Contents

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Projectile Motion

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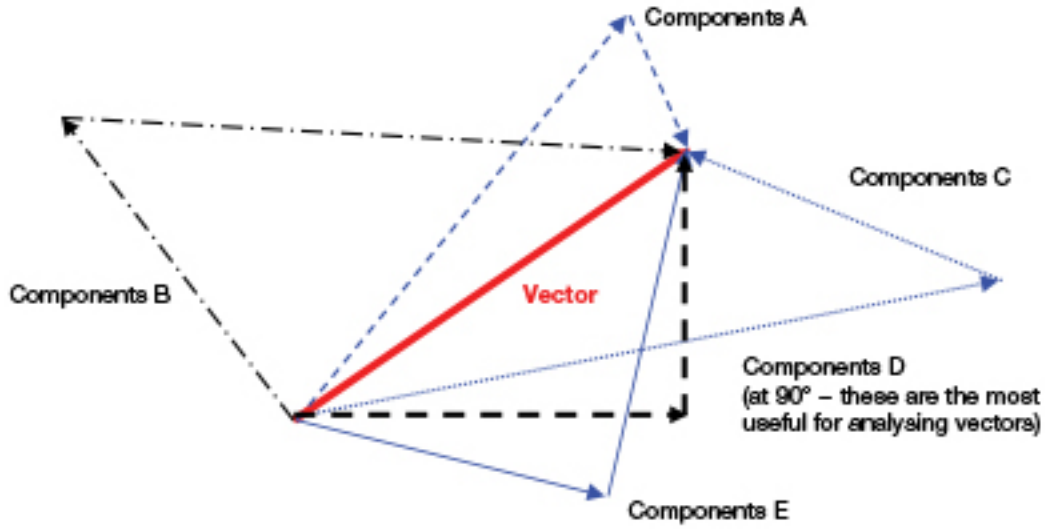
5.1 Components and Resolution Of Vectors

Analyse the motion of projectiles by resolving the motion into horizontal and vertical components, making the following assumptions: a constant vertical acceleration due to gravity and zero air resistance.

Components and resolution of vectors

The **components of a vector** are the **vectors we add together to get that vector**. For example, the vector shown below (in red) has many pairs of components (shown in various blues) and one pair at right angles (black).



When we refer to the components of a vector we specifically refer to the two vectors at 90° to each other, one **horizontal** and the other **vertical**, which would need to be added together to give that vector. In the diagram above, these would be components D, drawn in black.

When we **resolve** a vector into its components, then we are finding these two vectors at right angles.

Mathematically:

Horizontal component = vector cos θ

Vertical component = vector sin θ

Analysis of projectiles

- Horizontal and vertical components of projectile motion are independent of each other.
- Horizontal motion of a moving object is not subject to gravitational forces, and therefore experiences no acceleration.
- Vertical motion of an object near the surface of the Earth is affected by the downward force of gravity which gives it an acceleration of 9.8 ms^{-2}.

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Sample Questions

1. If the plane has a horizontal speed of 180 m s^{-1}, what is:
   (a) It flight speed?
   (b) Its vertical speed?

2. If the horizontal component of the tension in the leash held by the girl is 20 N what is:
   (a) The tension in the leash?
   (b) The vertical component of this tension?

3. If the vertical component of the tension in the leash is 18 N, find:
   (a) The tension in the leash.
   (b) The horizontal component on the tension.

4. If the missile in the photograph is moving at 2500 m s^{-1}, what are the components of its velocity?

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5.2 Analysing Projectile Motion

