Physics 3204

Projectile Motion

Kinematics Review

Equations:

$$v_2 = v_1 + at$$

$$d = v_2 t - \frac{1}{2} a t^2$$

$$d = \frac{1}{2}(v_1 + v_2)\, t$$

$${v_2}^2 = {v_1}^2 + 2ad$$

$$d = v_1 t + \frac{1}{2} a t^2$$

Kinematics Review

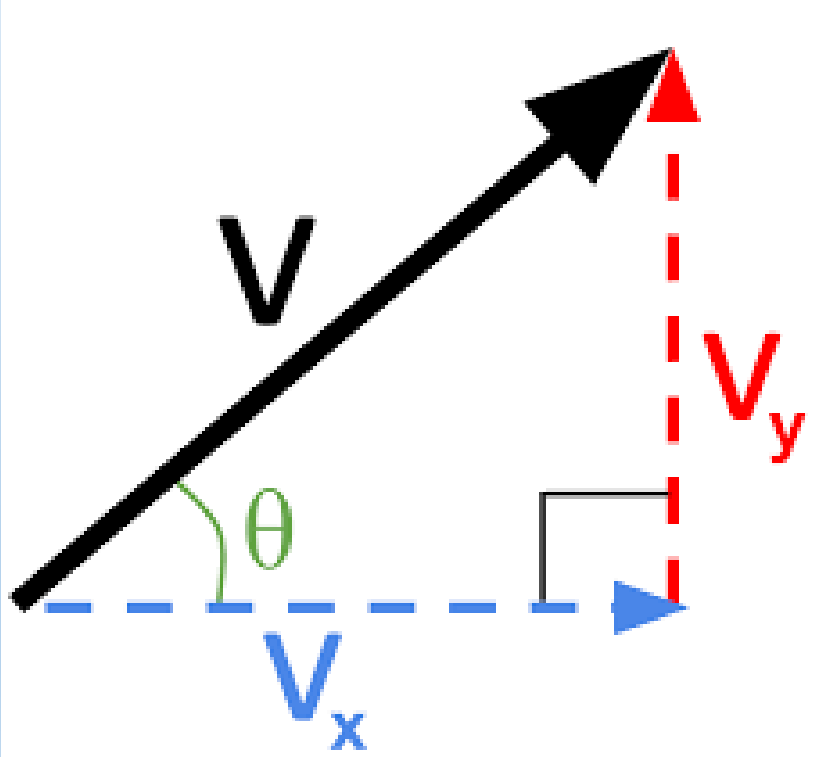
How long does it take a car to cross a 30.0 m wide intersection after the light turns green if it accelerates from rest at 2.00 m/s^2?

Kinematics Review

A ball is dropped from a tower that is 70.0 m high. Calculate the distance the ball has dropped after 1.00 s.

Vector Review

Recall that a vector is made up of an x and a y component.



