Projectile Motion

Motion near the Earth's surface,
moving under the influence of gravity.

Simplifying Assumptions

- Earth's curvature is negligible.

  OK if horizontal range is small compared to Earth's radius.

- Variation is the acceleration due to gravity is small.

  OK if altitude is small compared to the Earth's radius.

- Air resistance is negligible.

  OK if projectile speed and cross-sectional area of the projectile is small.

- The consequences of the Earth's rotation are also ignored.

With these assumptions…

…the horizontal and vertical components of the motion are completely independent of each other.

…we can solve trajectory problems via analysis of the horizontal and vertical components separately.

…we continue to assume that $g = 9.8\ \text{m/s}^2$.

Example #1

A stone is thrown from the top of a cliff at an angle 37° above the horizontal. The height of the cliff is 100 m. The stone hits the ground a distance of 200 m from the base of the cliff.

- Calculate the time the stone is in flight.
- Calculate the initial velocity of the stone.
- Calculate the maximum height of the stone.

Example #2

A object is fired with an initial speed of 50 m/s at an angle 55° above the horizontal. After passing through its highest point, the object strikes a hillside 60 m higher than the level of its launch.

- Calculate the time of flight of the object.
- How far does the object go horizontally?
- What is the velocity of the object the instant it strikes the hillside?

Example #3

An object is thrown out of a window with an initial speed of 8.0 m/s at an angle 20° below the horizontal. The object hits the ground 3.0 s later.

- How far from the base of the building does the object hit the ground?
- How high is the window?
- How long does it take for the object to reach 10 m below its launch point?

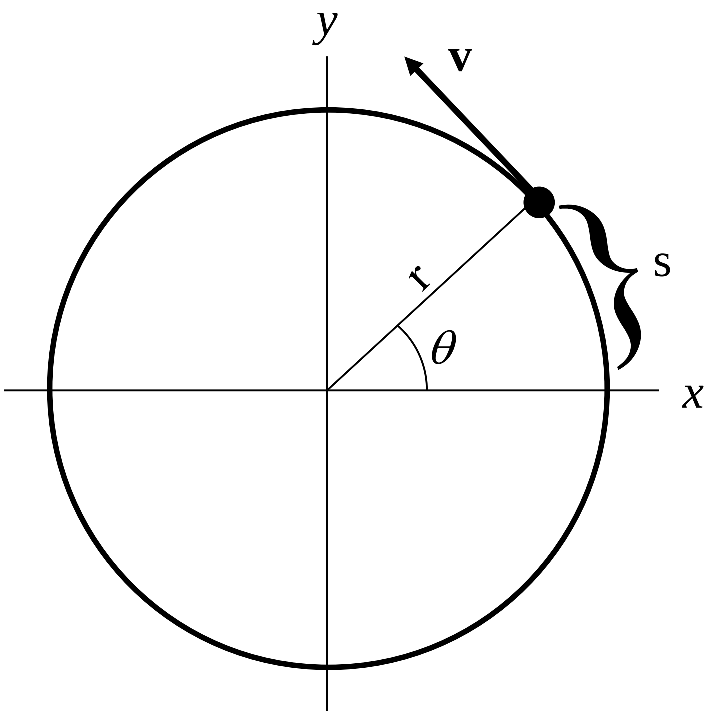
Example #4

An aircraft flies at a steady horizontal flight at a speed of 430 km/hr and at an altitude of 1.2 km. To drop a “care package” at a particular target, at what angle of sight (relative to the vertical) should the pilot release the payload?

A) 0^o B) 33^o C) 57^o D) 90^o

Uniform Circular Motion

A particle travel in a circle with a constant speed has acceleration!



Example #5

A satellite is in a circular orbit around the Earth at an altitude of 200 km. (Take g = 9.2 m/s^2 at this altitude.)

- Calculate the orbital speed of this satellite.
- Calculate the orbital period of this satellite.

(The radius of the Earth is 6.37 x 10^6 m.)

Example #6

How far does the Moon fall in 1.0 s?

Some possibly useful information:

Orbital radius of Moon:	3.82×10^8 m
Orbital period of Moon:	27.3 days

Relative Motion

The velocity of a particle depends on your frame of reference. For example:

Driving a car at 60 mi/hr with a passenger. Both you and your passenger travel at 60 mi/hr with respect to an observer standing on the side of the road, however, both of you are at rest with respect to the car.

Example #7

An aircraft has an air speed (speed of the craft with respect to the air) of aircraft 215 km/hr. The compass indicates that the craft is pointing due east. There is a steady cross wind of 65 km/hr due north.

- Calculate the velocity of the craft relative to the ground.
- How must the pilot change her heading so that the aircraft flies due east relative to the ground?
- Calculate her new ground speed if the air speed remains unchanged.

Example #8

A bat is flying with velocity relative to the ground according to

$$\mathbf{v}_{\mathbf{BG}} = (5.0\text{ m/s})\cos 50^{o}\ \mathbf{i} - (5.0\text{ m/s})\sin 50^{o}\ \mathbf{j}$$

An insect is flying with velocity relative to the ground according to

$$\mathbf{v}_{\mathbf{IG}} = (-4.0\text{ m/s})\cos 30^{o}\ \mathbf{i} + (4.0\text{ m/s})\sin 30^{o}\ \mathbf{j}$$

- What is the velocity of the insect as seen by the bat? (Give your answer in unit vector notation.)