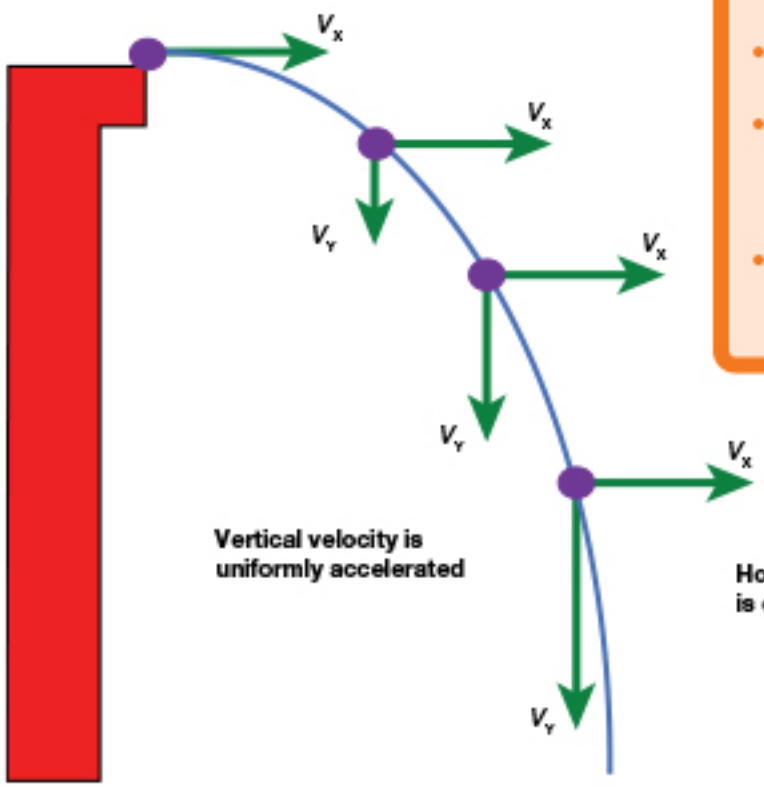
Apply the modelling of projectile motion to quantitatively derive the relationships between the following variables: initial velocity, launch angle, maximum height, time of flight, final velocity, launch height and horizontal range.

Analysing projectile motion

A projectile is any object thrown or shot into the air at any angle.

Trajectory of a projectile

- Only gravitational force acts on a projectile.
- The horizontal velocity of a projectile is constant.
- The vertical velocity of a projectile is accelerated – increasing if moving downwards, decreasing if moving upwards.
- The combination of these two velocities results in the object following a parabolic path.



Projectile motion and Newton's equations of motion

Equation used in straight line motion	Horizontal component of motion	Vertical component of motion
• $v = u + at$ • $v^2 = u^2 + 2as$ • $s = ut + \frac{1}{2}at^2$	• $u_x = u \cos\theta$ • $v_x = u_x \ (a_x = 0)$ • $v_x^2 = u_x^2$ • $\Delta x = u_x t$	• $u_y = u \sin\theta$ • $v_y = u_y + a_y t$ • $v_y^2 = u_y^2 + 2a_y \Delta y$ • $\Delta y = u_y t + \frac{1}{2}a_y t^2$

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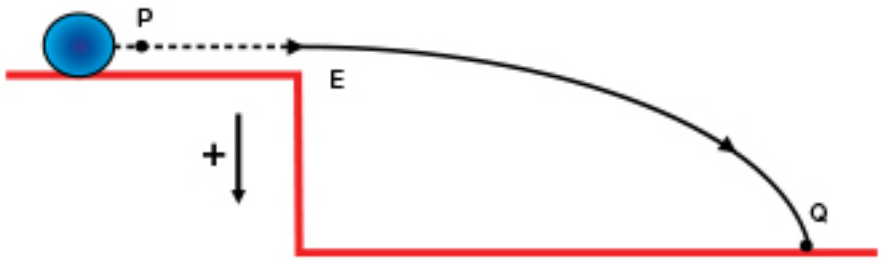
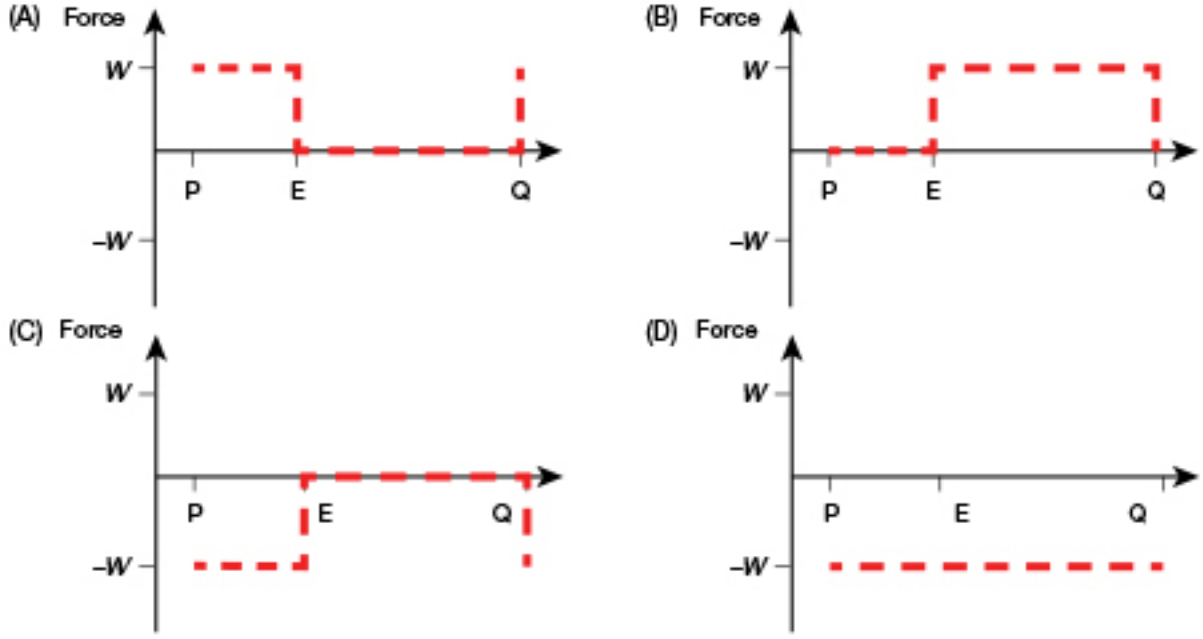
Sample Questions