Vector Review

$$\sin\theta = \frac{\text{Opp}}{\text{Hyp}} = \frac{V_y}{V}$$

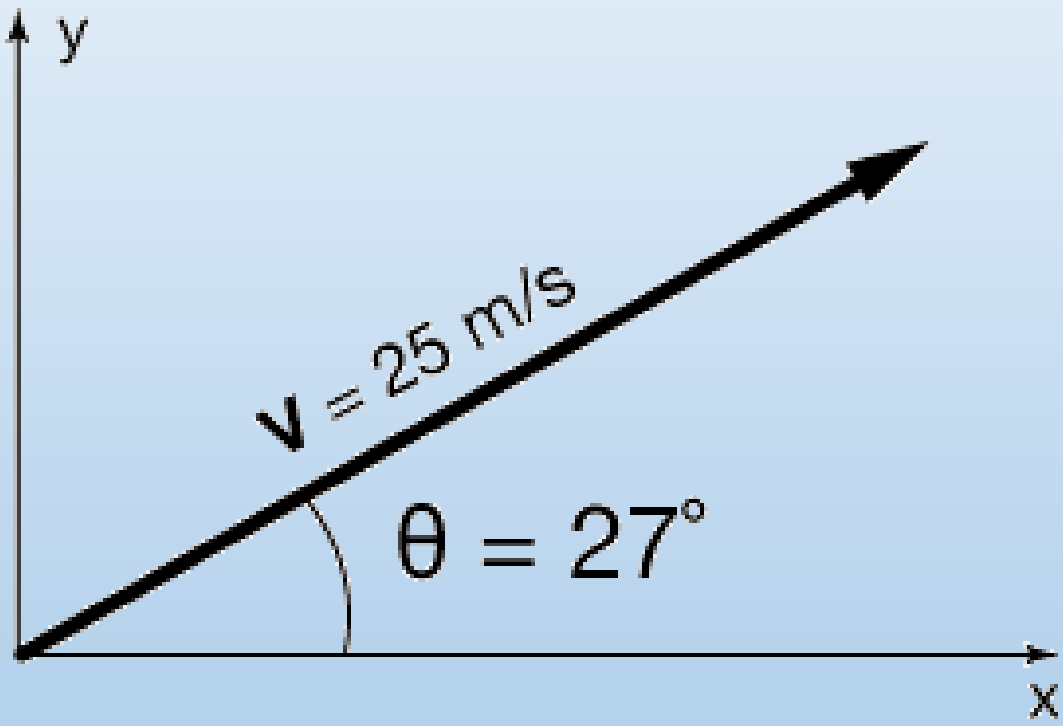
$$\boxed{V\sin\theta = V_y}$$

$$\cos\theta = \frac{\text{Adj}}{\text{Hyp}} = \frac{V_x}{V}$$

