# Kinematics

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# Learning Objectives

Linear Motion

Non-linear Motion

# Kinematics

Study of **motion** without **consideration** of the **causes of motion**

Instantaneous velocity $v = \frac{dx}{dt}$

Average velocity $\bar{v} = \frac{\sum v_i t_i}{\sum t_i} = \frac{\Delta x}{\Delta t}$

Instantaneous acceleration $a = \frac{dV}{dt} = v \frac{dV}{dx}$

Average acceleration $\bar{a} = \frac{\Delta v}{\Delta t}$

$s = \int v \, dt$

# Kinematics

For **constant** acceleration

$$v = u + at$$

$$s = ut + \frac{1}{2}at^2$$

$$s = \frac{u+v}{2} \text{ x } t$$

$$v^2 = u^2 + 2as$$

# Non-linear Motion (Parabolic Motion)

$v_y = v_0 \sin\theta$

$v_{x=} v_0 \cos\theta$

$x = v_x t$

$$y(x) = x\tan\theta - \frac{g x^2}{2 v_0^2 \cos\theta^2}$$

# Example 1

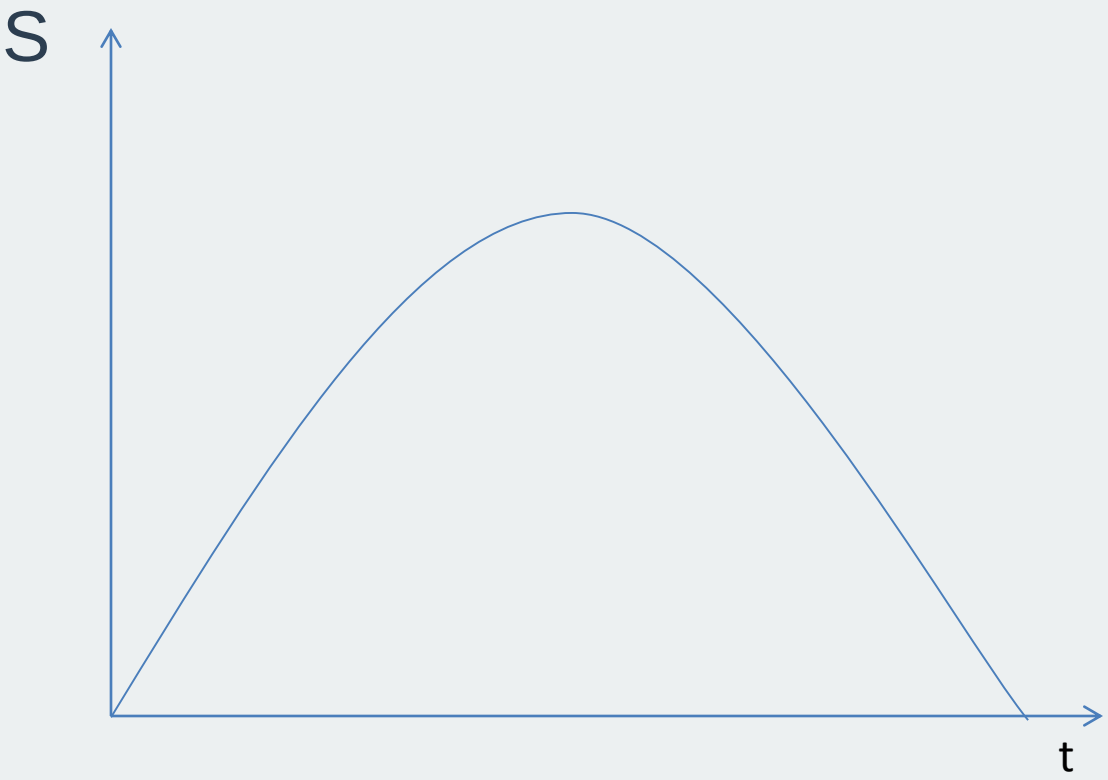
The motion of a car can be described as: velocity of car is 60 $ms^{-1}$ for the first 6 second, 20 $ms^{-1}$ for the next 2 second, and 40 $ms^{-1}$ for the last 2 second. Calculate the average velocity!

