Gravity – Free-Fall Acceleration

Falling objects have acceleration due to gravity

Free-fall Acceleration (g) – The acceleration due to the force of gravity (We all fall down)

$$g = -9.8 \text{ m/s}^2$$

Free Fall

Free Fall: motion of a body when gravity is the only force acting on the body

Without air resistance, all objects will fall at the same rate, regardless of mass

Air resistance is often called **"drag force"**

Weight vs. Mass

Weight is not the same as mass!!
Weight is a force and is measured in Newtons

Weight – The force of gravity acting on an object

Mass – The amount of matter in an object

Weight

Weight is calculated:

mass × free-fall acceleration

Weight comes from Newton's 2nd law:

$$F = ma \rightarrow \mathbf{W = mg}$$

Weight Example 1

What is the weight of a 20 kg rock?

$m = 20 \text{ kg}$ $\quad g = 9.8 \text{ m/s}^2$

$$\mathbf{W = mg}$$

$$W = (20 \text{ kg})(9.8 \text{ m/s}^2) = 196 \text{ N}$$

Weight Example 2

To lift a book, 25 Newtons of force was used. What is the mass of the book?

$W = 25 \text{ N}$ $\quad g = 9.8 \text{ m/s}^2$

$$\mathbf{W = mg} \rightarrow \mathbf{m = \frac{W}{g}}$$

$$m = \frac{25 \text{ N}}{9.8 \text{ m/s}^2} = 2.6 \text{ kg}$$

Gravity Factors

Gravitational force is affected by two things:

Masses of each object
More mass → more weight

Distance between center of both objects
Farther from Earth → less weight

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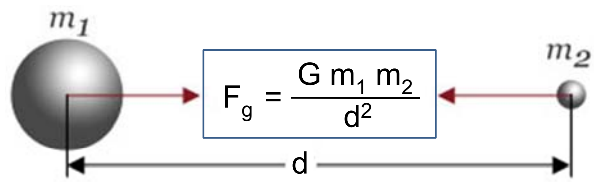
Newton's Law of Gravitation



F_g = weight
G = gravity constant
m = mass of objects
d = distance from centers

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Newton's Law of Gravitation

$$F_g = \frac{G\, m_1\, m_2}{d^2}$$

Mass is directly proportional weight
→ Doubling either mass will double weight

Distance has an inverse square relationship
→ If distance is doubled, weight is ¼ as much

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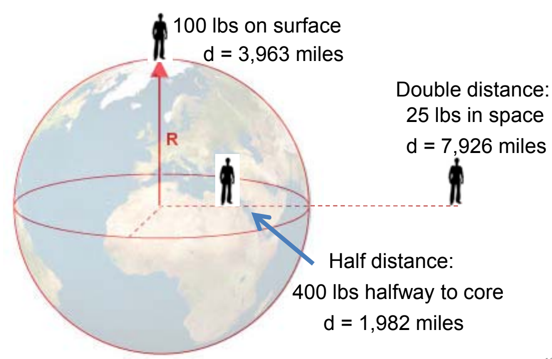
Effect of Distance on Gravity



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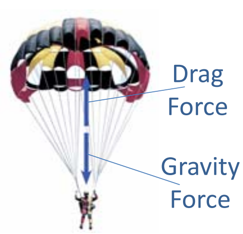
Terminal Velocity

Terminal Velocity: The fastest an object can fall.
This occurs when the air resistance is equal to the force of gravity



When $F_{drag} = F_g$ then an object will fall at a constant speed.

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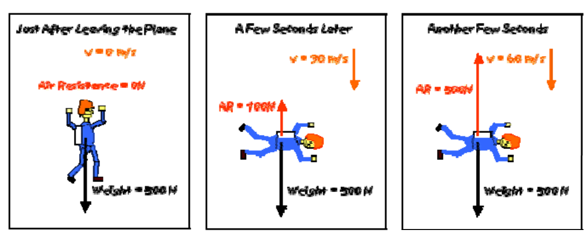
Terminal Velocity



As the person falls faster he will have more drag.
Once his drag force matches his weight he will fall at this maximum constant speed.

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Projectile Motion

Projectile motion is used for predicting the location of a launched object such as:
a bullet, cannonball, stunt jumper, football, etc.

Projectile – Any object that is launched, fired or thrown and is not self powered

Projectile Motion – The curved path an object follows when thrown, launched, etc. The shape will be a parabola.