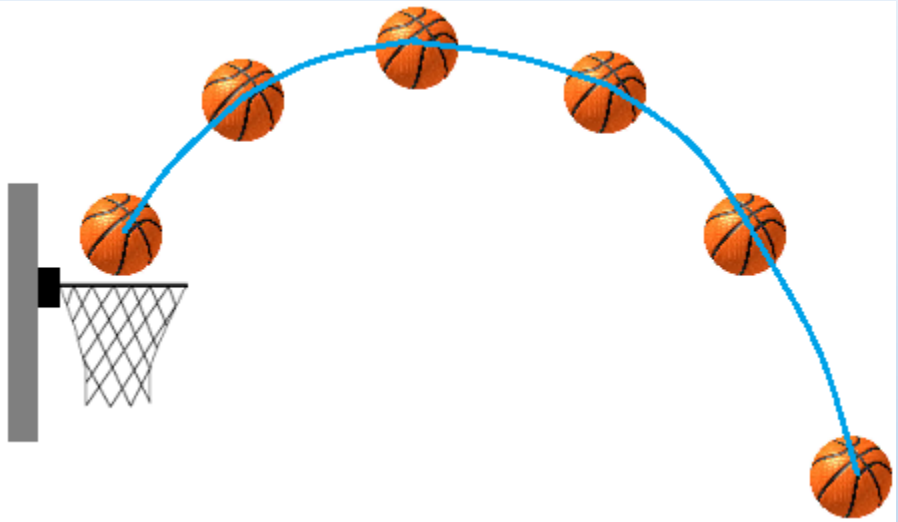
$$\boxed{V\cos\theta = V_x}$$

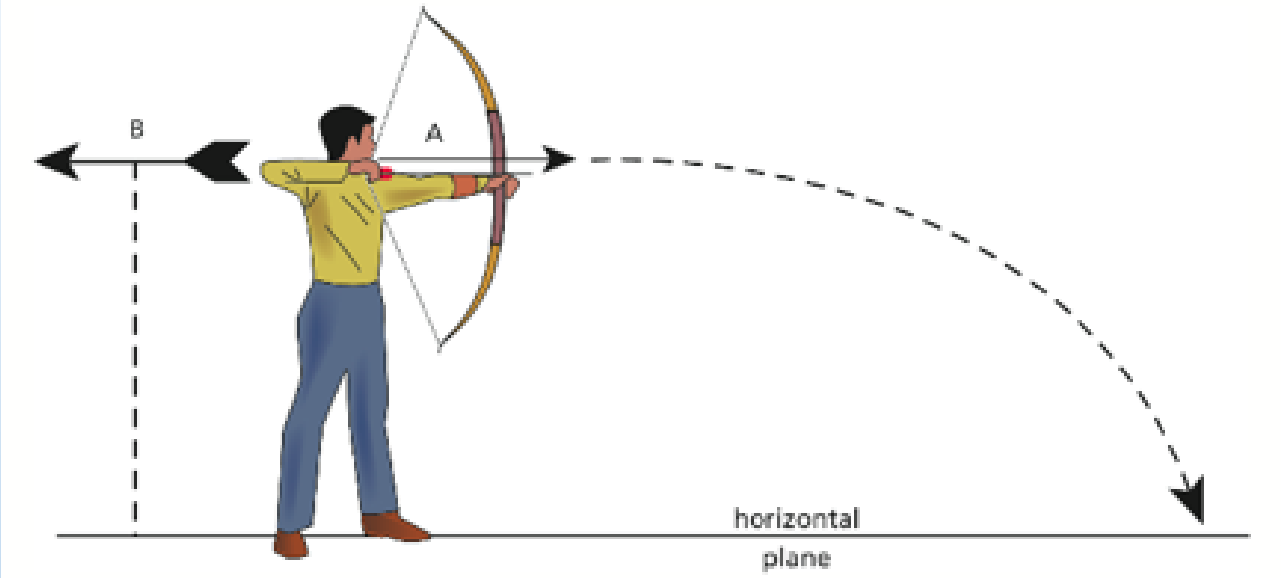
Vector Review

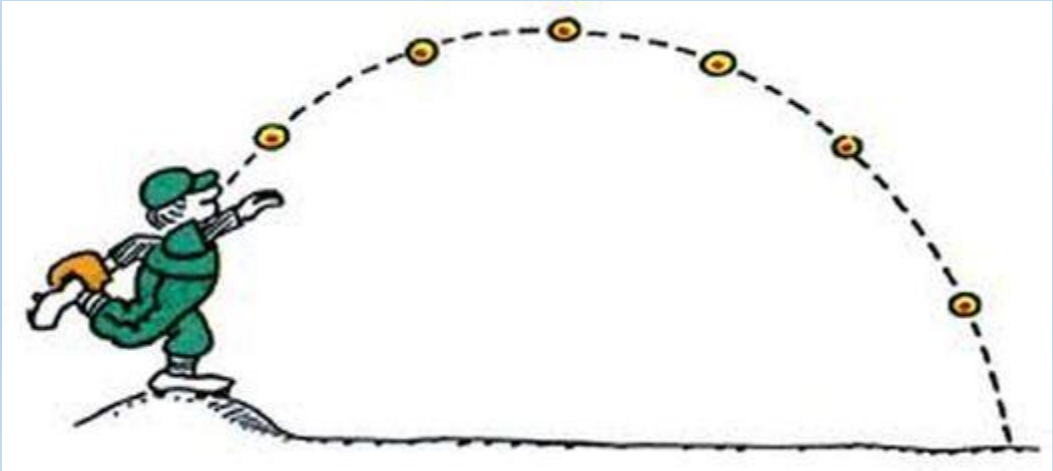
Find the x and y components of the velocity vector shown.



