Motion In 1D

Science Knowledge

My website: https://scienceknowledge.webador.com/

Learning Objectives

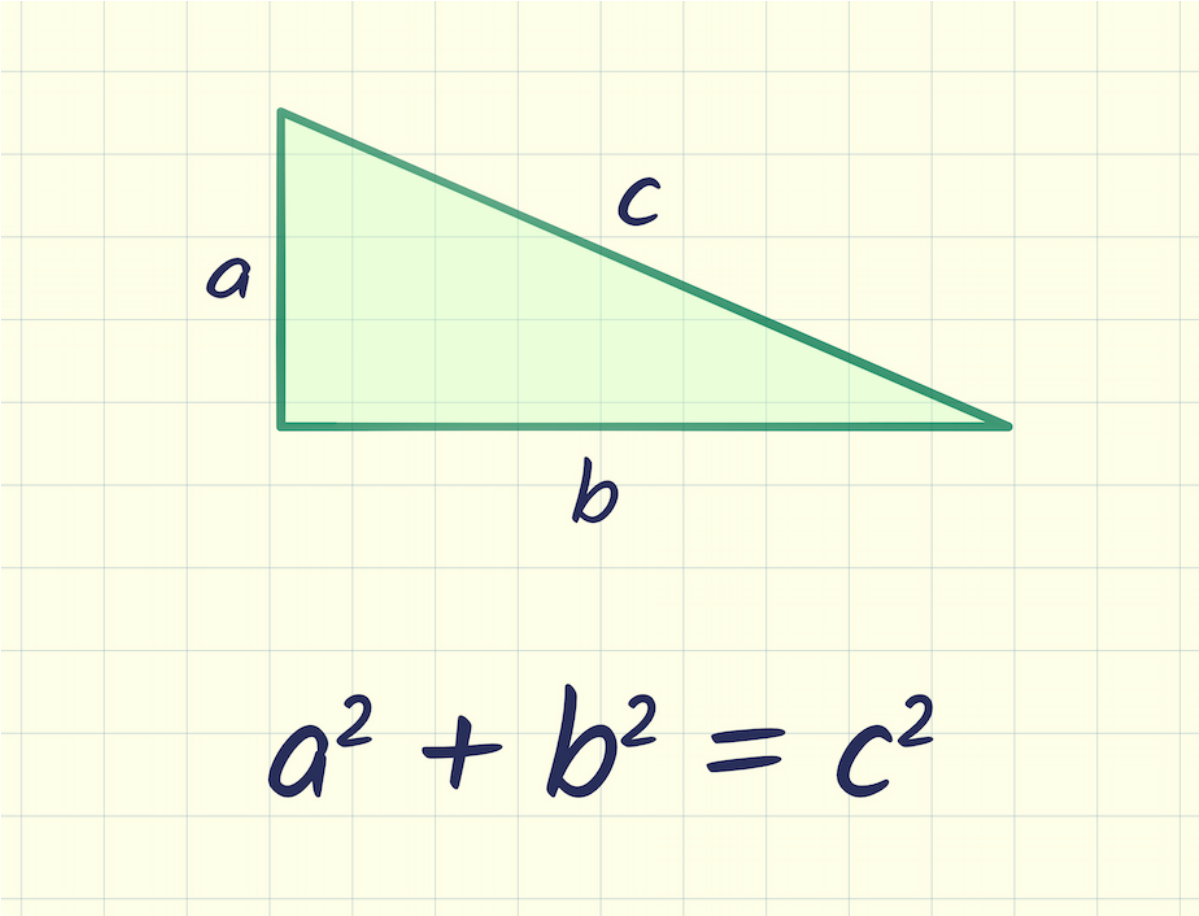
- Understand the difference between vector quanitites and scalar quantities
  - Displacement VS distancs
  - Velocity VS velocity
  - Acceleration, etc
- Being able to extract information from motions diagram
  - Know what gradient of a graph represents
  - Velocity VS Time (area under the curve, gradient, acceleration)
  - Acceleration VS Time
- Know how to use the kinematics equations
- Know how to do solve kinematics problems
- Understand Free fall motion

Vector and Scalar

Scalar Quantities	Vector Quantities
Have magnitude but no direction	Have magnitude and direction
Distance Speed Mass Energy Density Power Length, Area, Volume Time Temperature Work	Displacement Velocity Weight Acceleration Force Impulse Pressure Momentum Gravity Drag

Displacement and Distance

Calculating Displacement: Pythagorean theorem



Worked Example1 - Displacement

- A girl run to the left for 3 meters, and then goes up for 4 meters. What is the total displacment the girl travelled?

