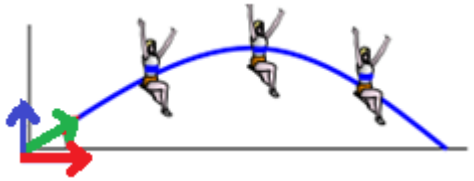
Projectile Motion

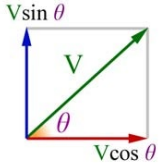
Definitions

Projectile motion Involves going up and down (vertically) **and** moving horizontally at the same time.



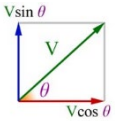
Whilst in the air, the object is called a **projectile**.

The **initial (starting) velocity** can be separated into two components at 90° to each other – **horizontal** and **vertical**.



Equations

To solve:



Vertically v = **v** sin θ

Horizontally v = **v** cos θ

Once these have been calculated, do the following:

Vertically, use this kinematic equation:

$$v_f = v_i + at$$

final velocity	v_f	m s^{-1}
initial velocity	v_i	m s^{-1}
acceleration	a	m s^{-2}
time	t	s

where v_i = vertical component, v_f = 0 and a = -9.8 since the weight force creates a downward acceleration to find t (the time until the projectile has reached the top of its flight).

Time of flight = 2 x t

Horizontally, use this kinematic equation:

$$d = v_i t + \frac{1}{2}at^2$$

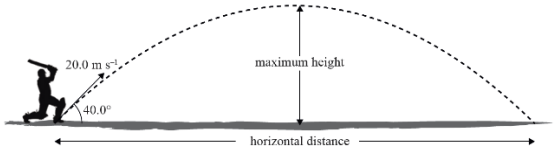
displacement	d	m
initial velocity	v_i	m s^{-1}
acceleration	a	m s^{-2}
time	t	s

where v_i = horizontal component, **a = 0** (as there are no forces acting horizontally) and t = time of flight to find d. (d =Range)

Questions

Projectile Motion (2016;2)

During a cricket game, a batsman hits the ball at an angle of 40.0° with the ground at a velocity of 20.0 m s^{-1}, as shown below.



(a) Show that the initial vertical component of the ball's velocity is 12.9 m s^{-1}.

(b) Calculate the time it takes the ball to reach its maximum height.

(c) Calculate the horizontal distance travelled by the ball before it hits the ground.

(d) Give a comprehensive explanation of the effect of the force(s) acting on the ball during its flight. Assume air resistance is negligible. In your answer, you should:

- Describe the horizontal motion.
- Discuss the effect of force(s) on horizontal motion.
- Describe the vertical motion.
- Discuss the effect of force(s) on vertical motion.

Terms

Kinematic equations of motion: Set of formulas used to describe motion mathematically.
Projectile: An object thrown into space either horizontally or at an angle and moves under the action of gravity.
Range: The horizontal distance traveled by a projectile.
Top of flight/Maximum height: The point where the projectile has reached its maximum height and (momentarily) has stopped in a vertical direction.
Time of flight: The time taken by a projectile from the moment it is thrown until it touches the ground.

Tips

- To solve projectile motion, you need trigonometry (your calculator should be in **degrees mode**)

Answers

(a) $v_v = 20 \times \sin 40° = 12.856 = 12.9$ m s^{-1} ("show that" question)

(b) $v_f = v_i + at$ so $0 = 12.9 + -9.8 \times t$
$t = 1.32$ s

(c) time of flight = $2t = 2 \times 1.32 = 2.64$ s
$v_H = 20 \times \cos 40° = 15.32 = 15.3$ m s^{-1}
$d_H = v_H$ x time of flight = 15.3 x 2.64 = 40.4 m

(d) Horizontal velocity remains constant, as there are no external forces in the horizontal direction, air resistance is negligible.
Going up, vertical velocity decreases/ball decelerates as the weight force/gravity acts downwards/in an opposite direction to the motion
Coming downwards, the vertical velocity increases/ball accelerates as the weight force/gravity is acting downwards/in the same direction as the motion.