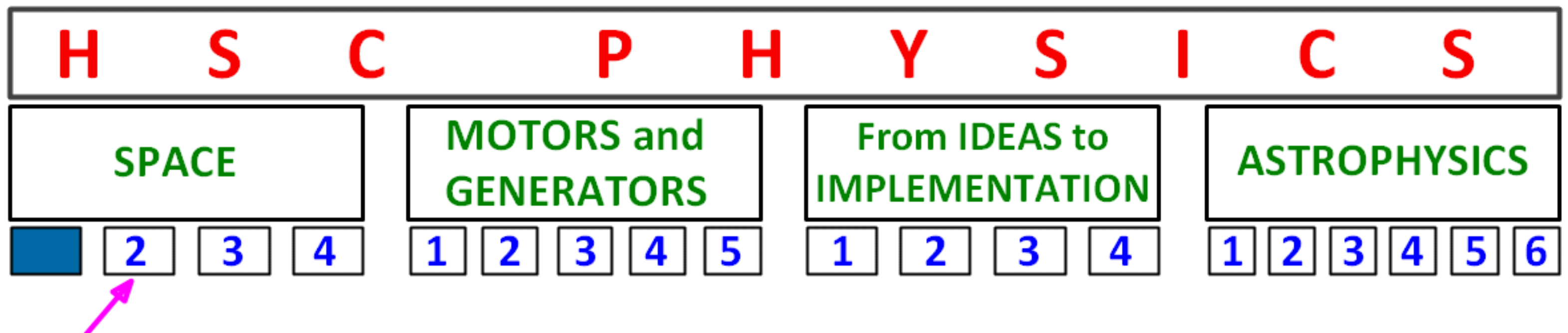


SPACE

1st Quarter; Module 1

PERIOD 6

Projectile Motion



SPACE 2

Many factors have to be taken into account to achieve a successful rocket launch, maintain a stable orbit and return to Earth

Students learn to:

- describe the trajectory of an object undergoing projectile motion within the Earth's gravitational field in terms of horizontal and vertical components
- describe Galileo's analysis of projectile motion
- explain the concept of escape velocity in terms of the:
 - gravitational constant
 - mass and radius of the planet
- outline Newton's concept of escape velocity
- identify why the term 'g forces' is used to explain the forces acting on an astronaut during launch
- discuss the effect of the Earth's orbital motion and its rotational motion on the launch of a rocket
- analyse the changing acceleration of a rocket during launch in terms of the:
 - Law of Conservation of Momentum
 - forces experienced by astronauts
- analyse the forces involved in uniform circular motion for a range of objects, including satellites orbiting the Earth
- compare qualitatively low Earth and geo-stationary orbits
- define the term orbital velocity and the quantitative and qualitative relationship between orbital velocity, the gravitational constant, mass of the central body, mass of the satellite and the radius of the orbit using Kepler's Law of Periods
- account for the orbital decay of satellites in low Earth orbit
- discuss issues associated with safe re-entry into the Earth's atmosphere and landing on the Earth's surface
- identify that there is an optimum angle for safe re-entry for a manned spacecraft into the Earth's atmosphere and the consequences of failing to achieve this angle

SPACE 2

Many factors have to be taken into account to achieve a successful rocket launch, maintain a stable orbit and return to Earth

Students:

- solve problems and analyse information to calculate the actual velocity of a projectile from its horizontal and vertical components using:

$$v_x^2 = u_x^2$$

$$v = u + at$$

$$v_y^2 = u_y^2 + 2a_y\Delta y$$

$$\Delta x = u_x t$$

$$\Delta y = u_y t + \frac{1}{2} a_y t^2$$

- perform a first-hand investigation, gather information and analyse data to calculate initial and final velocity, maximum height reached, range and time of flight of a projectile for a range of situations by using simulations, data loggers and computer analysis
- identify data sources, gather, analyse and present information on the contribution of one of the following to the development of space exploration: Tsiolkovsky, Oberth, Goddard, Esnault-Pelterie, O'Neill or von Braun
- solve problems and analyse information to calculate the centripetal force acting on a satellite undergoing uniform circular motion about the Earth using

$$F = \frac{mv^2}{r}$$

- solve problems and analyse information using:

$$\frac{r^3}{T^2} = \frac{GM}{4\pi^2}$$

SPACE	2001	2002	2003	2004	2005	2006	2007
1. The Earth has a gravitational field that exerts a force on objects both on it and around it							
2. Many factors have to be taken into account to achieve a successful rocket launch, maintain a stable orbit and return to Earth							
describe the trajectory of an object undergoing projectile motion within the Earth's gravitational field in terms of horizontal and vertical components	15,18bc	1	16c	1, <u>27*</u>	1,5	4	5,16
solve problems and analyse information to calculate the actual velocity of a projectile from its horizontal and vertical components using : $v_x^2 = u_x^2$ $v = u + at$ $v_y^2 = u_y^2 + 2 a_y \Delta y$ $\Delta x = u_x t$ $\Delta y = u_y t + \frac{1}{2} a_y t^2$	7,18bc	21a		16		16a	
3. The Solar System is held together by gravity							
4. Current and emerging understanding about time and space has been dependent upon earlier models of the transmission of light							

