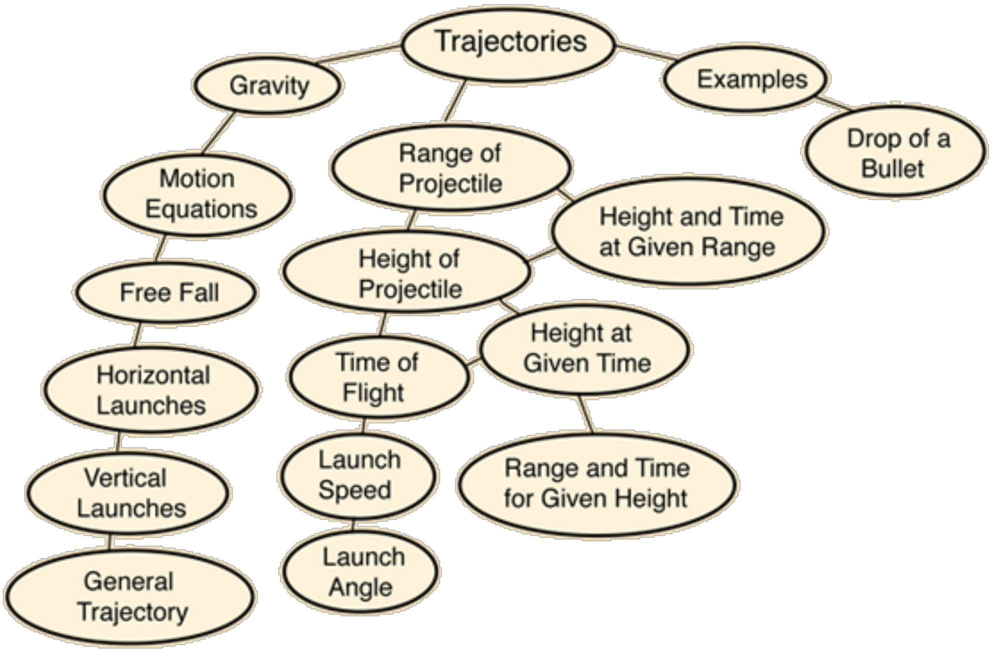


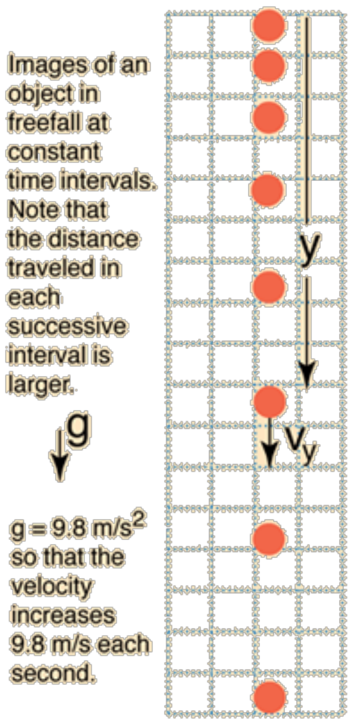

Note: This is a large HTML document. Wait until it finishes loading for full functionality.

[Index](#)

[Motion concepts](#)

[HyperPhysics](#)***** [Mechanics](#) *R Nave* [Go Back](#)

# Freefall




In the absence of frictional drag, an object near the surface of the earth will fall with the constant acceleration of gravity g. Position and speed at any time can be calculated from the [motion equations](#).

Illustrated here is the situation where an object is released from rest. It's position and speed can be predicted for any time after that. Since all the quantities are directed downward, that direction is chosen as the positive direction in this case.

$$v_y = gt \qquad \text{Taking } g = 9.8\ m/s^2$$
$$y = \frac{1}{2} g t^2 \qquad = 32.15\ ft/s^2$$

At time t = [ ] s after being

[Index](#)

[Trajectory concepts](#)

dropped,

the speed is $v_y$ = m/s = ft/s ,

The distance from the starting point will be

y = m= ft

Enter data in any box and click outside the box.

Note that you can enter a distance (height) and click outside the box to calculate the freefall time and impact velocity in the absence of air friction. But the calculation assumes that the gravity acceleration is the surface value g = 9.8 m/s$^2$, so the height is great enough for gravity to have changed significantly the results will be incorrect.