Projectile Motion



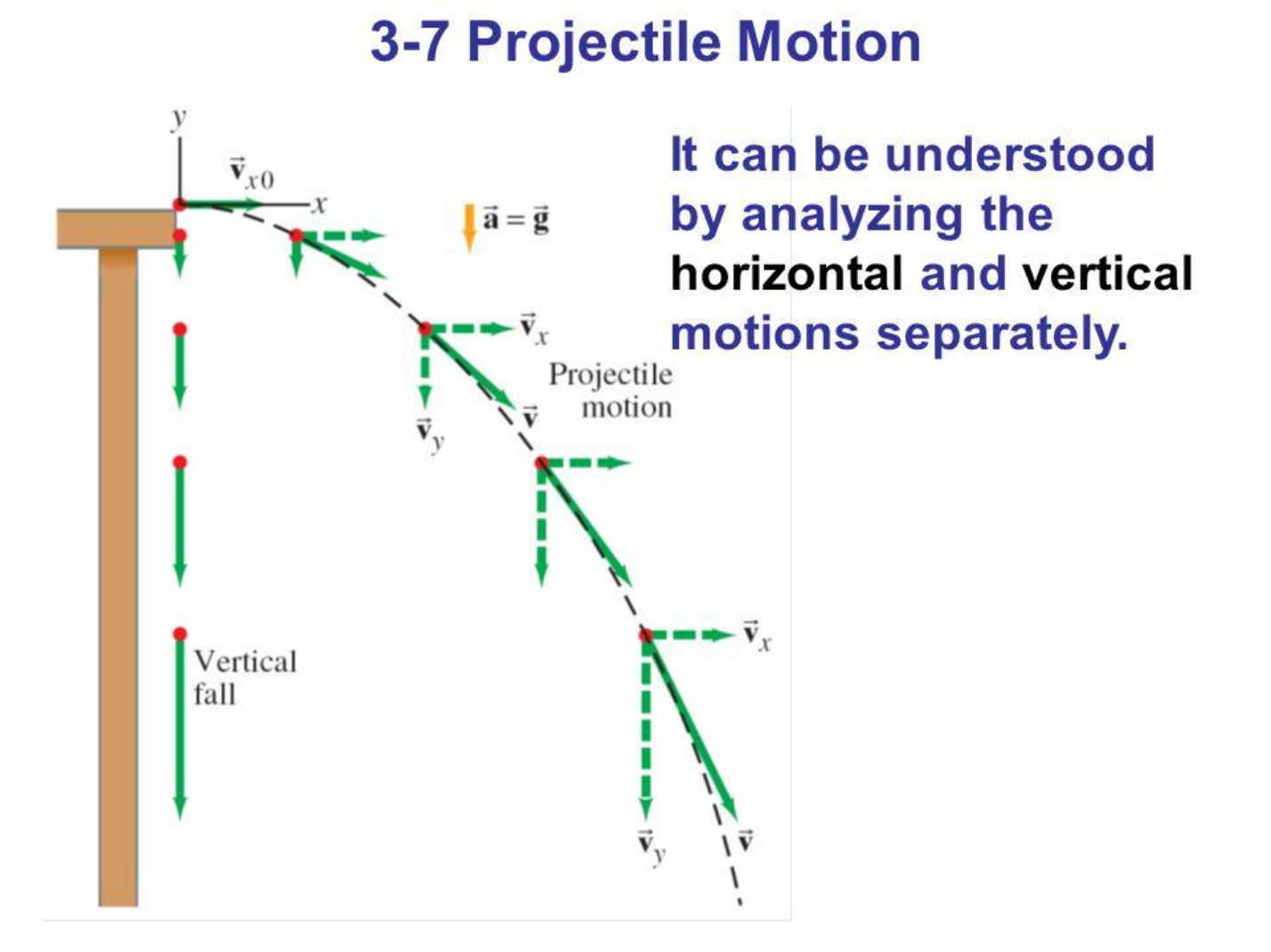


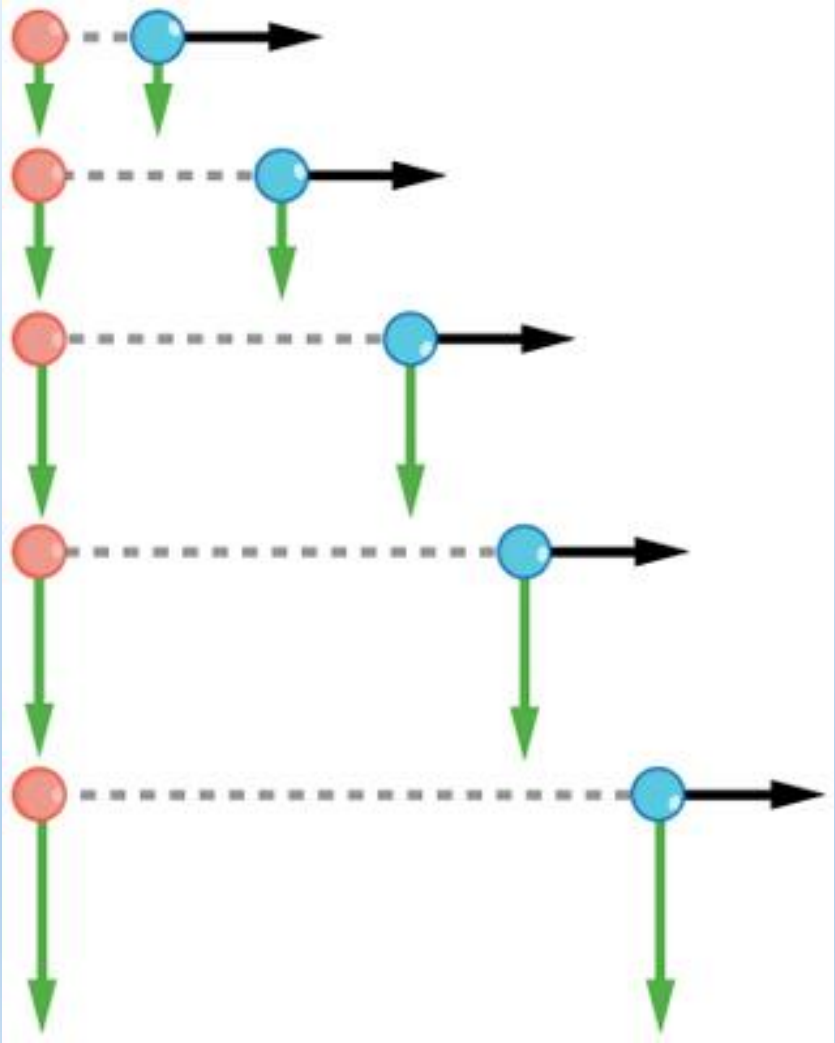


Horizontal Projectile Motion

Galileo was the first to accurately describe projectile motion. He stated that in order to understand projectile motion, the horizontal and vertical components of the velocity must be treated separately.

Horizontal Projectile Motion





Horizontal Projectile Motion

x-direction: Horizontal velocity is constant.

Equation: $d_x = v_x t$

y-direction: Vertical velocity is increasing.