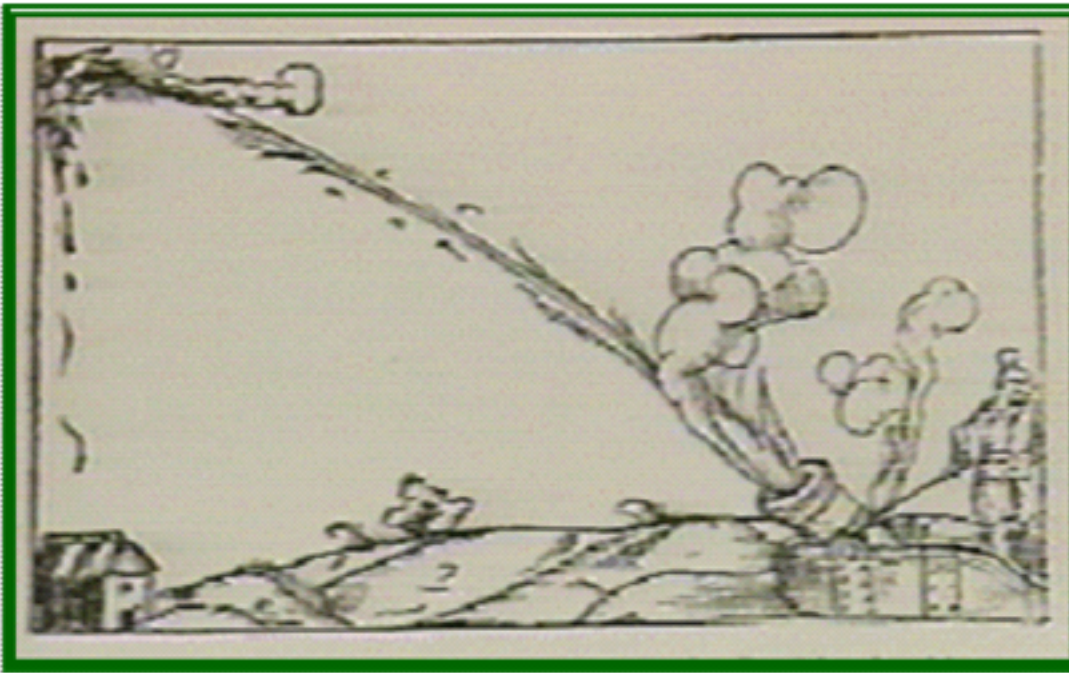
A **PROJECTILE** is any object that is thrown, dropped or otherwise launched into the air. This includes such things as a box dropped from a plane, a thrown ball, a struck golf ball, a kicked football, or even a fired bullet or cannonball.

It does not include a rocket, because the thrust of a rocket continues well into its flight.

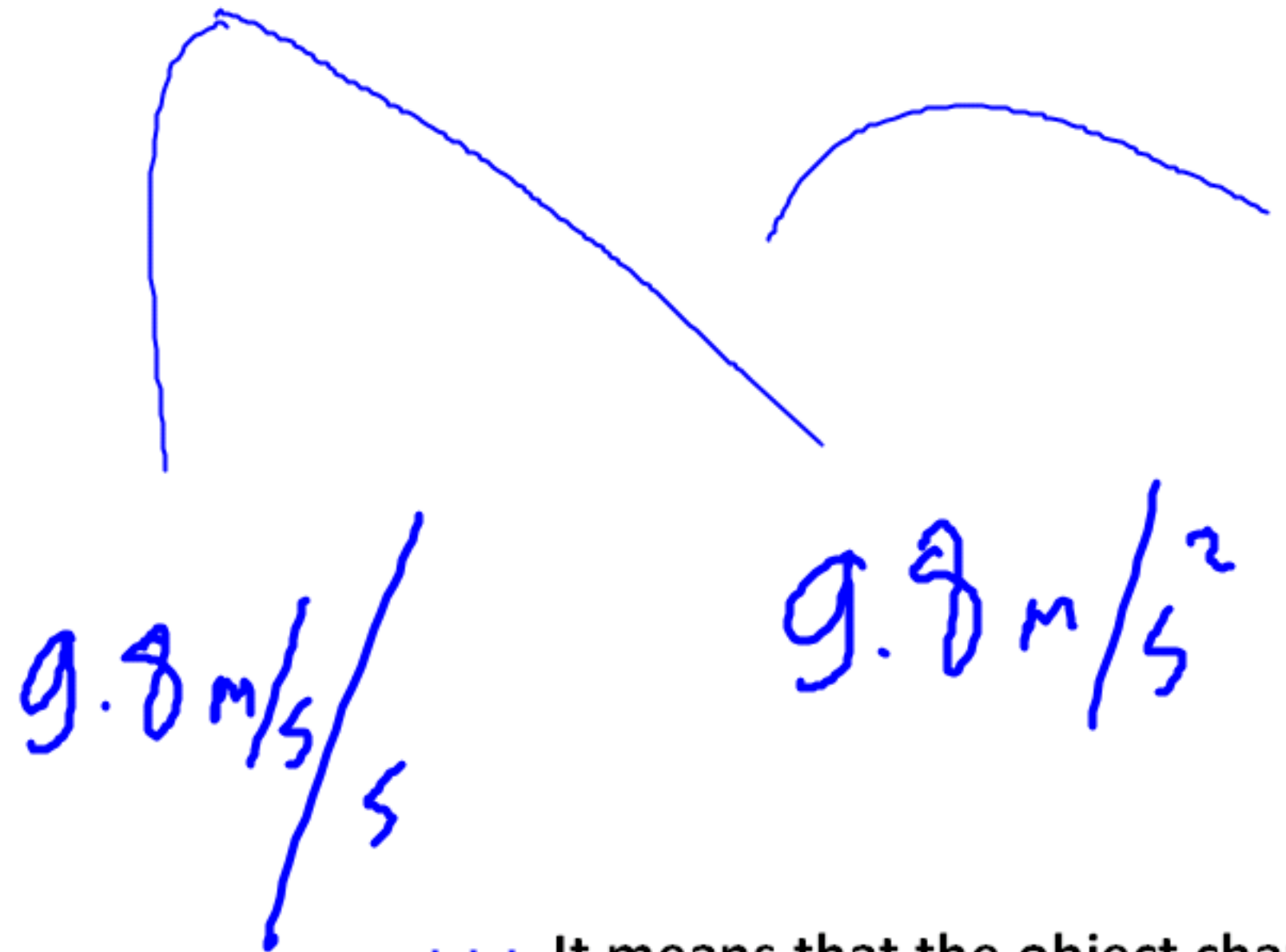
Projectiles are projected into the air and then left to complete their unpowered flight.