Worked Example 2

- In a Cartesian coordinates plane, a ball initially locates at the position of (3,6). After a certain period of time, the ball is being moved to the position of (11,3) by winds. What is the total displacement travelled by the ball?

Velocity and Speed

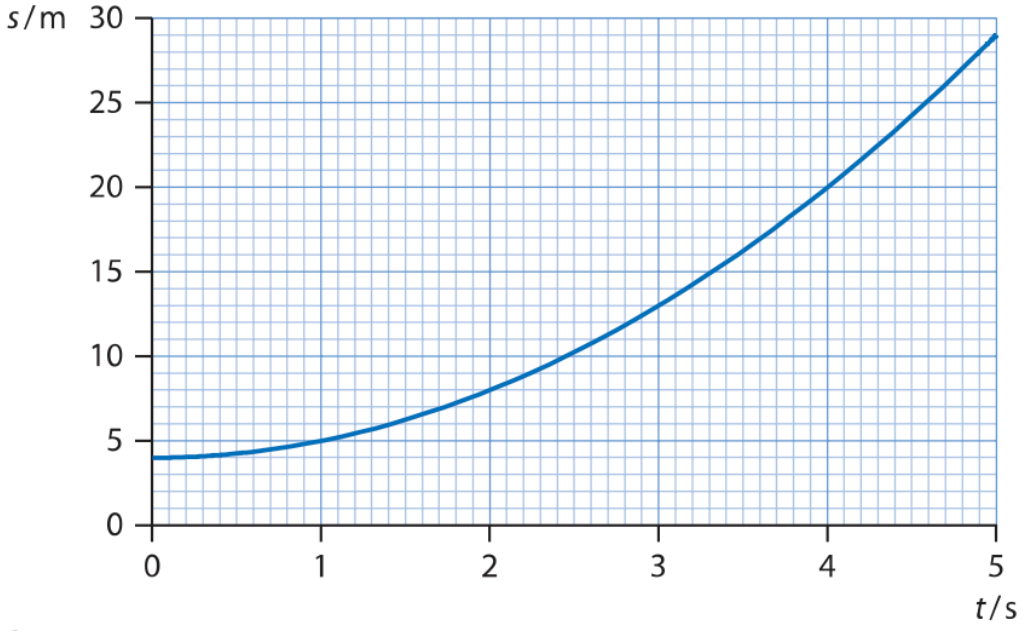
Worked Example

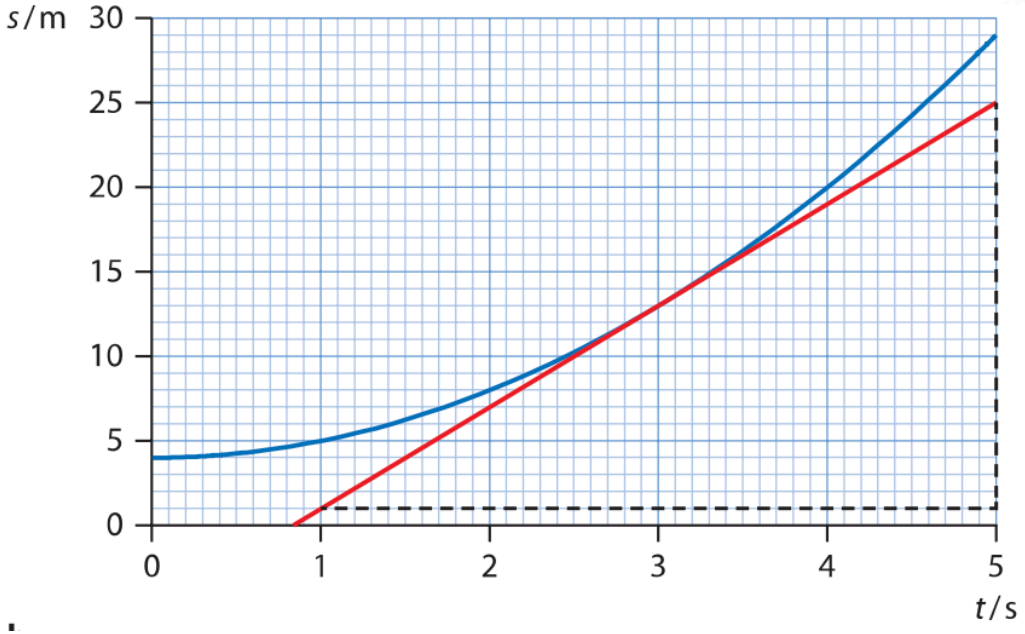
- A person runs to the left at 3m/s for 10 seconds, then he turns his direction and runs to the northern direction at 4m/s for 15 seconds.
  - What is the total displacement and distance?
  - What is the average velocity and average distance?