Free fall with air friction

Free fall from great height

Free fall experiment with spark timer

HyperPhysics***** Mechanics

R Nave

Go Back

Peak at

m at

t=

s

# Vertical Trajectory

Vertical motion under the influence of gravity can be described by the basic motion equations. Given the constant acceleration of gravity g, the position and speed at any time can be calculated from the motion equations:

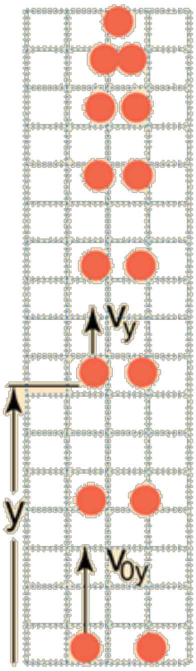
$$v_y = v_{0y} - gt \qquad \text{Taking } g = 9.8 \text{ m/s}^2$$
$$y = v_{0y}t - \frac{1}{2}gt^2 \qquad = 32.15 \text{ ft/s}^2$$

You may enter values for launch velocity and time in the boxes below and click outside the box to perform the calculation.

For launch speed $v_{0y}$ = m/s = ft/s

Index

Trajectory concepts



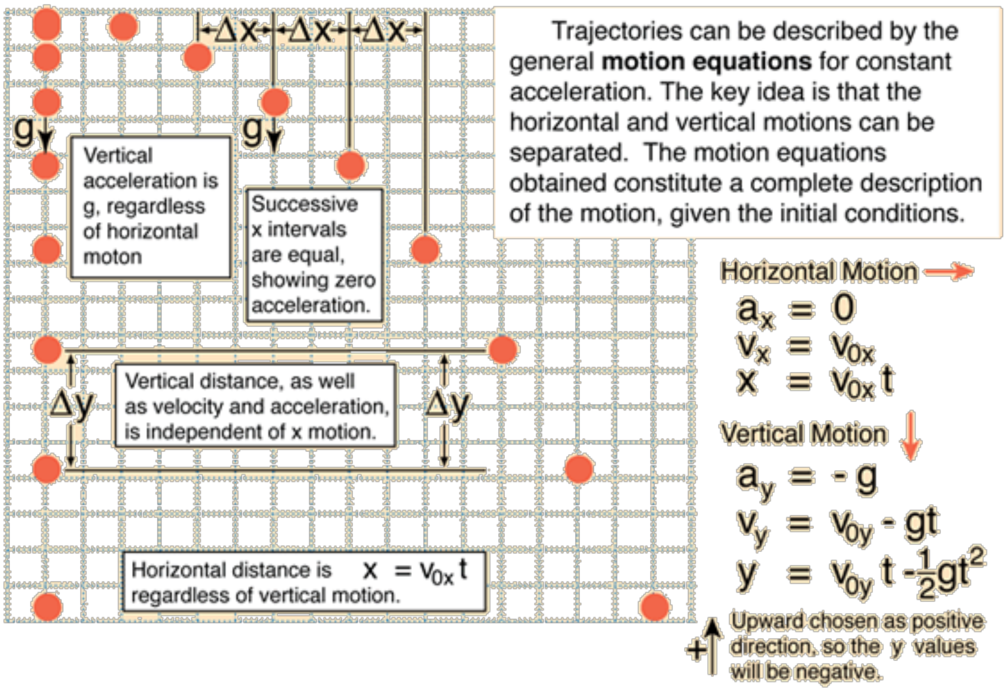

and time t = [ ] s ,

The values below are output values; those boxes will not accept input for calculation. The velocity will be

$v_y$ = [ ] m/s = [ ] ft/s

and the height will be y = [ ] m = [ ] ft

[HyperPhysics](http://hyperphysics.phy-astr.gsu.edu/hbase/hframe.html)***** [Mechanics](http://hyperphysics.phy-astr.gsu.edu/hbase/hph.html#mechcon) *R Nave* [Go Back](javascript:history.go(-1))




[Index](http://hyperphysics.phy-astr.gsu.edu/hbase/hph.html)

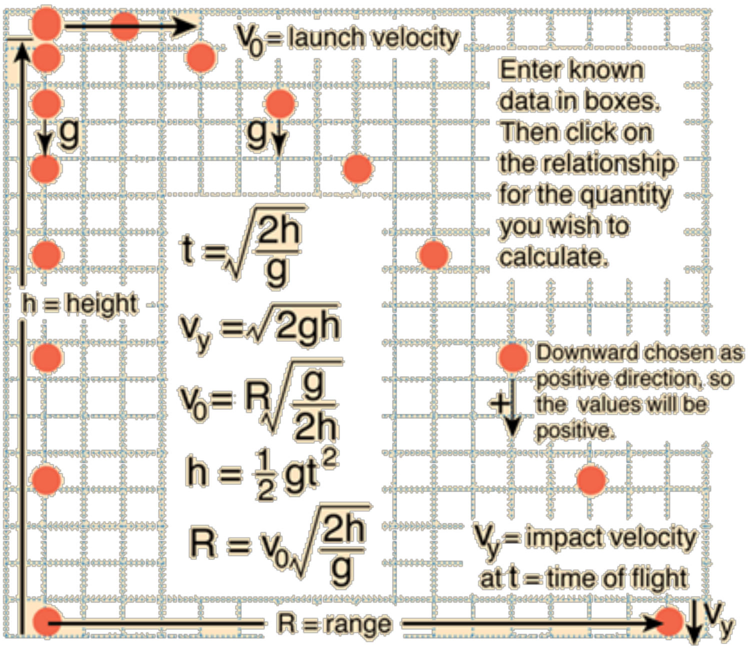
[Trajectory concepts](http://hyperphysics.phy-astr.gsu.edu/hbase/traj.html#tra2)