1. A ball of weight W rolls across a horizontal surface and over the edge E, falling to the floor as shown in the diagram.

Which graph best shows the upward force acting on the ball as it moves from P to Q?





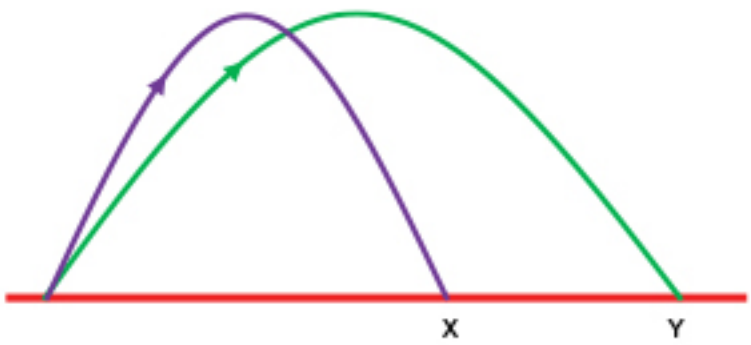
2. A projectile is fired from the top of a cliff with speed v at an angle θ above the horizontal.

Air resistance is negligible. What is the horizontal component of the projectile's velocity after time t?

(A) $v \cos \theta$ (B) $v \cos \theta - gt$ (C) $v \sin \theta - gt$ (D) $v \sin \theta$

3. The diagram shows the paths of two projectiles, X and Y, which rise to the same height. Which of the following is identical for both projectiles X and Y?

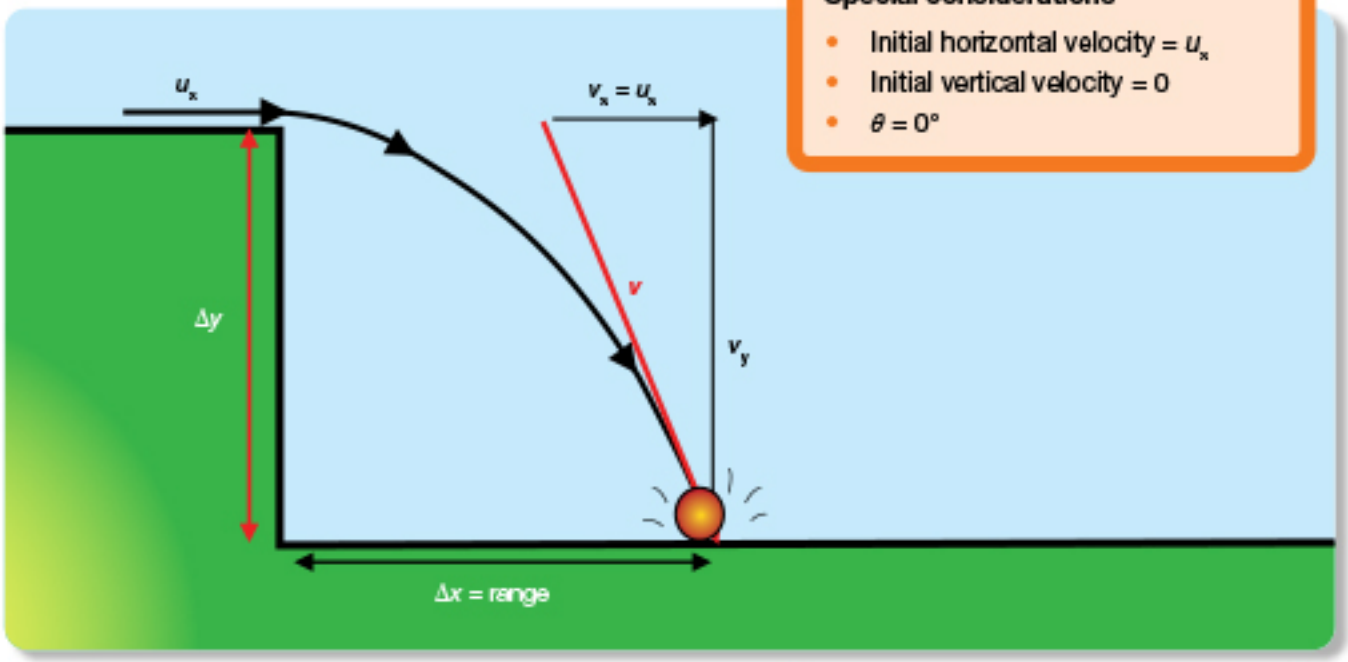
(A) Initial horizontal velocities.
(B) Initial vertical velocities.
(C) Initial velocities.
(D) Horizontal displacements.



