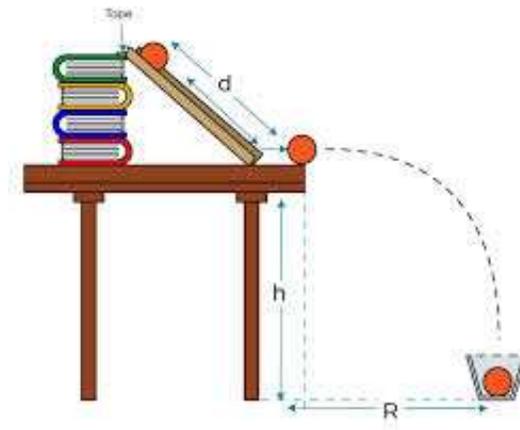
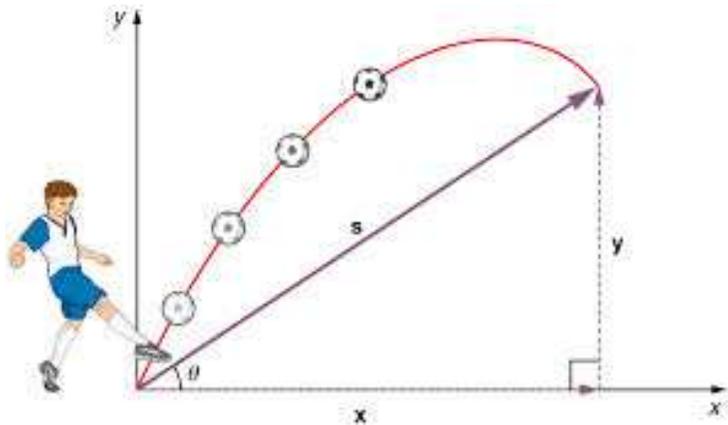
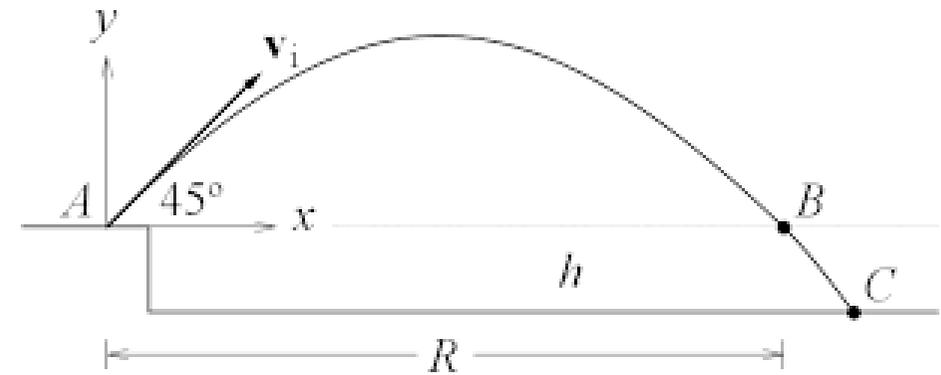
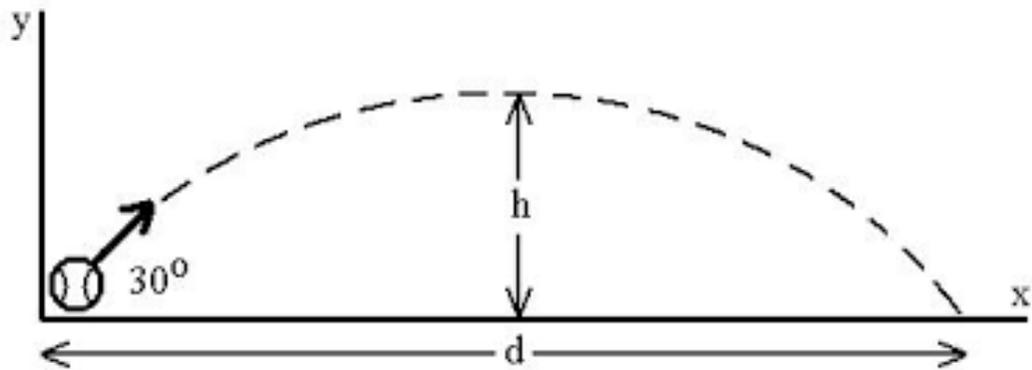


Motion in two dimensions – projectile motion

Projectile motion is a form of motion in which an object is thrown at an certain angle, and it moves along a curved path under the action of gravity only. When the object in the air, the only force acting on the object is gravity. These are the examples of projectile motion we are going to study.



Motion in two dimensions – projectile motion cont.