[Calculation](http://hyperphysics.phy-astr.gsu.edu/hbase/traj.html#tra4)

[HyperPhysics](http://hyperphysics.phy-astr.gsu.edu/hbase/hframe.html)***** [Mechanics](http://hyperphysics.phy-astr.gsu.edu/hbase/hph.html#mechcon) *R Nave* [Go Back](javascript:history.go(-1))

# Horizontal Launch

All the parameters of a horizontal launch can be calculated with the motion equations, assuming a downward acceleration of gravity of 9.8 m/s$^2$.




Time of flight
t = 0.142857142 s

Vertical impact velocity
$v_y$ = 1.400000000 m/s

Launch velocity
$v_0$ = 20 m/s

Height of launch
h = 0.1 m

Horizontal range
R = m

Calculation is initiated by clicking on the formula in the illustration for the quantity you wish to calculate.

Include demonstration apparatus

Index

Trajectory concepts

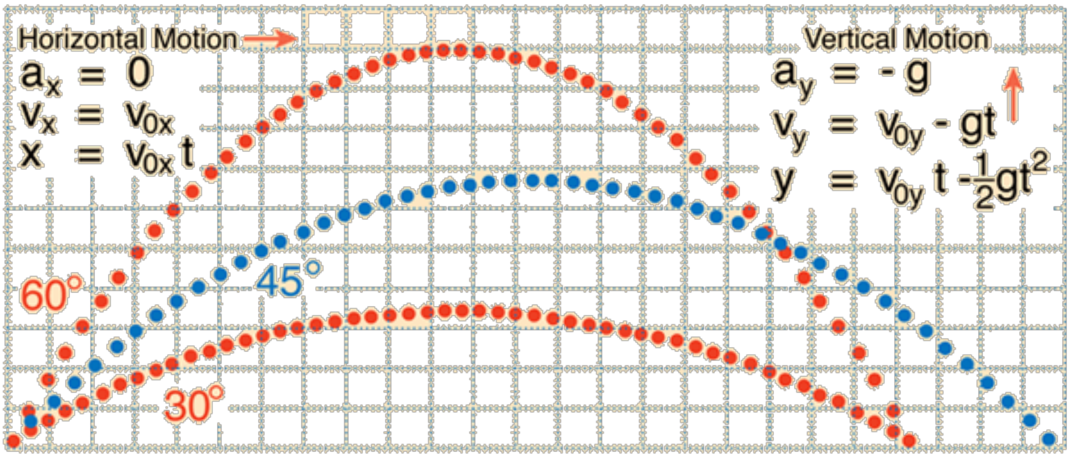
HyperPhysics***** Mechanics

*R Nave*

Go Back

# General Ballistic Trajectory

The motion of an object under the influence of gravity is determined completely by the acceleration of gravity, its launch speed, and launch angle provided air friction is negligible. The horizontal and vertical motions may be separated and described by the general motion equations for constant acceleration. The initial vector components of the velocity are used in the equations. The diagram shows trajectories with the same launch speed but different launch angles. Note that the 60 and 30 degree trajectories have the same range, as do any pair of launches at complementary angles. The launch at 45 degrees gives the maximum range.

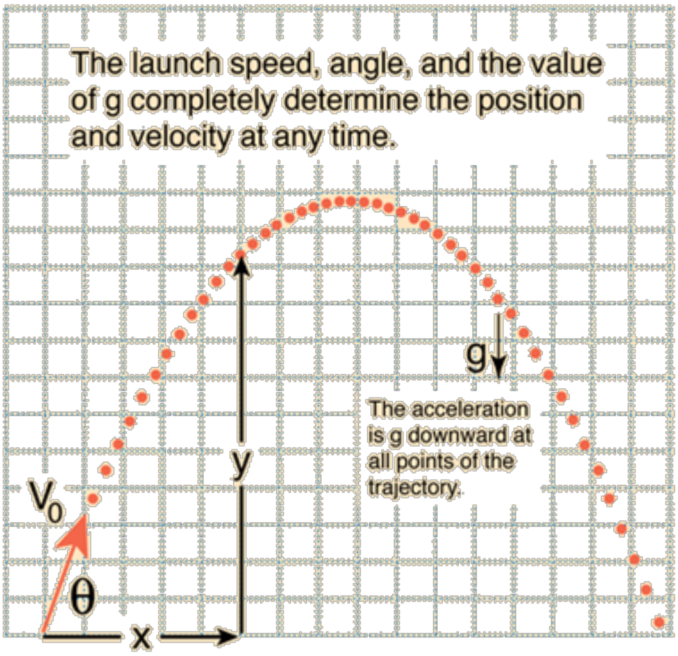



Index

Trajectory concepts

Calculation

HyperPhysics***** Mechanics *R Nave* Go Back




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.