Misconceptions about Projectile Motion

- ✓ Aristotle thought that projectiles had a property called "impetus". When the object lost its impetus, it fell to the ground.



- ✓ Heavier objects fall faster than lighter ones.

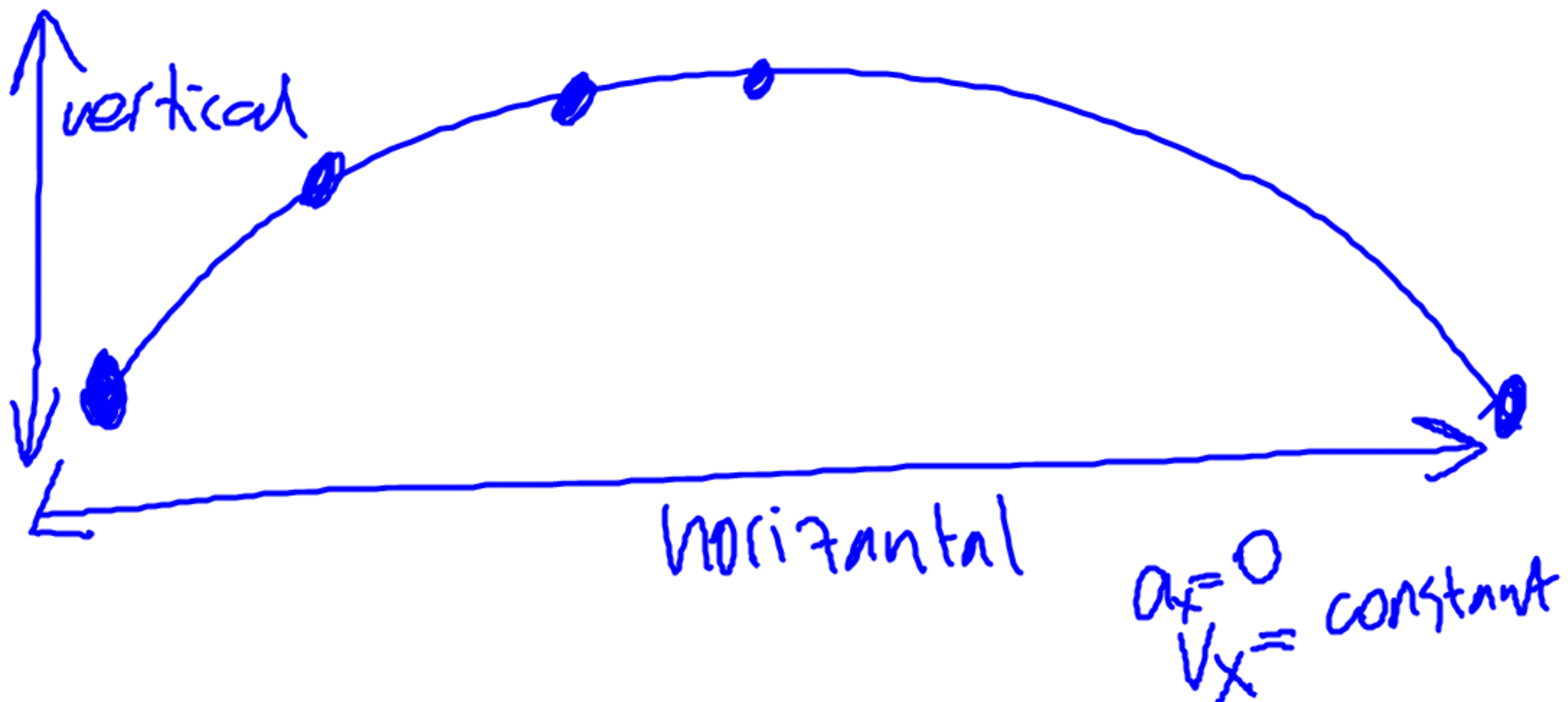


*** It means that the object changes its velocity by 9.8 m/s every second. (speeds up if coming down, slows down if going up)

