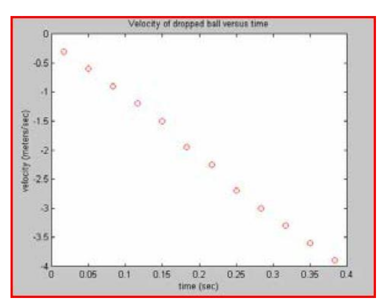
Motion of a dropped ball

- How is the motion of a dropped ball different from the motion of the cart?
- How is, or how could, the motion in the two cases be the same?

Motion of a dropped ball



Motion of a dropped ball



Mass vs. weight

- The spring scale measures the *weight* of an object.
- The weight measures of the gravitational *force* on an object.
- Weight is *not* equal to mass.
- Force has units of Newtons (N) and mass has units of kilograms (kg).

Mass versus Weight

- Anything that has mass has weight.
- Anything that has weigh has mass.
- They are related, but they are NOT the same.
- Doubling mass, doubles weight.

$$\vec{W} = m\vec{g}$$

More than one force

- If there is one external force on an object, the object will accelerate
- What happens when there is more than one external force on an object?
- Will the application of forces on an object *always* result in the object accelerating?

Total force

- If there is more than one force, then one must calculate the sum of the forces. If the sum of the forces is nonzero, the object will accelerate.
- If $\Sigma\vec{F}_i \neq 0$, then the object's state of motion will change, i.e. accelerate.
- If $\Sigma\vec{F}_i = 0$, then the object's state of motion will NOT change, i.e. the velocity will remain constant.

Mechanical equilibrium

Let's focus on the case where

$$\Sigma\vec{F}_i = 0.$$

This equation defines *mechanical equilibrium*.

Examples of mechanical equilibrium?

Mechanical equilibrium

- A book on a table
- An object hanging motionless on a spring scale; the more the spring is stretched, the more the needle is deflected; measuring weight of the object
- A train travelling at constant velocity
- One then one force involved in each case. What are they?

Mechanical equilibrium

The sketch on the side screen shows a painter's scaffold in mechanical equilibrium. The person in the middle weighs 250 N, and the tensions in each rope are 200 N. What is the weight of the scaffold?

Terminal velocity

- Yet another example of mechanical equilibrium
- What are the two forces involved here?

Dropping objects in vaccuum

- Galileo demonstrated that objects with *different* weights fell at the *same* rate, i.e. they had the same acceleration, when air resistance effects were neglected! Wow!

Equations for a dropped object

- For a dropped object (in vacuum), its acceleration is constant

$$v_{av} = \frac{1}{2}(v_i + v_f)$$

$$\Delta v = a\Delta t$$

$$\Delta y = v_{av}\Delta t$$

Hang time

If the world record vertical standing jump is 1.25 m, how long is the person in the air?