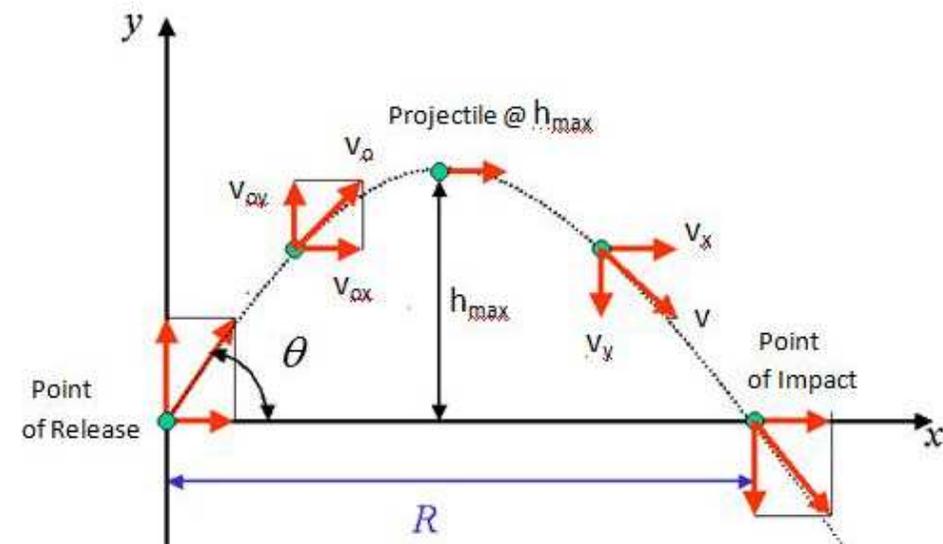
An object undergoing a projectile motion has two components, a horizontal and a vertical component. To make things easier, it is always convenient to treat the components **separately**. We can use the coordinate system such that the vertical component is along the y-axis and the horizontal component is along the x-axis. The starting point or the reference point is at the origin. Thus the variables become a_y, u_y, v_y, s_y and a_x, u_x, v_x, s_x .

Vertical motion

In the air the object is under the influence of gravity, which is pulling it down. The acceleration due to gravity is $g = 9.8 \text{ ms}^{-2}$ and is downward. Thus $a_y = g$. During an upward motion, a vertical component of the velocity (v_y) of an object gradually decreases to zero at the maximum point. On its way down, v_y gradually increase and reach a maximum when it hits the ground.

Horizontal motion

On the other hand, there is no force acting on the object along the horizontal direction. This implies that the horizontal component of the acceleration is zero ($a_x = 0$). Furthermore, this means that the horizontal component of the velocity is constant **i.e.** $u_x = v_x$.



Problem solving strategies involving projectile motion

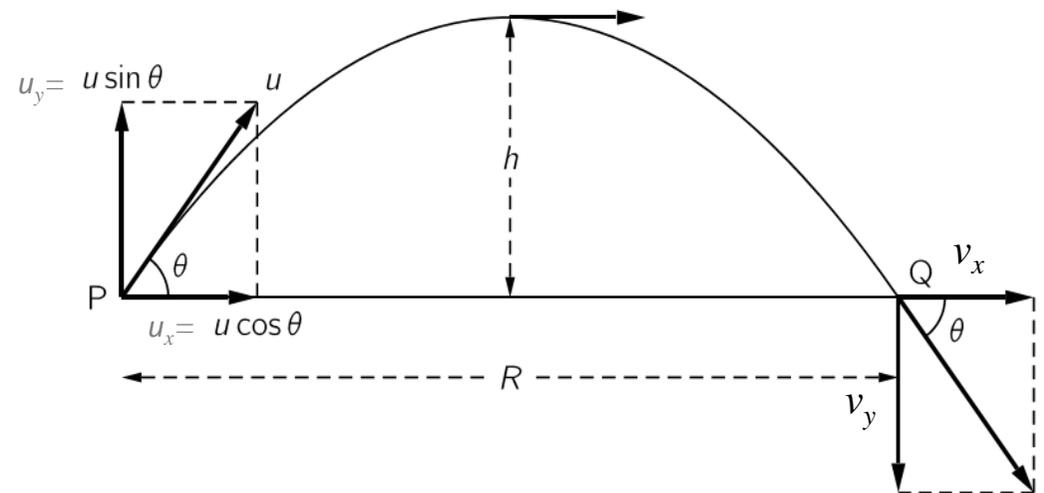
1. **Draw a diagram** to represent the situation
2. **Choose a set of coordinate axes** and decide which directions are to be called positive and negative.
3. List all the given variables and those you can deduce from the statement, including their appropriate signs according to your choice of coordinate axes. Separate them into horizontal (x) and vertical (y) components.
4. Solve for an unknown variable using the following equation

$$\begin{aligned}v_x &= u_x + a_x t \\s_x &= u_x t + \frac{1}{2} a_x t^2 \\v_x^2 &= u_x^2 + 2 a_x s_x\end{aligned}$$

$$\begin{aligned}v_y &= u_y + a_y t \\s_y &= u_y t + \frac{1}{2} a_y t^2 \\v_y^2 &= u_y^2 + 2 a_y s_y\end{aligned}$$

Given the initial velocity (u) and its direction θ , u can be resolved into u_x and u_y . The magnitude of the final velocity is obtained from v_x and v_y using $v = \sqrt{v_x^2 + v_y^2}$.

The displacement along the x- and y-components is sometimes called the range (R) and height (h), respectively.



Examples

Example

A soccer ball is kicked with a speed of 20 ms^{-1} at an angle 60° with the ground. Determine,

- the maximum height reached by the ball,
- time it takes to hit the ground, and
- the range,

Example 2.8: Projectile motion

An aeroplane flying 1000 m above level ground at 120 ms^{-1} drops a relief package over a remote area. Ignoring air resistance, calculate

- how long the package takes to hit the ground,
- the horizontal and vertical components of the package's velocity, and hence
- the speed and the angle at which the package hits the ground.