$v_2 = v_1 + at$

$d = \frac{1}{2}(v_1 + v_2)\, t$

$d = v_1 t + \frac{1}{2} a t^2$

$d = v_2 t - \frac{1}{2} a t^2$

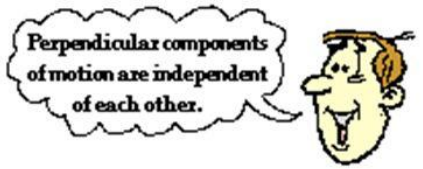
$v_2{}^2 = v_1{}^2 + 2ad$

Horizontal Projectile Motion

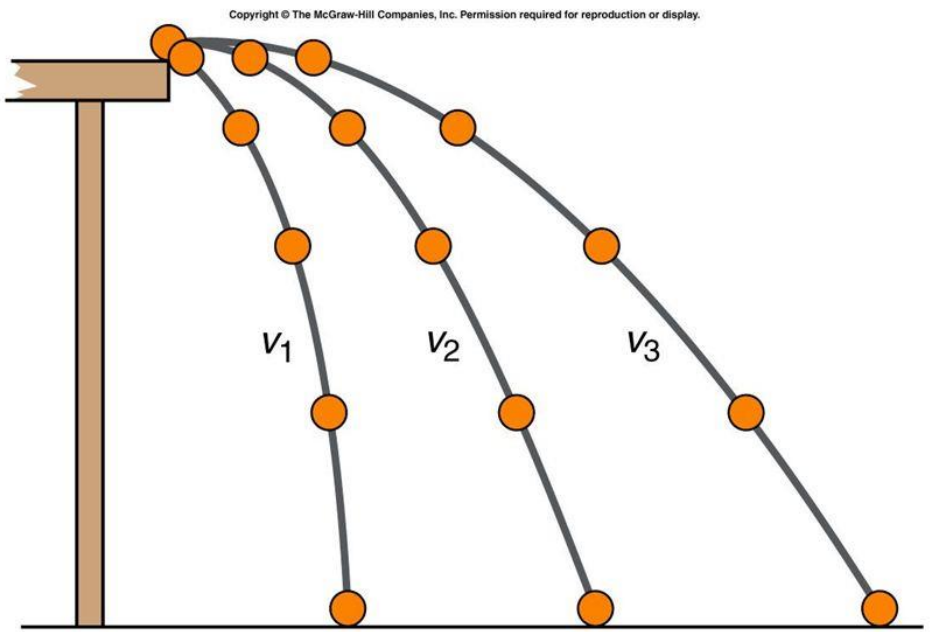
Consider two identical steel balls – one dropped vertically from a table's edge and the other projected horizontally outward from the same height.

Which ball will hit the ground first, or will they hit at the same time?

Independence of Motion



- All the balls fall at the same rate
- The horizontal and vertical motions are independent of each other