Index

Trajectory concepts

Vertical Motion ↑+

Upward chosen as positive direction for y motion.

$$a_y = -g = -9.8 m/s^2$$

$$v_y = v_{0y} - gt$$

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

Vertical velocity

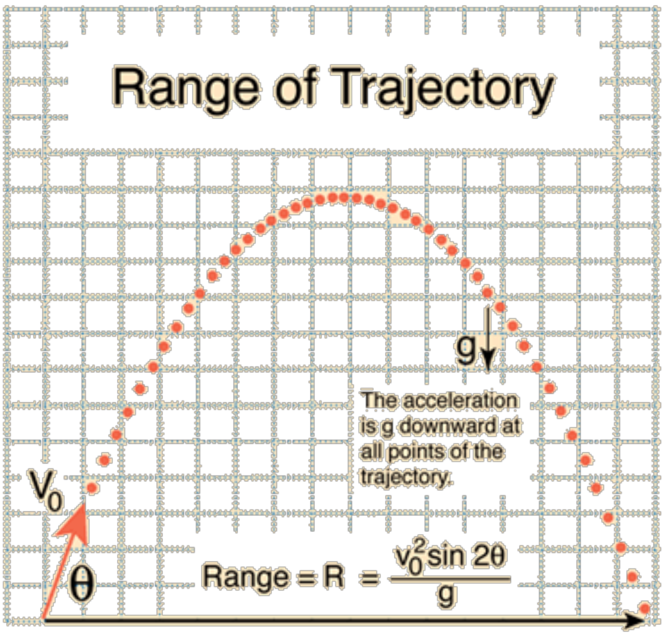
$v_y$ = m/s.

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

Vertical position

y = m.

HyperPhysics***** Mechanics | *R Nave* | Go Back




The basic motion equation

$$x = v_{0x}t$$

can be used to find the range. By symmetry, the total time of flight is equal to twice the time at the peak:

$$t_{range} = 2t_{peak} = \frac{2v_{0y}}{g}$$

This gives:

$$R = \frac{2v_{0x}v_{0y}}{g}$$

$$R = \frac{2v_0^2 \sin\theta\cos\theta}{g}$$

$$R = \frac{v_0^2 \sin 2\theta}{g}$$ Calculation

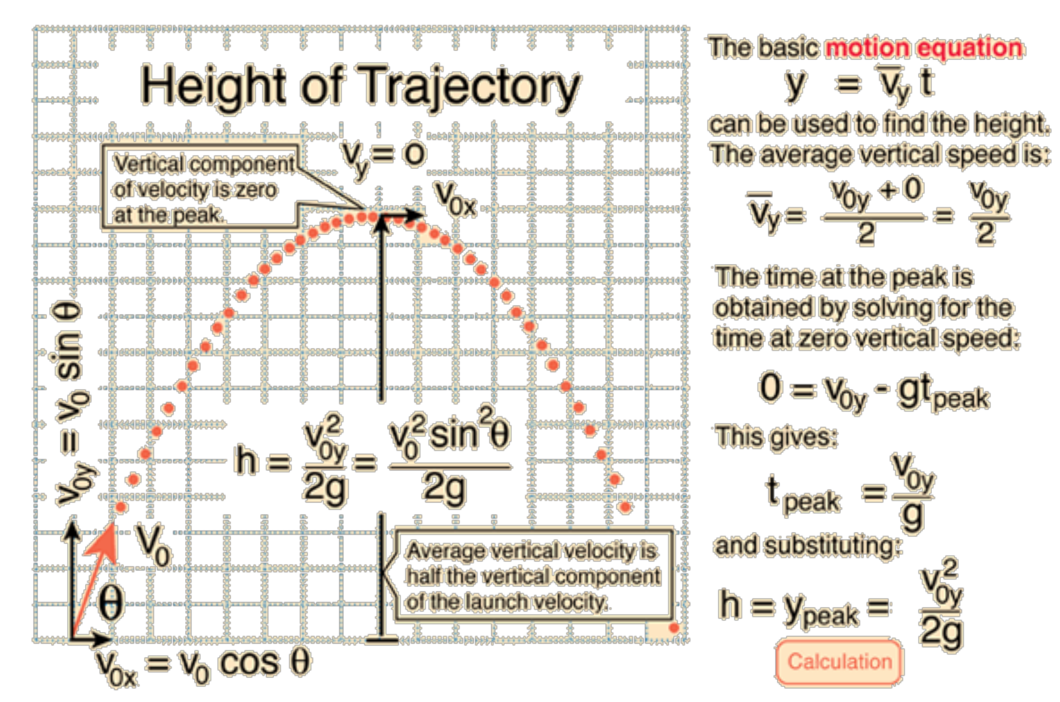
using the trig identity:

$$\sin 2\theta = 2\sin\theta\cos\theta.$$

Index

Trajectory concepts

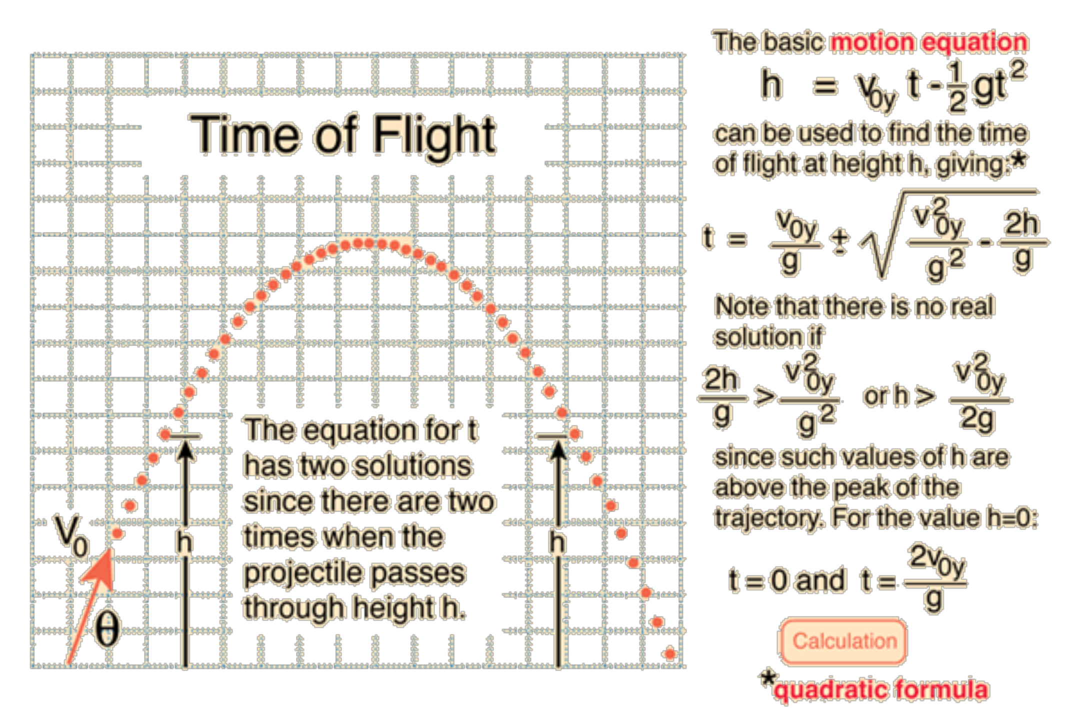
HyperPhysics***** Mechanics | *R Nave* | Go Back




Index

Trajectory concepts

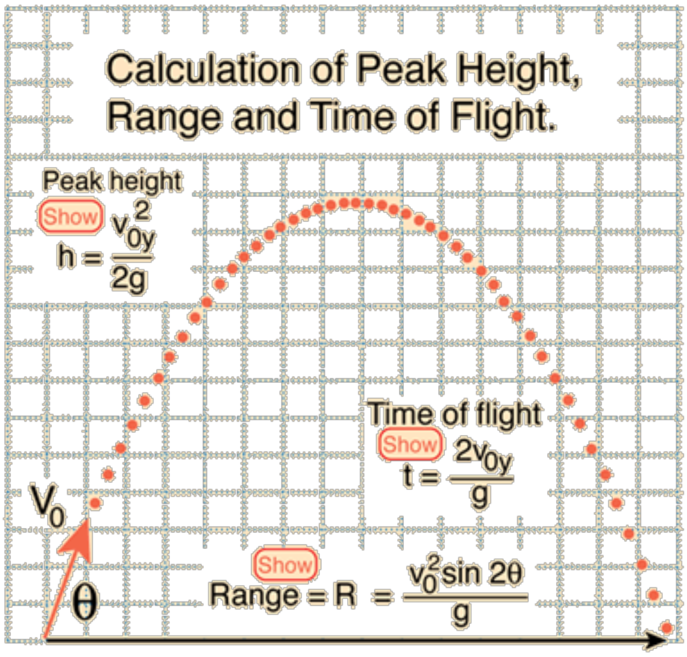
HyperPhysics***** Mechanics *R Nave* Go Back




Index

Trajectory concepts

HyperPhysics***** Mechanics *R Nave* Go Back




For launch velocity
$v_0$ =
m/s,
launch angle
θ =
degrees,
The horizontal range is
R =
m.
The total time of flight is
t = s.
The peak height is
h =
m.