Solution:

$\bar{v} = \frac{\sum v_i t_i}{\sum t_i}$ , hence $\bar{v} = \frac{60 \text{ x } 6 + 20 \text{ x } 2 + 40 \text{ x } 2}{6 + 2 + 2} = 48 \text{ ms}^{-1}$

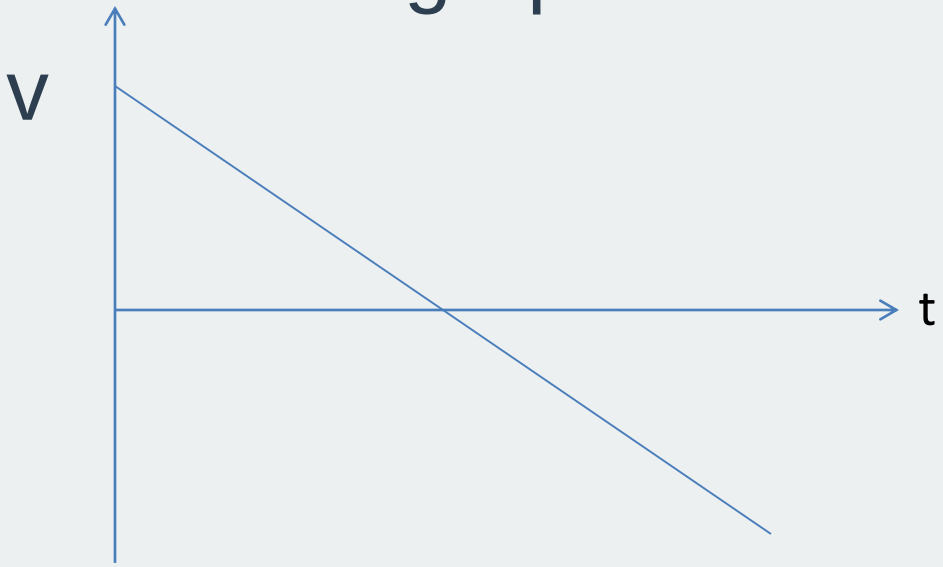
# Example 2

Sketch the graph of velocity-time graph given the displacement-time graph is:



# Example 2

**Solution**: velocity is the gradient of the displacement-time graph, do not forget to consider the time where the velocity is zero, hence the graph is



# Example 3

**Section A**

A ball is projected horizontally from a roof top with a velocity of 40 m/s. What is the speed after 3 second? (assume no air resistance)

A. 60 m/s

B. 50 m/s

C. 40 m/s

D. 20 m/s

E. 0 m/s

**Ans: B**

# Example 4

The angle of elevation of anti-spacecraft gun is $30^0$ an the muzzle velocity is 1000 m/s. For what time after firing should the fuse be set if the shell is to explode at an altitude of 2000 m ?