Galileo's Analysis of Projectile Motion

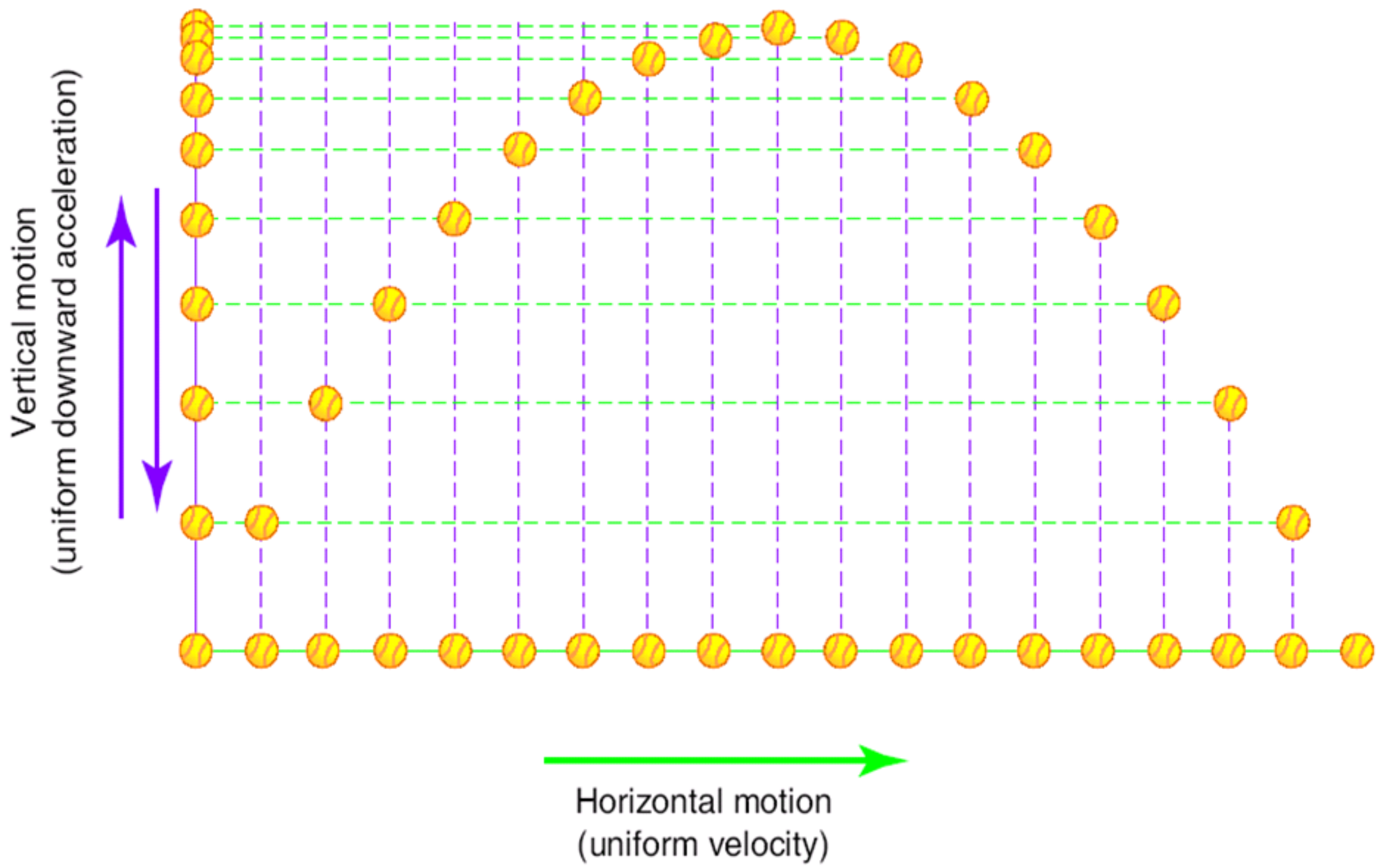
- ✓ The horizontal and vertical components of PM are independent of each other
- ✓ The horizontal motion is not subject to gravitational forces \Rightarrow no acceleration
- ✓ The vertical motion is affected by gravitational forces which gives an acceleration of 9.8 m/s^2 to all objects regardless of their mass or size (famous pizza tower experiment)