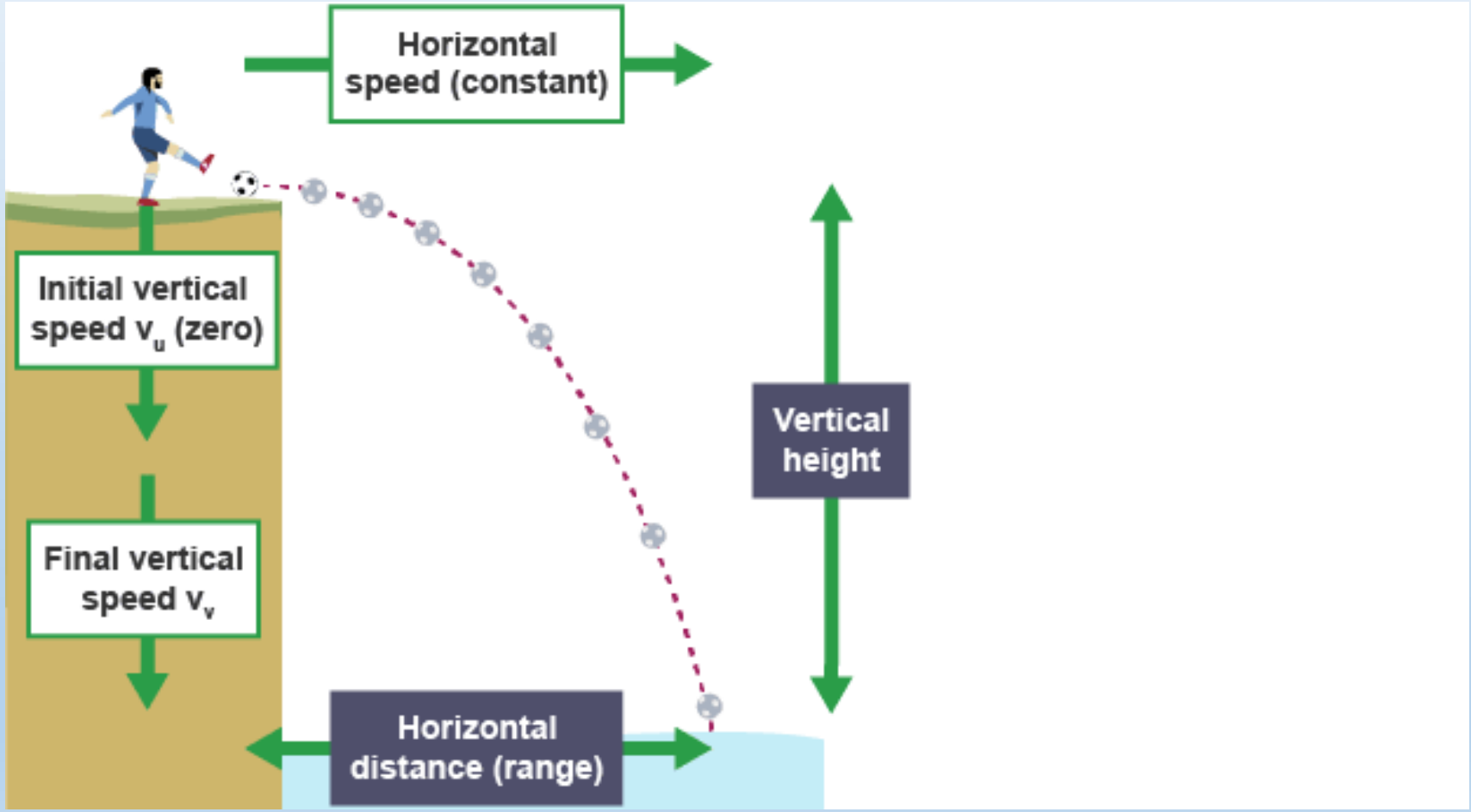


Horizontal Projectile Motion

When solving projectile motion problems it is useful to use a horizontal/vertical chart to help keep the directions separate.

Horizontal	Vertical
d_x	$a_y = -9.80\ \mathrm{m}/s^2$
v_{1x}	$v_{1y} = 0\ m/s$
t	d_y
	t

Horizontal Projectile Motion



Horizontal Projectile Examples

A movie stunt driver on a motorcycle speeds horizontally off a 50.0 m high cliff. If the motorcycle left the cliff at a speed of 28.2 m/s, calculate how far horizontally from the base of the cliff the bike lands.