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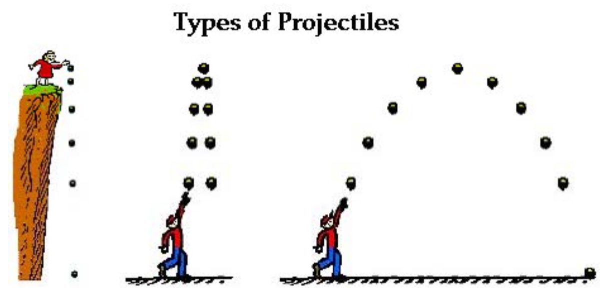
Projectile Motion Examples



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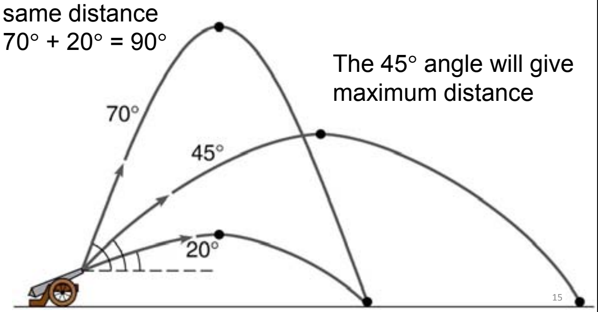
Launch Angle and Distance

Angles that add up to 90° will reach the same distance
70° + 20° = 90°

The 45° angle will give maximum distance



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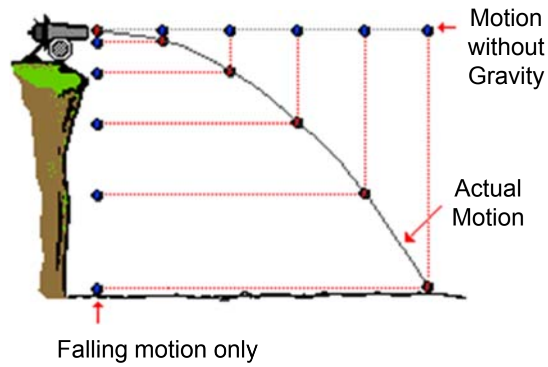
Breaking Up Projectile Motion



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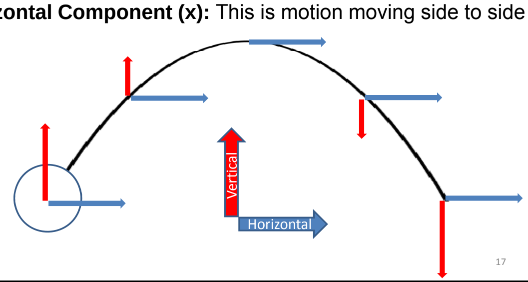
Projectile Components

Motion can be broken up into vertical and horizontal parts.

Vertical Component (y): This is motion going up or down

Horizontal Component (x): This is motion moving side to side



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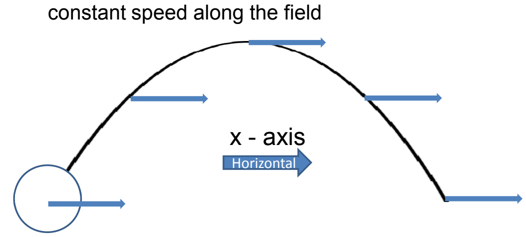
Horizontal Component

Air resistance is usually ignored. This means the motion from left to right will be a constant speed.

Example: The shadow of a punted football will be moving at a constant speed along the field



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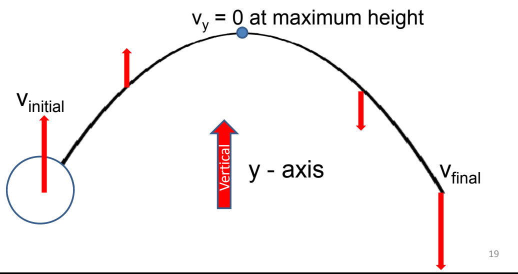
Vertical Component

The vertical component is affected by gravity at 9.8 m/s^2. At the highest point, the speed up or down is 0, and the object will hit the ground at the same speed it was launched.



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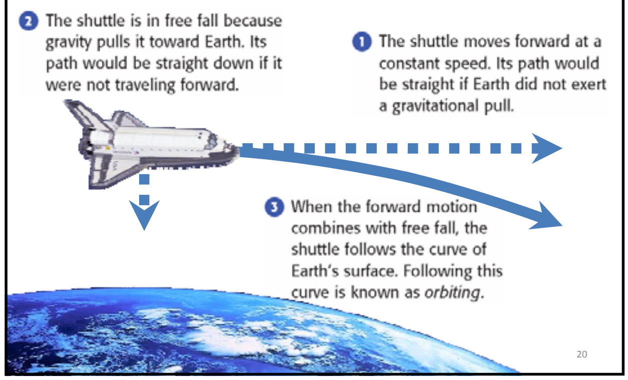
How Orbiting Works



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