[Index](#)

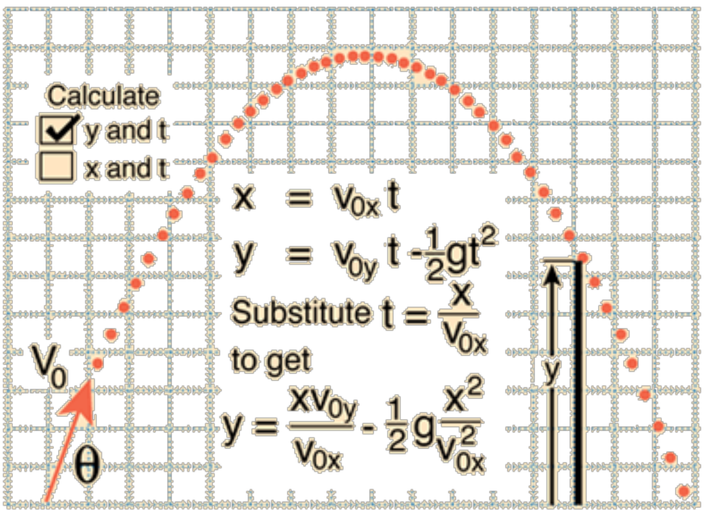
[Trajectory concepts](#)

[HyperPhysics](#)***** [Mechanics](#) *R Nave*

[Go Back](#)

# Will it clear the fence?

The basic motion equations can be solved simultaneously to express y in terms of x.




For launch velocity
$v_0$ =
m/s
=
ft/s, launch angle
θ =
degrees,
and horizontal range
x =

[Index](#)

[Trajectory concepts](#)

m =

ft,

the calculated height is

y =

m =

ft.

The time of flight is

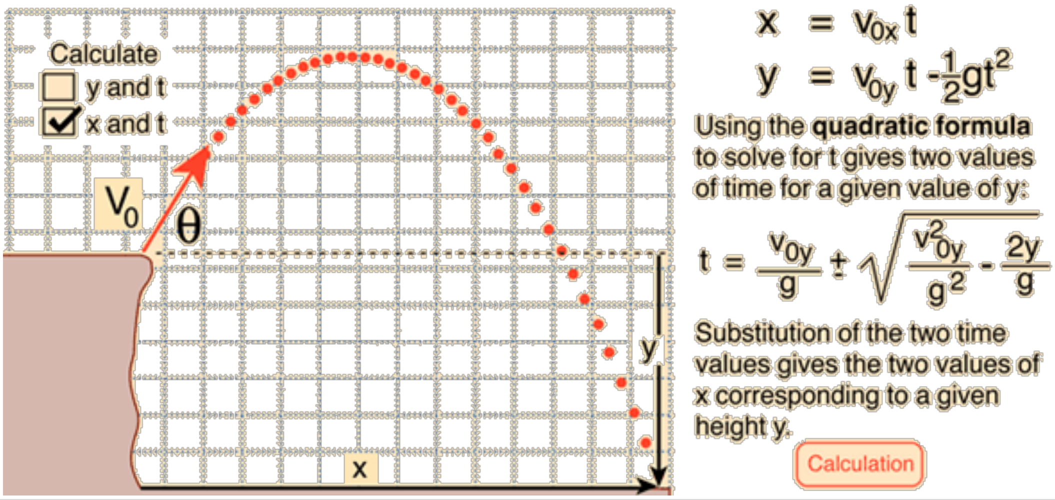
t =

s.

HyperPhysics***** Mechanics *R Nave* Go Back

# Where will it land?

The basic motion equations give the position components x and y in terms of the time. Solving for the horizontal distance in terms of the height y is useful for calculating ranges in situations where the launch point is not at the same level as the landing point.