A. 4.2 m/s

B. 5.5 m/s

C. 6.7 m/s

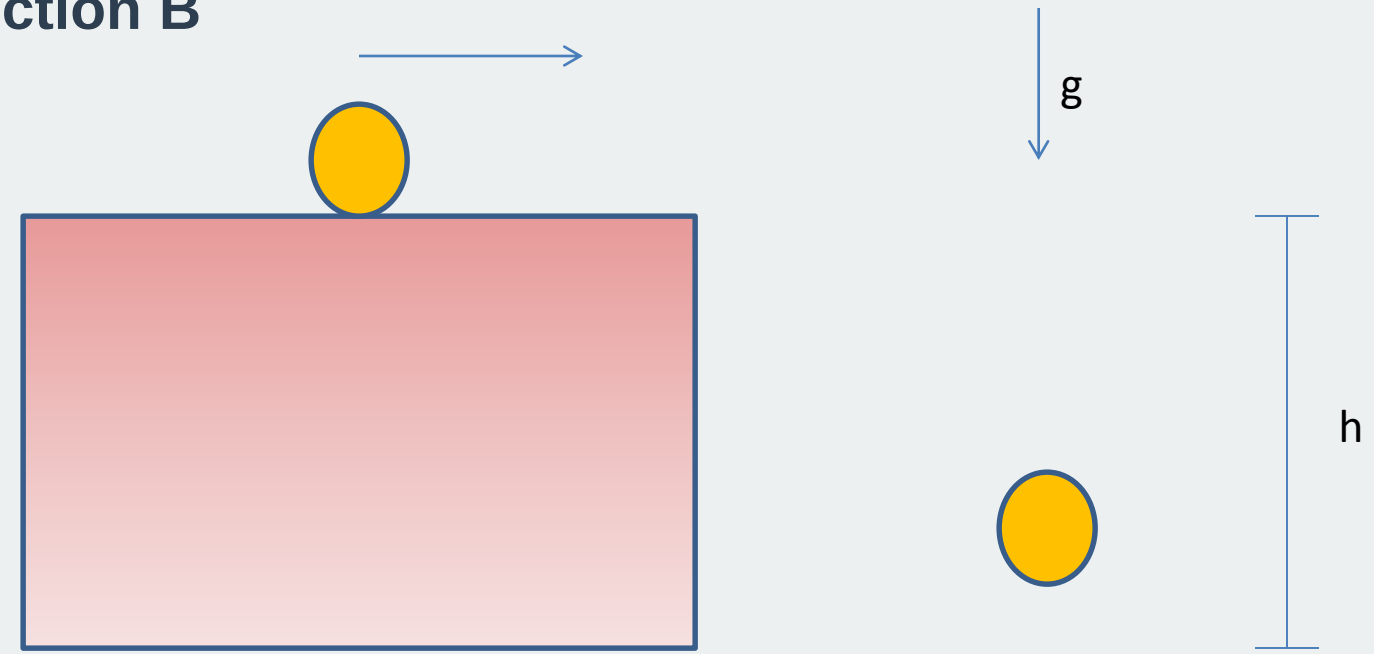
D. 9.0 m/s

E. 11.3 m/s

**Ans: A**

# Example 5

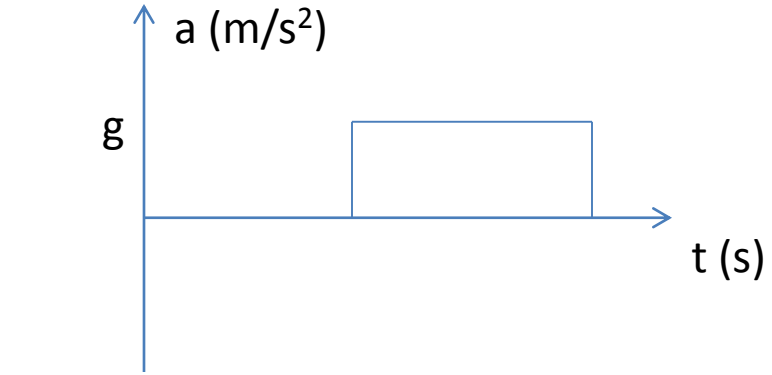
**Section B**

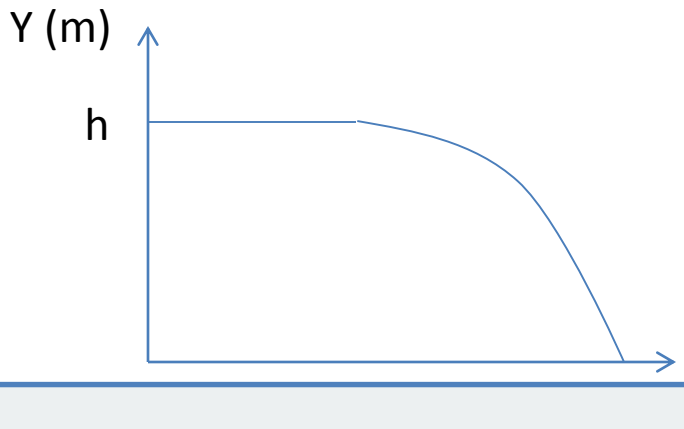



Sketch the acceleration-time and height versus time graph (assume ball doesn't bounce back)

