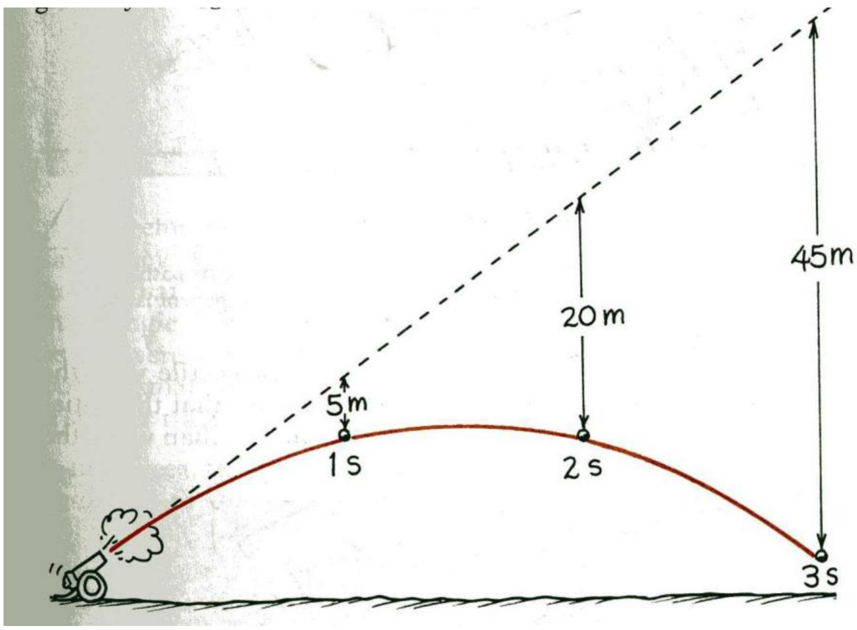
Projectile Motion Notes: continued

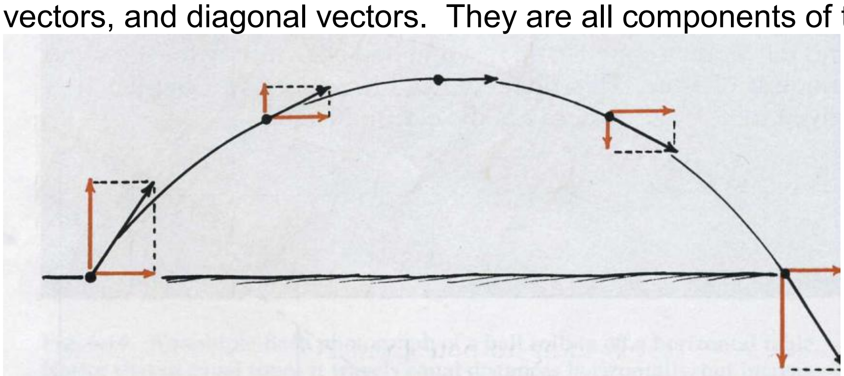
Projectiles Shot up at an Angle

Think about a cannonball shot up at an angle, or a football punt kicked into the air, or a pop-fly thrown into the air.

When a projectile is fired at an angle with the horizontal, the principles of independent velocities still holds. The initial velocity of the projectile can be "resolved" into 2 components. One component is directed horizontally and the second is directed vertically. These are still treated separately.



Look at all the vectors on the picture below. There are horizontal vectors, vertical vectors, and diagonal vectors. They are all components of the cannonball's velocity.



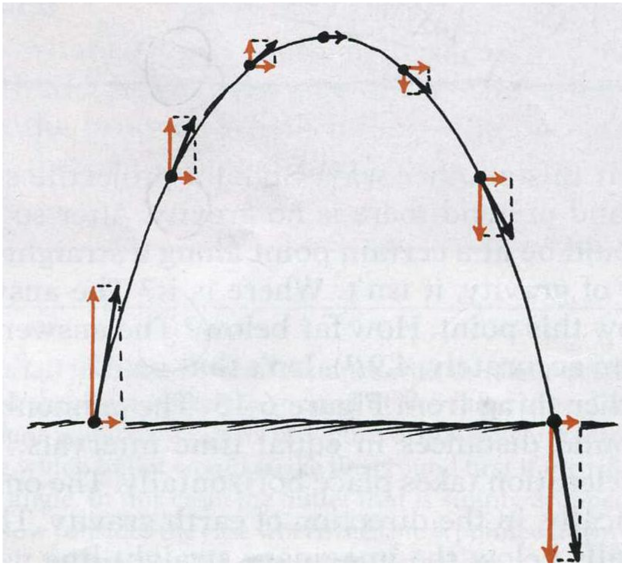
Horizontally: Look at all the horizontal vectors—They are all equally spaced apart.
There is still no acceleration in the horizontal direction so the cannonball moves

equal horizontal distances in equal time intervals.

Vertically: Look at all the vertical vectors—They get shorter and shorter then disappear at the top of the path, then get longer and longer.
This is because there is acceleration vertically (in the directions of earth's gravity). The vertical velocity and therefore distance gets bigger and bigger each second the object is still moving.

Notice that the horizontal component vector is the same length at any point along the cannonball's path. The vertical component gets smaller then disappears then gets bigger.
These vectors represent the horizontal and vertical component of velocity. The ACTUAL velocity of the object is represented by the diagonal of the parallelogram formed by the components.

At the top of the path the vertical component vanishes, or becomes zero, so the ACTUAL velocity of the cannonball at the top of the path is the exact same as the horizontal velocity at all other points (instead of a combination of the hor and vert).



The above picture has the same launching speed as the last picture and is the same idea as the last picture except the object is projected at a steeper angle. Notice the initial velocity vector has a greater vertical component than in the last picture when the projection angle was smaller. This bigger vertical component results in a higher path, but the horizontal component is less so the range is less.

This picture shows the paths of several projectiles all with the same initial speed but different projection angles. So, they have different heights and ranges.

Which of these above angles can add up to 90 degrees?

Look at the trajectories for the 75 and 15 degree angles or the 60 and 30 degree angles—what pattern do you see?

An object thrown up into the air at 60 degrees will have the same horizontal distance (or range) as if it were thrown at 30 degrees. The only difference is the height the objects go and the time they are in the air. This is true for any objects that when thrown up into the air, have projected angles that equal 90 degrees.

Which angle would make an object go the furthest or have the biggest range?
45 degrees

Study the above picture and make observations about it.

A projectile will rise to its maximum height in the same time it takes to fall from that height to the ground.

An object moving upward slows down due to gravity and an object moving downward speeds up due to gravity. The speed lost while going up equals the speed gained while going down.

This is because the deceleration due to gravity going up equals the acceleration due to gravity while coming down. 9.8 m/s^2

So the projectile arrives at the ground with the same speed it had when it was projected from the ground.

Examples

1. A projectile is fired at such an angle that the vertical component of its velocity is 39 m/s and the horizontal component of its velocity is 50 m/s. (a) How long does the projectile remain in the air? (b) What horizontal distance does it travel?

2. A famous motorcyclist plans to jump across a canyon that is 3.5 km wide. To do this, the cyclist plans to jump off a 30degree ramp on one side of the canyon at a speed of 196 m/s. If the motorcyclist can attain this speed, will he reach the other side of the canyon on the jump?

This is a several step problem

1. First find the horizontal and vertical component of the velocity
2. Then, find the **total time** the motorcycle is in the air
3. Then, find the horizontal distance the bike travels
4. Does it make the 3.5 km? If yes, how much further does it go? If not, by how much does it fall short?