Index

Trajectory concepts

HyperPhysics***** Mechanics *R Nave* Go Back

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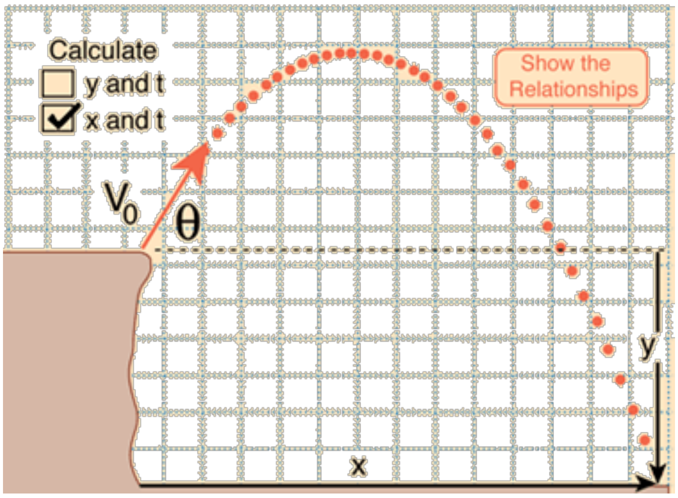



Launch velocity

$v_0$ = [ ] m/s = [ ] ft/s,

launch angle

θ = [ ] degrees,

and trajectory height

y = [ ] m = [ ] ft,

The two calculated times are

$t_1$ = [ ] s and

$t_2$ = [ ] s.

The corresponding ranges are

$x_1$ = [ ] m = [ ] ft

and

$x_2$ = [ ] m = [ ] ft.

Note that the value y in the illustration is downward and it is presumed that upward is positive. To reproduce the scenario in the diagram, the input value of y should be negative.

Index

Trajectory concepts

HyperPhysics***** Mechanics

*R Nave*

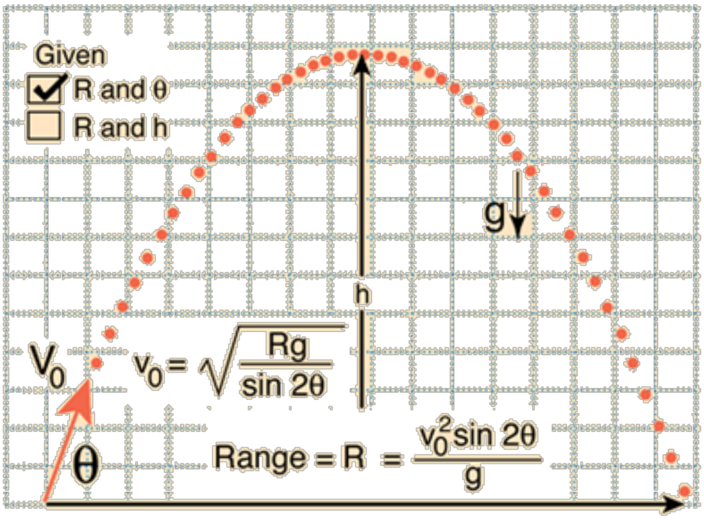
Go Back

# Launch Velocity

Index

Trajectory concepts

The launch velocity of a projectile can be calculated from the range if the angle of launch is known. It can also be calculated if the maximum height and range are known, because the angle can be determined.




From the range relationship, the launch velocity can be calculated. For range R = [ ] m = [ ] ft, and launch angle θ = [ ] degrees,

the launch velocity is $v_0$ = [ ] m/s = [ ] ft/s.

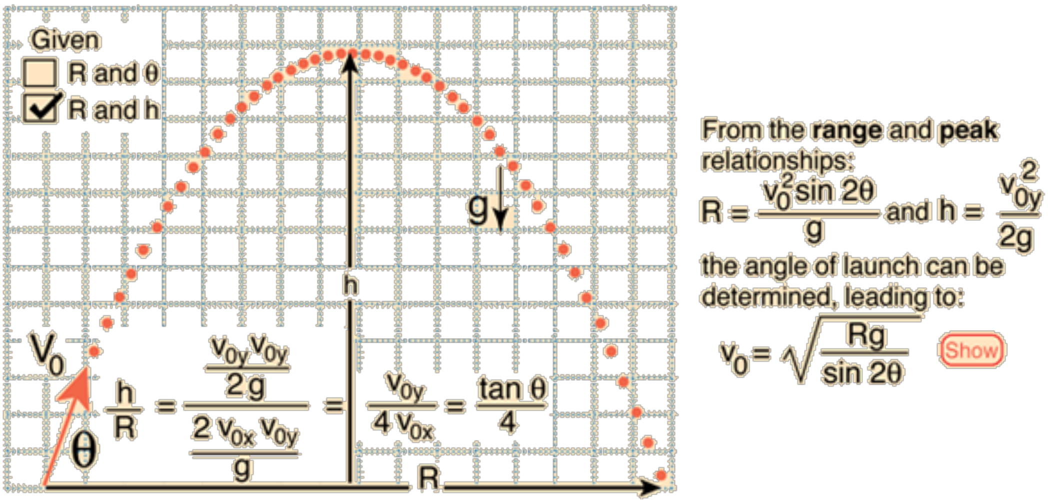
HyperPhysics***** Mechanics *R Nave* Go Back

# Launch Velocity

The launch velocity of a projectile can be calculated from the range if the angle of launch is known. It can also be calculated if the maximum height and range are known, because the angle can be determined.