# Example 5

## Solution



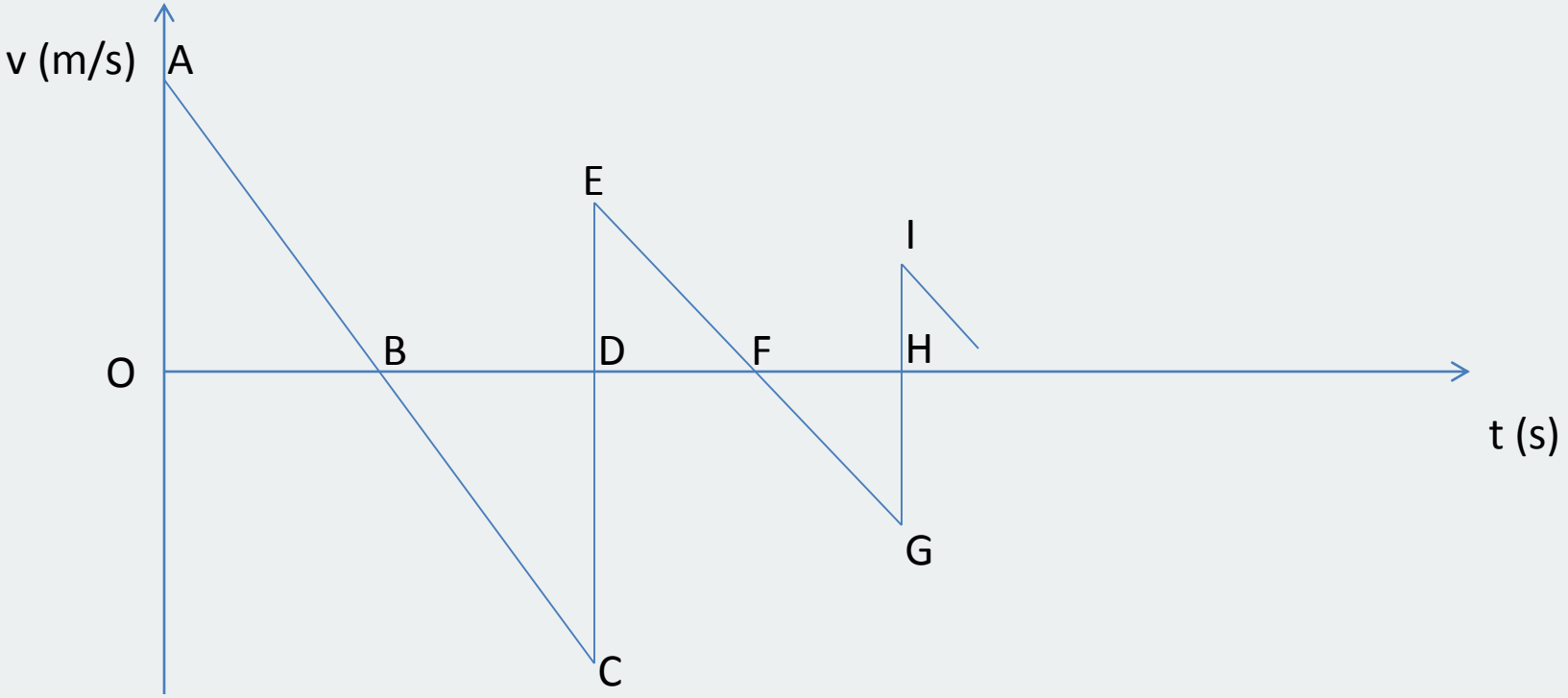
# Example 6

A basket ball is thrown vertically upwards by devina and falls on a smooth suface, the ball then bounches up and down with decreasing speed

A. Draw the velocity-time graph for the ball's motion.
B. This experiment can be used to determine the rough value of g (gravitational constant), how we determine this constant?
C. Show, from the graph, how can we determine the maximum height and the distance the ball travelled when it first reach the ground.