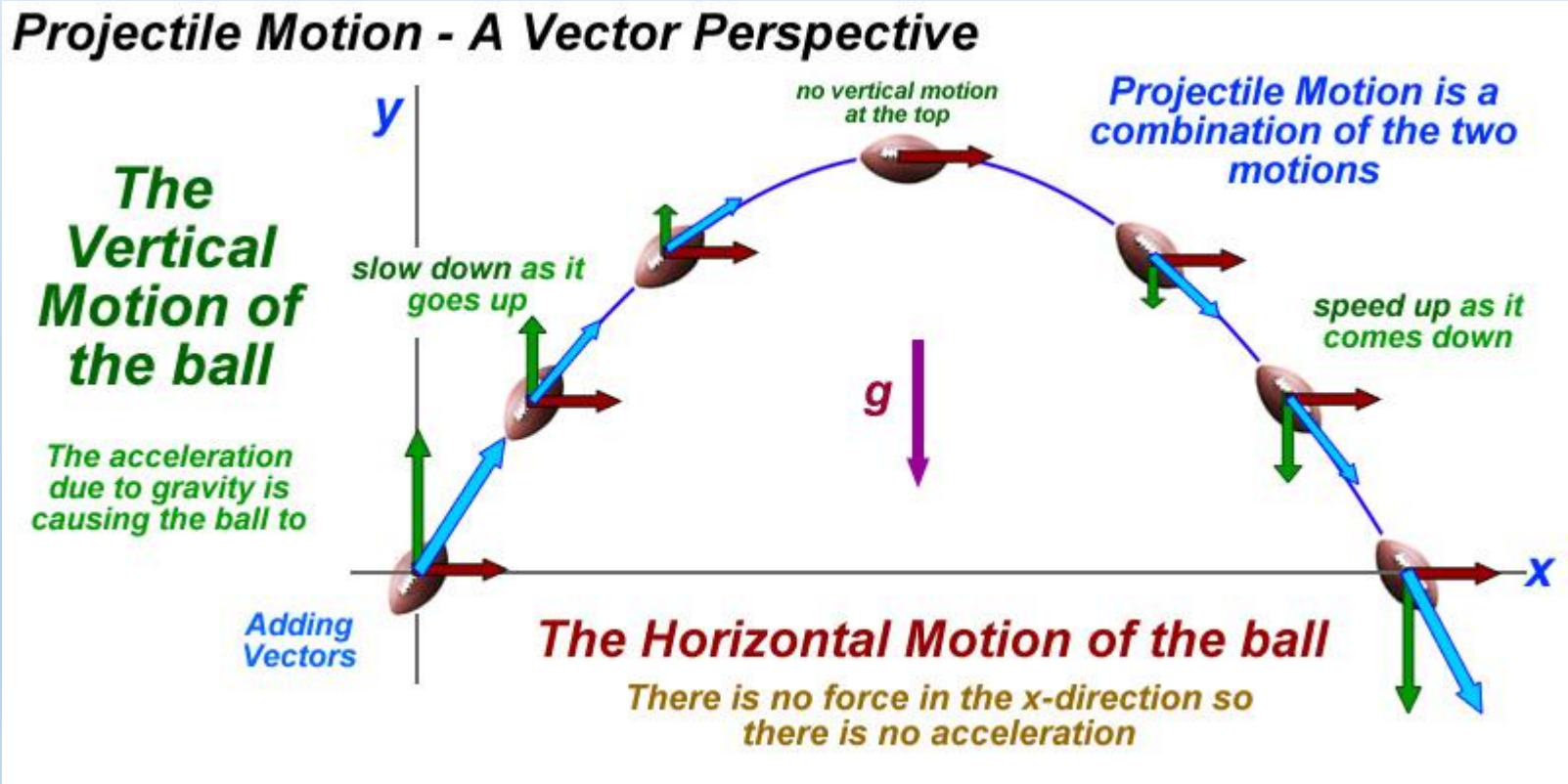
Horizontal Projectile Examples

A rock is thrown horizontally from a height of 22 m. It strikes the ground 35 m from the base of the cliff.

a) At what speed was the rock thrown?
b) Determine the magnitude of the resultant velocity when the rock strikes the ground.

Angled Projectiles

Projectiles can also be launched at an angle.



Angled Projectiles

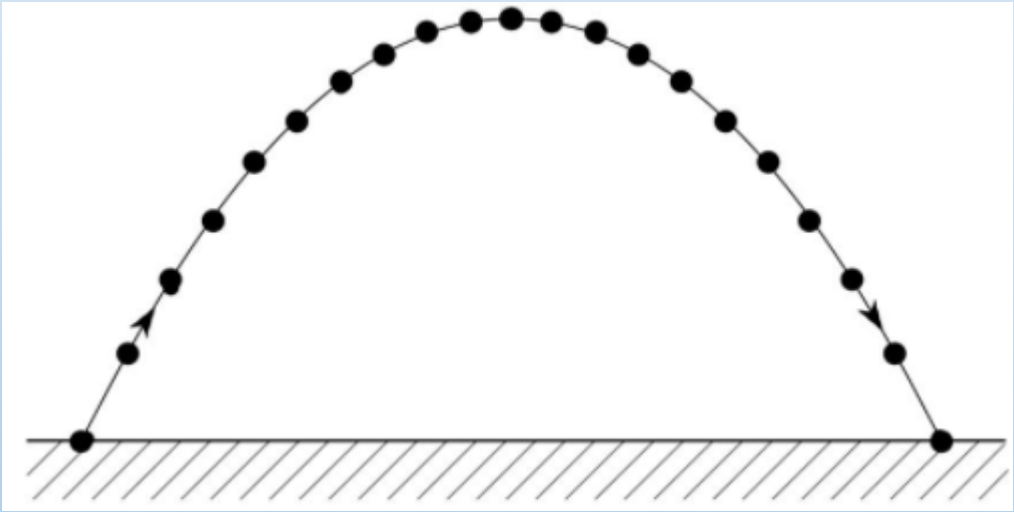
For angled projectiles it is still useful to use a horizontal/vertical chart to help keep the directions separate.

Horizontal	Vertical
d_x	$a_y = -9.80\ \mathrm{m}/s^2$
v_{1x}	v_{1y}
t	d_y
	t

Angled Projectiles

Angled projectiles can be symmetrical or nonsymmetrical.

symmetrical



time up = time down

nonsymmetrical

Symmetrical Example

A football is kicked at an angle of 37° above the ground with a velocity of 20.0 m/s. Calculate:

a) The maximum height reached by the ball.

b) The time of travel before the football hits the ground (hang time).

Symmetrical Example

c) The range of the ball.

d) The velocity of the ball at maximum height.

e) The acceleration of the ball at maximum height.