Index

Trajectory concepts




For range

R = m = ft,

and peak height

h = m = ft,

the launch velocity is

$v_0$ m/s = ft/s.

The required launch angle is

θ = degrees.

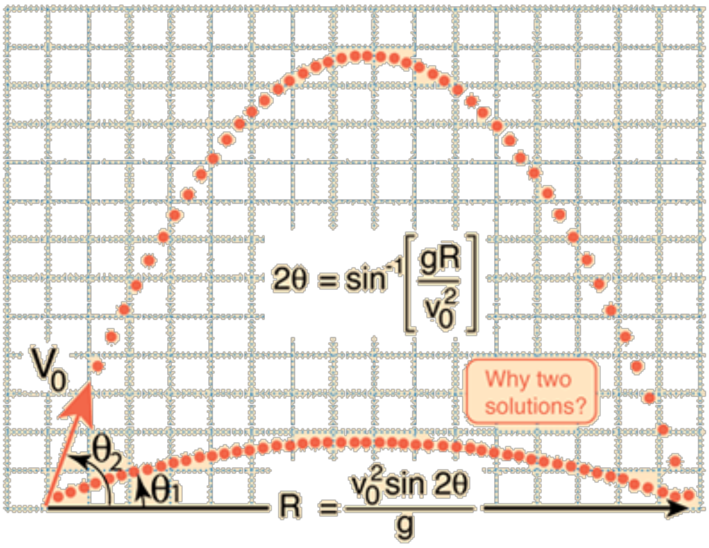
HyperPhysics***** Mechanics *R Nave* Go Back

# Angle of Launch

Variation of the launch angle of a projectile will change the range. If the launch velocity is known, the required angle of launch for a desired range can be calculated from the motion equations.

Index

Trajectory concepts

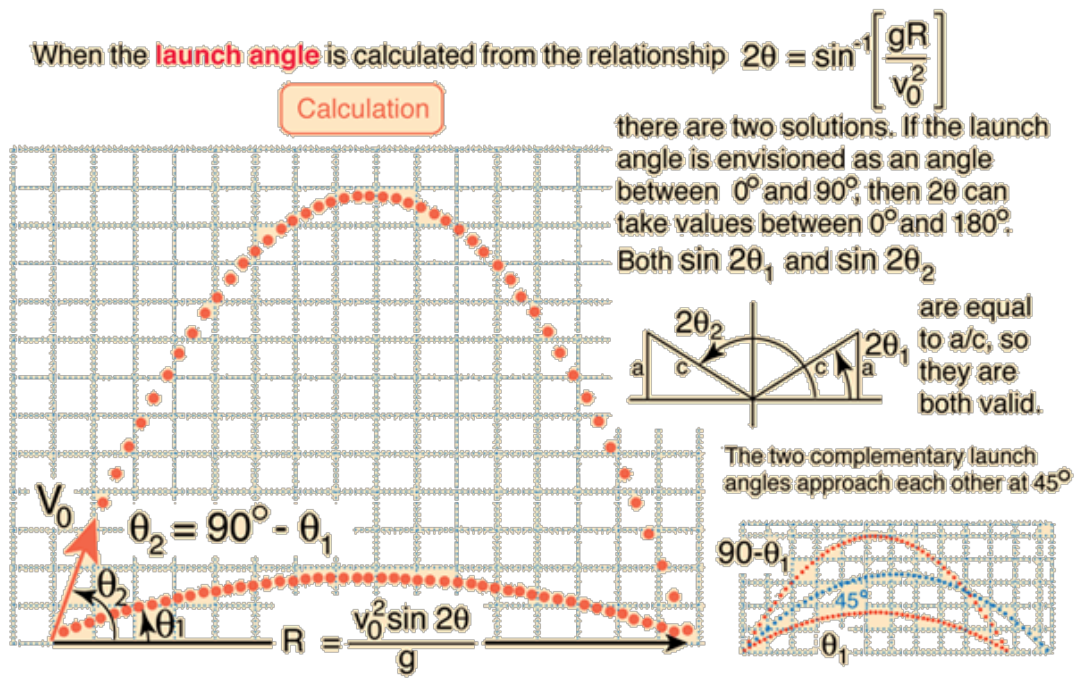



From the range relationship, the angle of launch can be determined. For range

R =

m =

HyperPhysics***** Mechanics *R Nave* Go Back




| | |
|---|---|
| | Index<br><br>Trajectory concepts |
| HyperPhysics***** Mechanics      *R Nave* | Go Back |