# Example 6

## Solution



# Example 6

A. Note:

- Line AC and EG have same gradient
- Point I has lower velocity than Point E, and Point E has lower velocity than Point A

B. g is represented by gradient of line AC or EG

C. Maximum heigth can be determined by calculating the area of triangle AOB, and the distance the ball travelled when it first reach the ground is represented by triangle BCD

# Example 7

A man drops vertically downwards from a helicopter  at an altitude 200 m. He fall under gravity without opening the parachute for the first 4 seconds.

A. Calculate the vertical velocity and the distance travelled during the first 4 seconds.

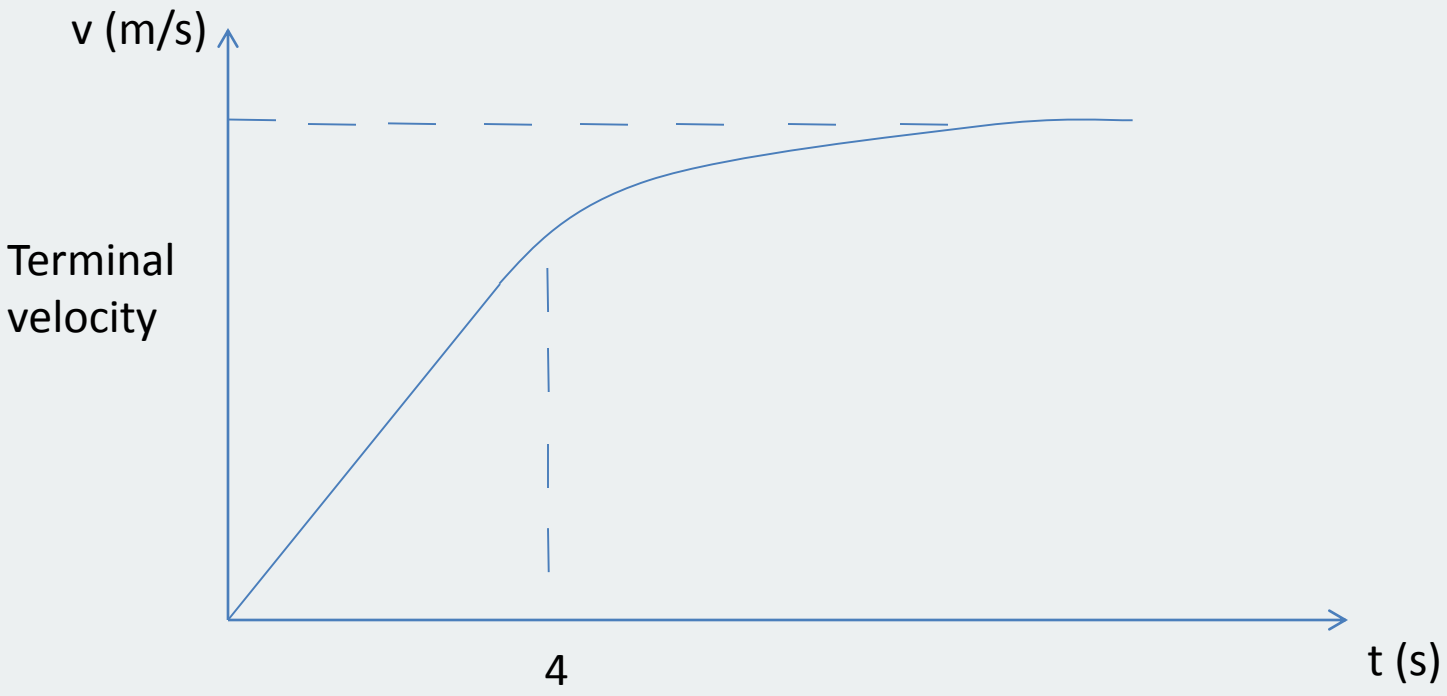
B. After 4 seconds he open the parachute, draw the velocity-time graph for his motion starting from t = 0 second

# Example 7

**Solution**

A. $v = u + at = 0 + 9.81 \times 4 = 39.24$ m/s

$s = ut + 0.5at^2 = 0 + 0.5 \times 9.81 \times 4^2 = 78.48$ m



# References

A level complete guide, Themis Publisher,

www.xtremepapers.com,

Physics MCQ with helps (topical).