$$a_y = 9.8 \text{ m/s}^2 \downarrow \quad V_y \neq \text{constant}$$



FOLLOWING GALILEO'S FOOTSTEPS > THE PROJECTILE MOTION

$a_y = 9.8 \text{ m/s}^2$



FOLLOWING GALILEO'S FOOTSTEPS > THE VERTICAL COMPONENT ONLY

$$a_y = -9.8 \text{ m/s}^2$$

up +
down -

u_y : initial ver. velocity

V_y : final ver. velocity

y : vertical displacement

a_y : ver. acceleration

t : time

$$V_y = u_y + a_y t = u_y + g t \quad (1)$$

$$y = u_y \cdot t + \frac{1}{2} g t^2 \quad (2)$$

$$V_y^2 = u_y^2 + 2g \cdot y \quad (3)$$

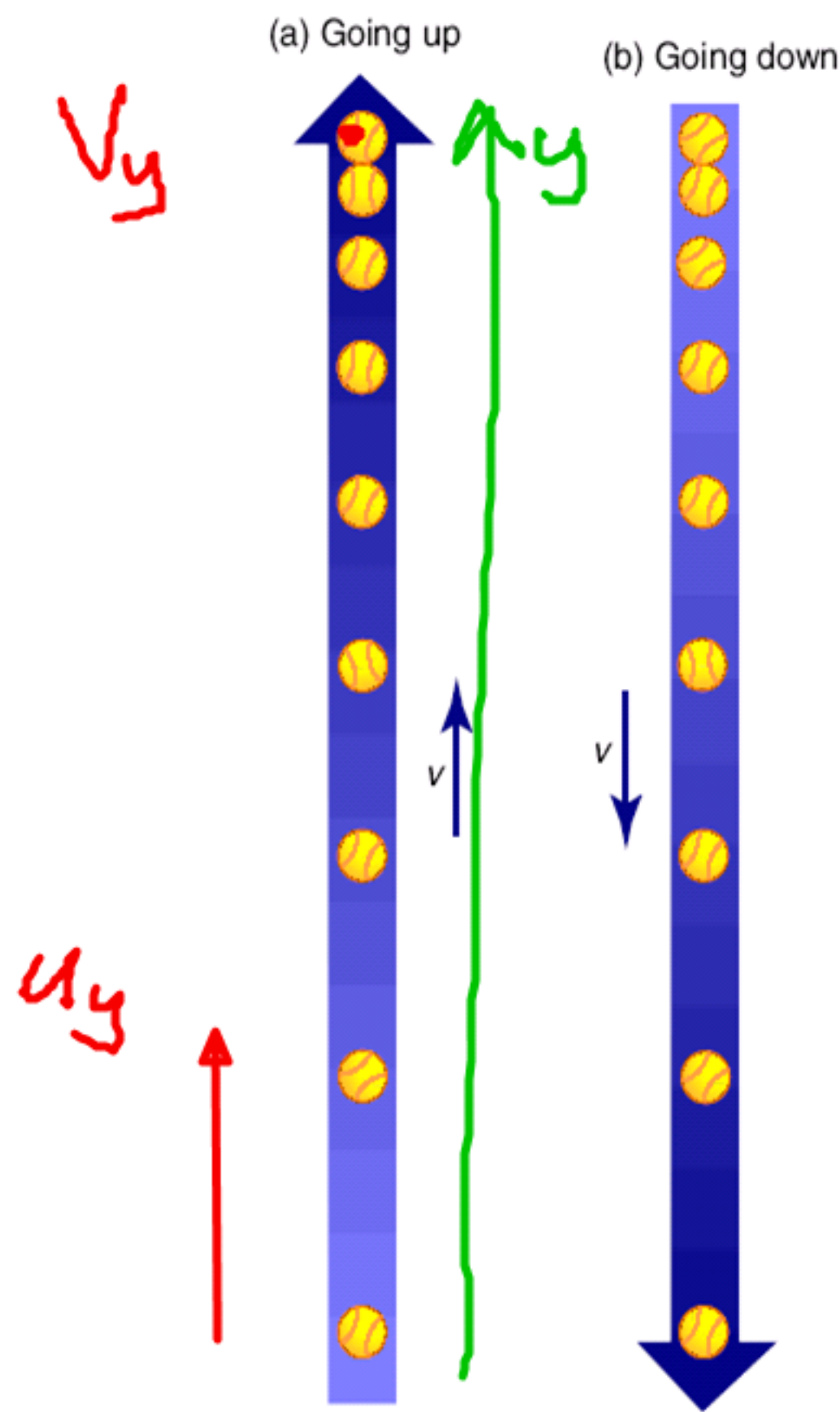
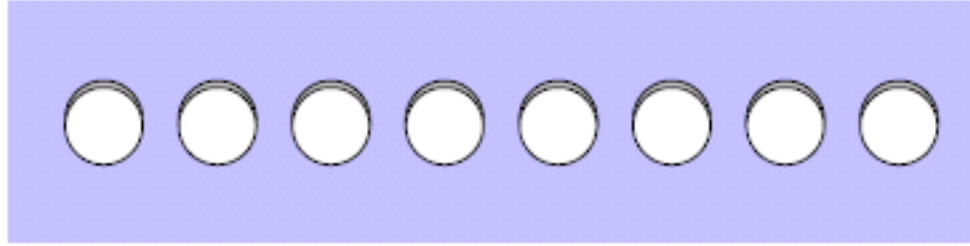


Figure 2.5 (a and b) The motion of a ball thrown vertically upwards

FOLLOWING GALILEO'S FOOTSTEPS > THE HORIZONTAL COMPONENT ONLY



$$a_x = 0 \Rightarrow u_x = v_x$$

$$x = v_x \cdot t$$

(^)

$$\begin{aligned} \boxed{v} &= u + \cancel{at} \quad a=0 \\ v^2 &= u^2 + \cancel{2ax} \\ x &= u \cdot t + \cancel{\frac{1}{2}at^2} \end{aligned}$$

2 QUESTIONS FOR TONIGHT!

Question 1

An air gun is fired horizontally at a target 81 m away and the bullet takes just 0.35 s to strike it. What was the velocity of the bullet?

Question 2

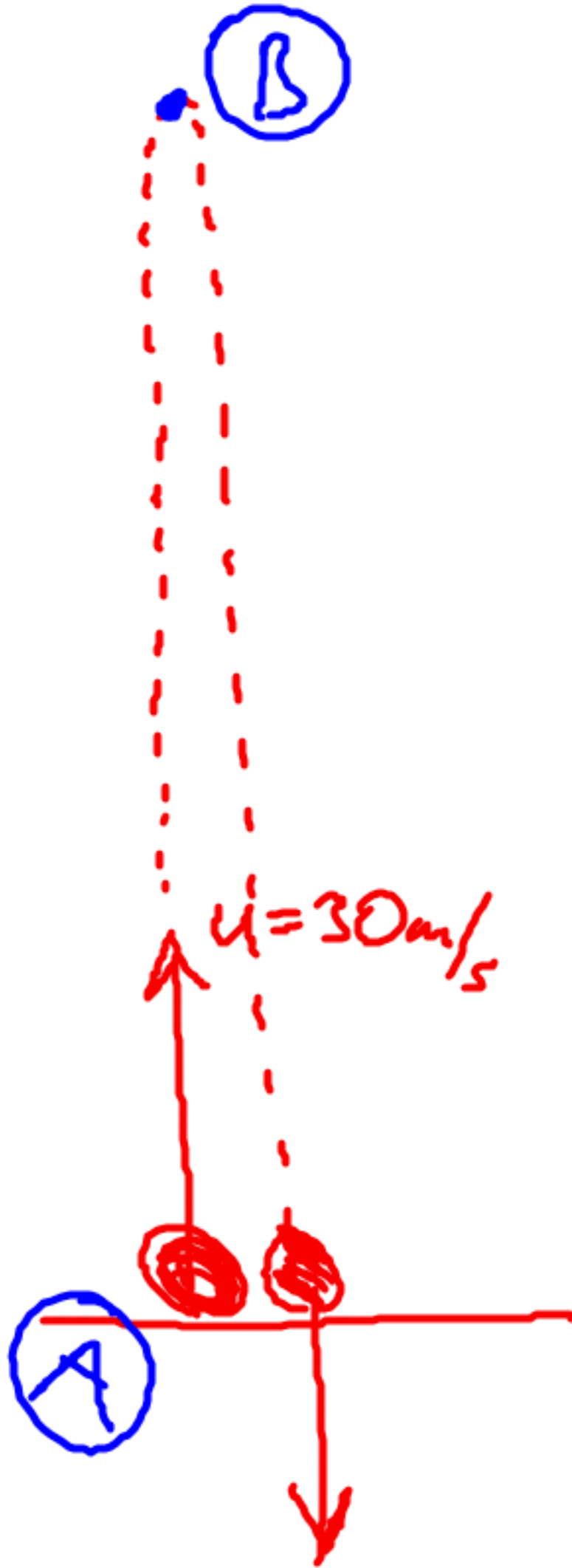
A ball is thrown directly upwards with a velocity of 30m/s. Ignoring air resistance, determine (take g as 10 m/s^2):

- (a) its peak height
- (b) its time of flight
- (c) its velocity after 0.5 s
- (d) its velocity after 1.5 s.