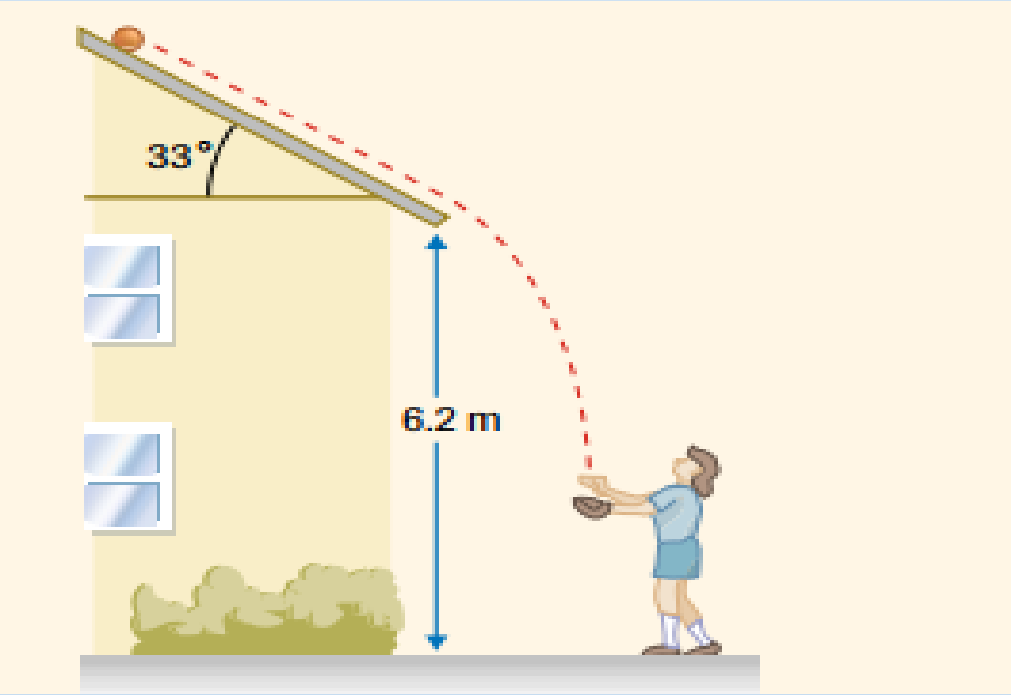
NonSymmetrical Example

An object is kicked at a velocity of 20.0 m/s at an angle of 37° to the horizontal, from a height of 1.00 m. Calculate the range of the object.

Example

A ball rolls off the roof of a house and leaves the roof at a velocity of 3.2 m/s. The girl who catches the ball is holding the glove at 1.0 m above the ground. Calculate:

a) The horizontal distance of the glove from the house.



Example

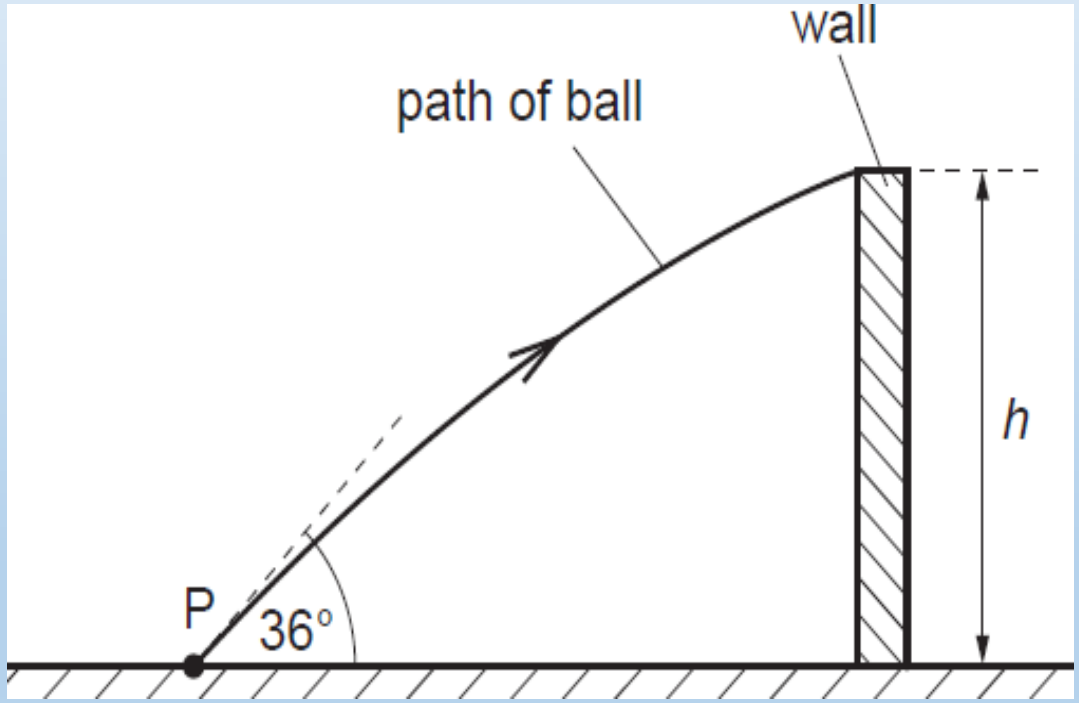
b) The velocity of the ball as it lands in the glove.

Example

A ball is projected toward a wall with a velocity of 12.4 m/s at an angle of 36° to the ground as shown. It takes 0.17 s for the ball to reach the wall. Calculate:

a) The horizontal distance from the wall.

b) The height of the wall.



Example

A projectile is launched at some initial speed v_1 at an angle of 34.5° above the horizontal, and lands 539 m ahead on a long flat firing range. Calculate the initial velocity of the projectile if it is in the air for a total time of 8.69 s.