5.3 Projectile Motion Problems

Solve problems, create models and make quantitative predictions by applying the equations of motion relationships for uniformly accelerated and constant rectilinear motion.

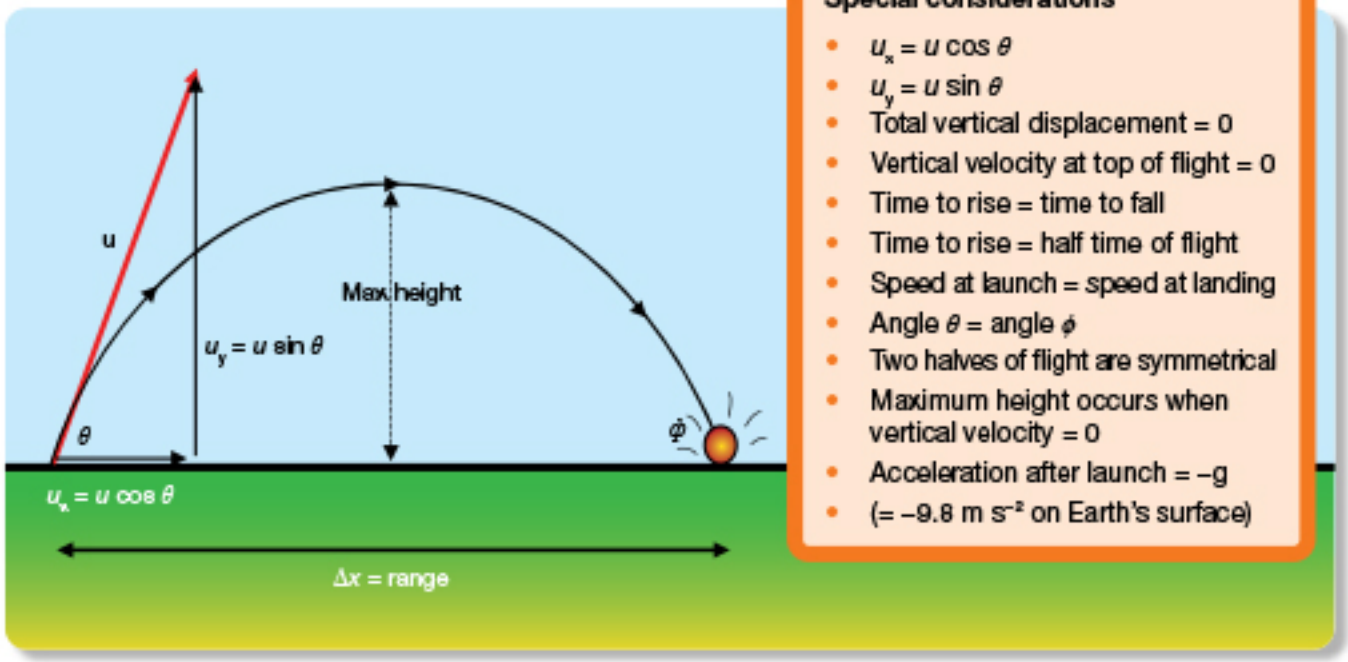
Objects projected from a horizontal surface



Special considerations

- Initial horizontal velocity = u_x
- Initial vertical velocity = 0
- $\theta = 0°$

Objects thrown up and landing at same level



Special considerations

- $u_x = u \cos \theta$
- $u_y = u \sin \theta$
- Total vertical displacement = 0
- Vertical velocity at top of flight = 0
- Time to rise = time to fall
- Time to rise = half time of flight
- Speed at launch = speed at landing
- Angle θ = angle ϕ
- Two halves of flight are symmetrical
- Maximum height occurs when vertical velocity = 0
- Acceleration after launch = –g
- (= –9.8 m s^{-2} on Earth's surface)

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