HOMEWORK QUESTION 2

A ball is thrown directly upwards with a velocity of 30m/s. Ignoring air resistance, determine (take g as 10 m/s²):

- (a) its peak height (b) its time of flight (c) its velocity after 0.5 s (d) its velocity after 1.5 s.



$$u = +30 \text{ m/s}$$

$$v = 0$$

$$t = ?$$

$$y = ?$$

$$a = -10 \text{ m/s}^2$$

$$(b) \quad v = u + at$$

$$0 = 30 + (-10) \cdot t$$

$$t = 3 \text{ s}$$

$$t_f = 6 \text{ s}$$

$$(a) \quad y = ut + \frac{1}{2}at^2$$

$$= 30 \times 3 + \frac{1}{2}(-10) \cdot 3^2$$

$$H = 45 \text{ m}$$

HOMEWORK QUESTION 1:

An air gun is fired horizontally at a target 81 m away and the bullet takes just 0.35 s to strike it. What was the velocity of the bullet?



$$u = ?$$

$$v = ?$$

$$t = 0.35 \text{ s}$$

$$x = 81 \text{ m}$$

$$a = 0$$

$$x = v \cdot t$$

$$81 = v \cdot 0.35$$

$$v = \frac{81}{0.35} = 231 \text{ m/s}$$

Steps in solving PM questions.

Step 1 > Read the question.

Step 2 > Understand the question.

Step 3 > Make sure you understand "What is given/provided" and "What is asked".

Step 4 > Draw a diagram.

Step 5 > Select your interval (A to B). Mark A and B on your diagram.

Step 6 > Draw the data table and fill in the details as much as you can. Mark unknowns.

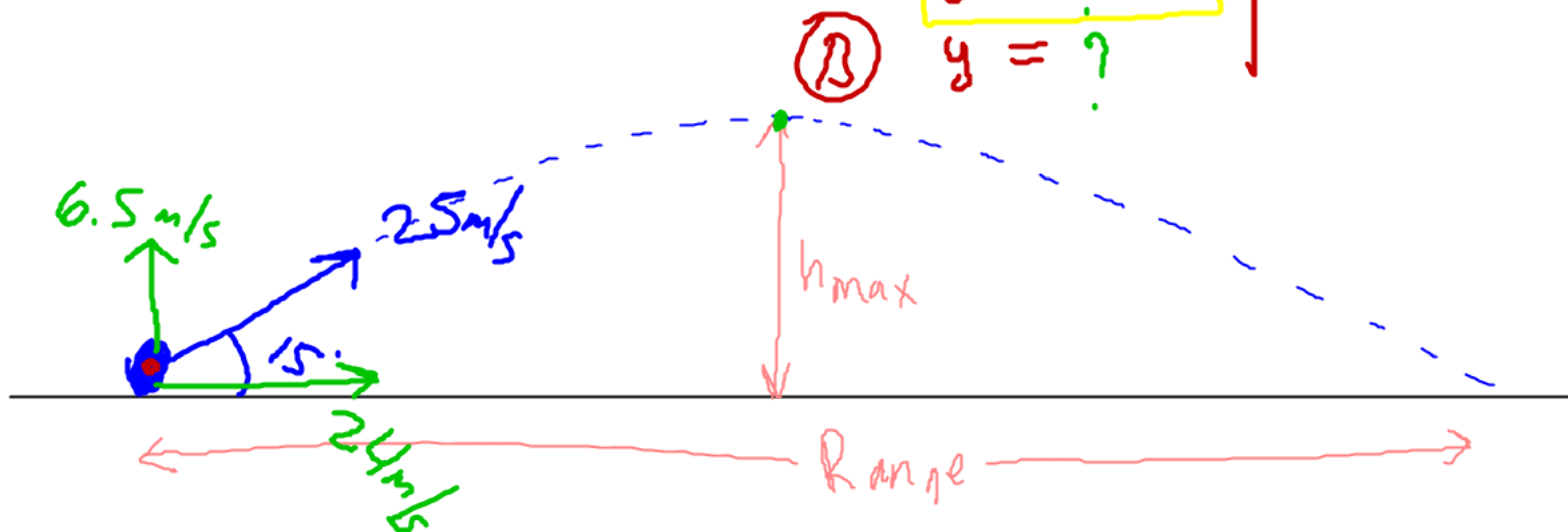
Step 7 > Select the appropriate formula and solve it for unknowns.

YOUR FIRST PROJECTILE MOTION QUESTION!

A tennis ball is struck at a velocity of 25 m/s 15° above horizontal.

- Calculate the maximum height reached by this ball.
- Determine the time it takes to return to the ground.
- Calculate the range of its trajectory.

