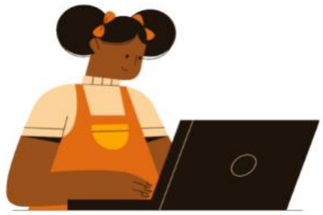


T-Shirt Launcher

Exercises

T-shirt launchers are fun, and the school would like to incorporate one at football games to bolster spirit and fan participation at games. As such, the school's cheerleaders purchased a t-shirt launcher, and upon using it for the first time, promptly launched all the t-shirts out of the stadium. They quickly realized that you must set the launch **velocity** (how fast they will travel) prior to shooting, in order to launch shirts the correct **distance**.

They also plan to use it at volleyball games, so another factor must be considered – the height of the arena (t-shirts launched directly into rafters don't improve spirit).

As it doesn't make sense to be performing calculations during a game, the cheerleaders have asked you to write a program that will quickly and easily calculate the **trajectory** of launched shirts.

Your program should calculate, given a `launchAngle` and a `launchVelocity`, the complete 'path' of the **projectile** (calculated every second), until the t-shirt reaches the ground (its Y-position returns to 0).

Using this information (and the size of the field / arena of course), the cheerleaders will be launching shirts accurately in no time! To make calculations simpler, we'll assume that air resistance friction is negligible and that the t-shirts are being launched from the ground. Sample program run, calculating positions at one second increments (user input shown in red):

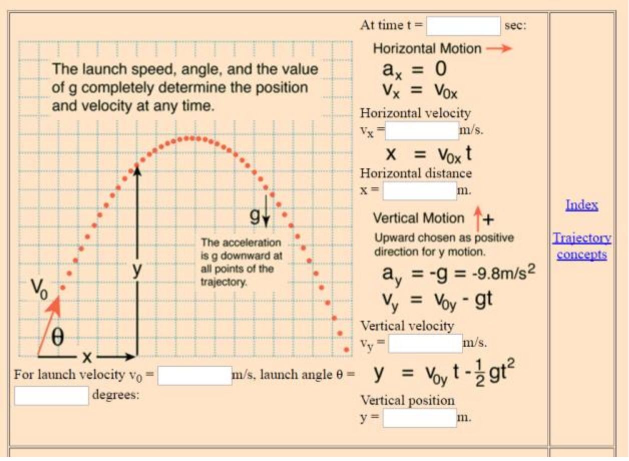
```
Enter launch velocity (m/s) >>> 15
Enter launch angle (degrees) >>> 60

Projectile's path:

Time: 0s
   x-pos: 0.0m
   y-pos: 0.0m
Time: 1s
   x-pos: 7.500000000000002m
   y-pos: 8.090381056766578m
Time: 2s
   x-pos: 15.000000000000004m
   y-pos: 6.380762113533155m
Time: 3s
   x-pos: 22.500000000000007m
   y-pos: 0m
```

Continue…

Help

Help with the t-shirt launcher calculations

To find the X- and Y-components of the t-shirt's displacement (distance) at a specific time, you need to first find the X- and Y-components of the t-shirt's velocity (the distance traveled divided by the time it took), then apply projectile motion equations. Here is an excellent graphic with the basic equations of ballistic trajectory:



At time t = ▭ sec:

Horizontal Motion →

$a_x = 0$

$v_x = v_{0x}$

Horizontal velocity

v_x = ▭ m/s.

$x = v_{0x} t$

Horizontal distance

x = ▭ m.

Vertical Motion ↑+

Upward chosen as positive direction for y motion.

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

$v_y = v_{0y} - gt$

Vertical velocity

v_y = ▭ m/s.

$y = v_{0y} t - \frac{1}{2} g t^2$

Vertical position

y = ▭ m.

The launch speed, angle, and the value of g completely determine the position and velocity at any time.

The acceleration is g downward at all points of the trajectory.

For launch velocity v_0 = ▭ m/s, launch angle θ = ▭ degrees:

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Trajectory concepts

http://hyperphysics.phy-astr.gsu.edu/hbase/traj.html#tra3

A t-shirt's position (displacement) can be found at any particular time with the following equations (with time in seconds, and using 9.8 for the gravity constant):

```
xPosition = cosine of launch angle * time * launchVelocity;

yPosition = sine of launch angle * time * lanuchVelocity – 0.5 * 9.8 * time2
```

Note that the Math.cos() and Math.sin() methods expect a value in radians! To calculate the sine of a 60 degree angle, you'll need to convert the value in degrees to radians, like this:

```
Math.sin(Math.toRadians(60))
```

The method call `Math.toRadians(60)` returns the value of 60 degrees in radians, which is then passed to the `Math.sin()` method, that will return the sine of the parameter.

After some time, the t-shirt will hit the ground (its Y position goes back 0). T-shirts don't generally burrow into the ground, so we'll say the loop is finished at this point (print the final X location with Y at 0).

Continue…

Pseudo-Code

Pseudo-code:

```
Get starting launch angle and velocity from the user
While the t-shirt hasn't hit the ground
    Print current stats (time, location, etc.)
    Increment time
    Calculate new X and Y positions
    //t-shirts don't generally burrow into the ground, they should stop at 0
```