VER.	HOR.
$u_y = 6.5 \text{ m/s}$	$u = v = 24 \text{ m/s}$
$v_y = 0$	$t = ?$
$a = -10$	$x = ?$
$t = ?$	
$y = ?$	



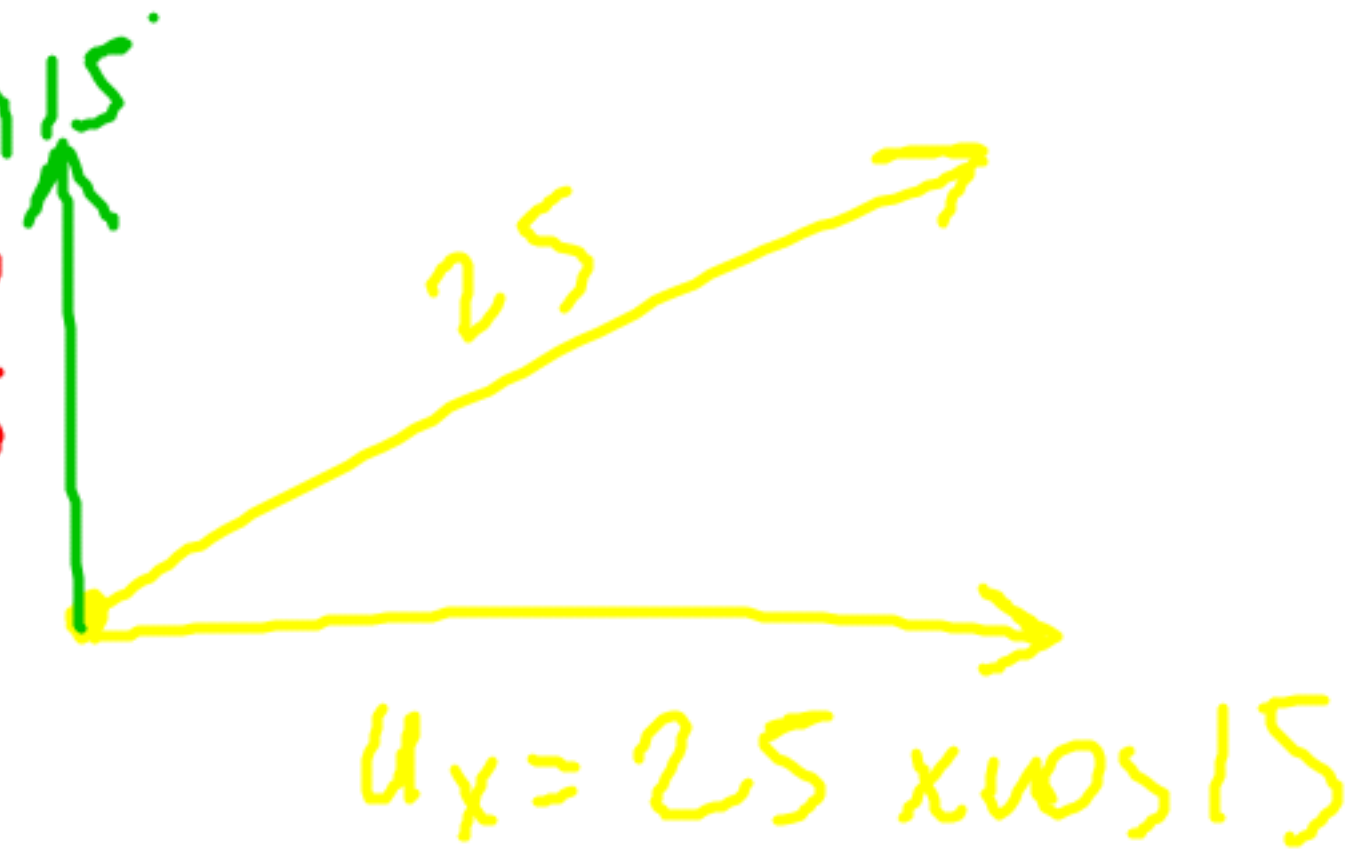
Steps in solving PM questions.

1. Read the question.
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5. Select your interval (A to B). Mark A and B on your diagram.
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7. Select the appropriate formula and solve it for unknowns.

VELOCITIES IN PROJECTILE MOTION

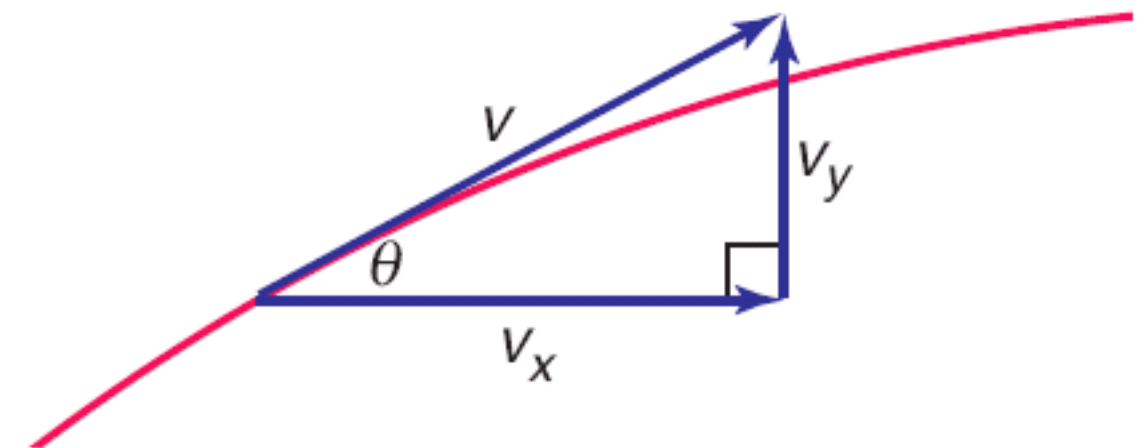
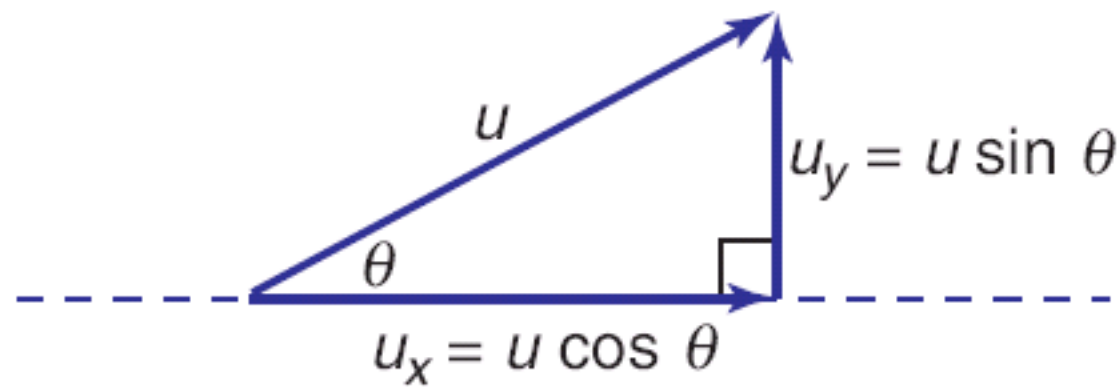
THE VELOCITY IS COMPOSED OF
ITS VERTICAL COMPONENT
AND
ITS HORIZONTAL COMPONENT

$$u_y = 25 \times \sin 15^\circ$$
$$= 6.5 \text{ m/s}$$



A diagram showing a yellow vector labeled '25' originating from a point. It is resolved into two components: a vertical green component and a horizontal yellow component. The angle between the vector and the horizontal is 15 degrees.

$$u_x = 25 \times \cos 15^\circ$$
$$= 24 \text{ m/s}$$



Exercise 2: A tennis ball is struck at a velocity of 25 m/s 15° above horizontal.

- a) Calculate the maximum height reached by this ball.
- b) Determine the time it takes to return to the ground.
- c) Calculate the range of its trajectory.

Steps in solving PM questions.

1. Read the question.
2. Understand the question.
3. Make sure you understand "What is given/provided" and "What is asked".
4. Draw a diagram.
5. Select your interval (A to B). Mark A and B on your diagram.
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Exercise 2: A tennis ball is struck at a velocity of 25 m/s 15° above horizontal.

- a) Calculate the maximum height reached by this ball.
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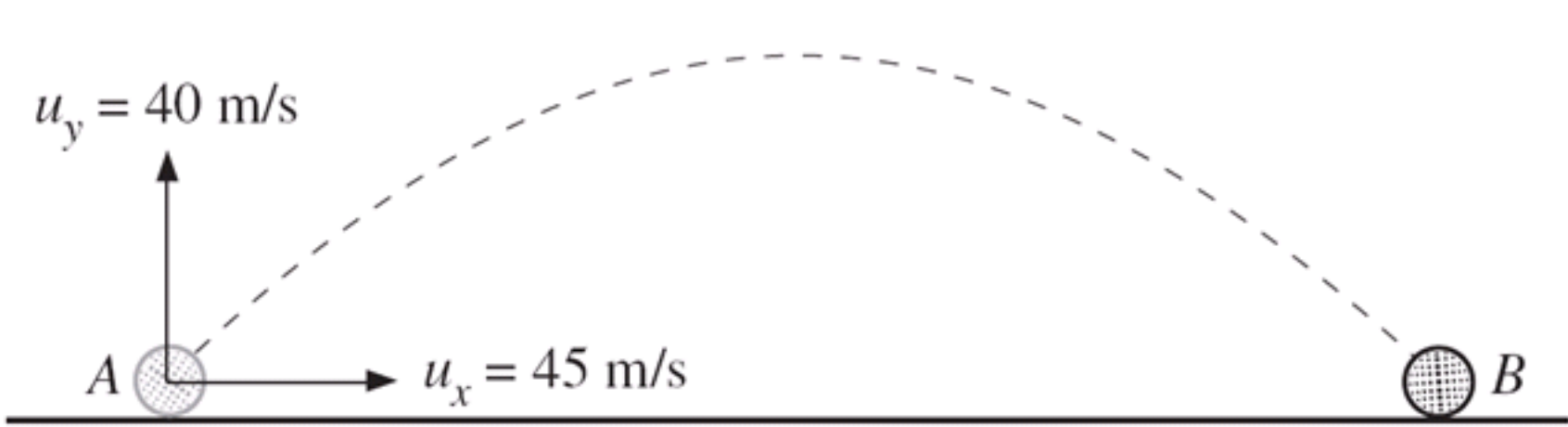
Steps in solving PM questions.

1. Read the question.
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7. Select the appropriate formula and solve it for unknowns.

2006 HSC PAPER

Question 16 (6 marks)

A projectile leaves the ground at point A with velocity components as shown in the diagram. It follows the path given by the dotted line and lands at point B .



- (a) State the horizontal component of the projectile’s velocity when it lands.

1

.....
- (b) Find the magnitude of the initial velocity of the projectile.

1

.....

.....
- (c) Calculate the maximum height attained by the projectile.

2
- (d) Calculate the range of the projectile, if it lands level with its starting position.

2

HOMEWORK

- ✦ Homework is an integral part of your "Learning Curve", take it seriously!
- ✦ Target minimum 1 hour of Physics everyday
- ✦ Divide your physics home study in three segments;
 - ✓ Revision (past)
 - ✓ Homework (present)
 - ✓ Tomorrow (future)
- ✦ Homework is due next period, unless otherwise stated
- ✦ If you cannot do all, at least do a few from each piece

*Apart from **reading the relevant pages from the textbook and solving the rest of the questions in this booklet** your homework is:*

1. Chapter 2 Questions 1-13
2. Examine

"http://phet.colorado.edu/simulations/sims.php?sim=Projectile_Motion

NEXT PERIOD >

PROJECTILE MOTION continued