Instantaneous Velocity and Speed

- Velocity changes→instantaneous velocity
  - Average velocity during an infinitely small time interval
  - Is equal to the slope of the tangent line
  - Magnitude = instantaneous speed

$$v = \lim_{\Delta t \to 0} \frac{\Delta s}{\Delta t}$$





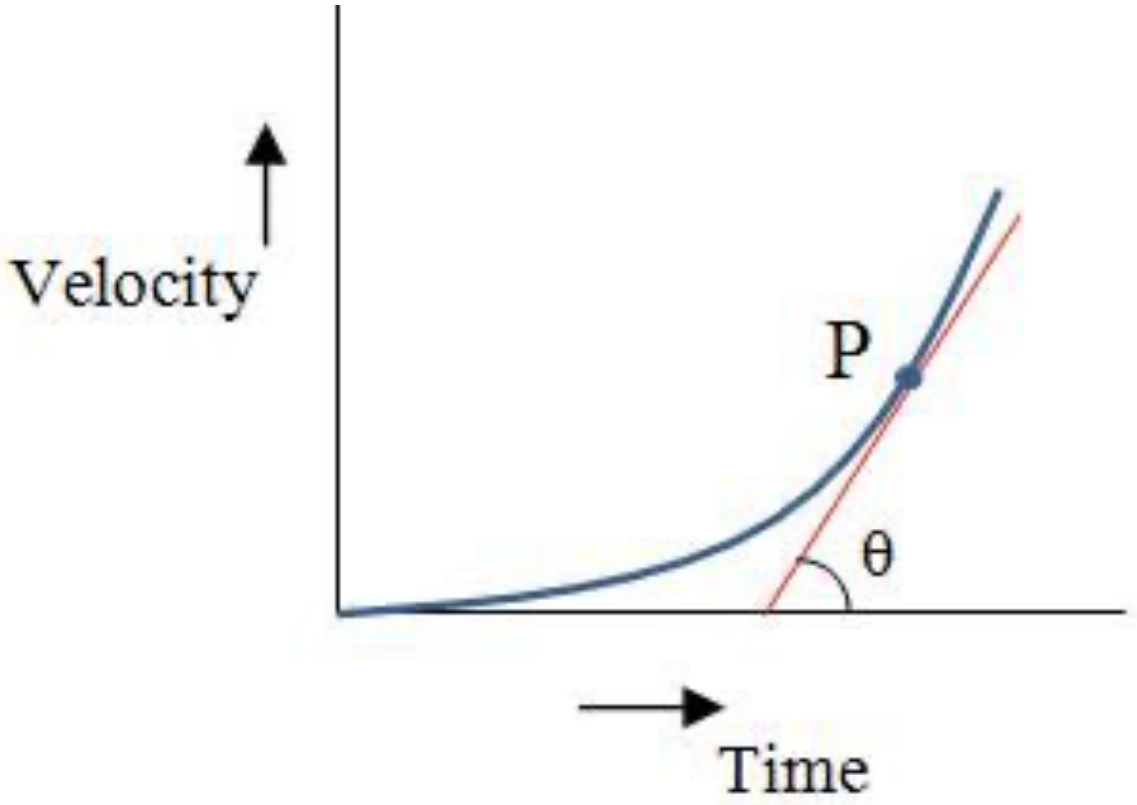
Acceleration

- **Acceleration** is a vector quantity, referring to the rate of change of the velocity of an object with respect to time

$$a = \frac{\Delta v}{\Delta t} = \frac{v_f - v_i}{\Delta t}$$

- Average acceleration: Rate at which velocity changes over a specified time interval. A vector quantity with SI units of m/s^2
- Instantaneous acceleration: Rate at which velocity changes at a specific instant in time. A vector quantity with SI units of m/s^2

Instantaneous acceleration



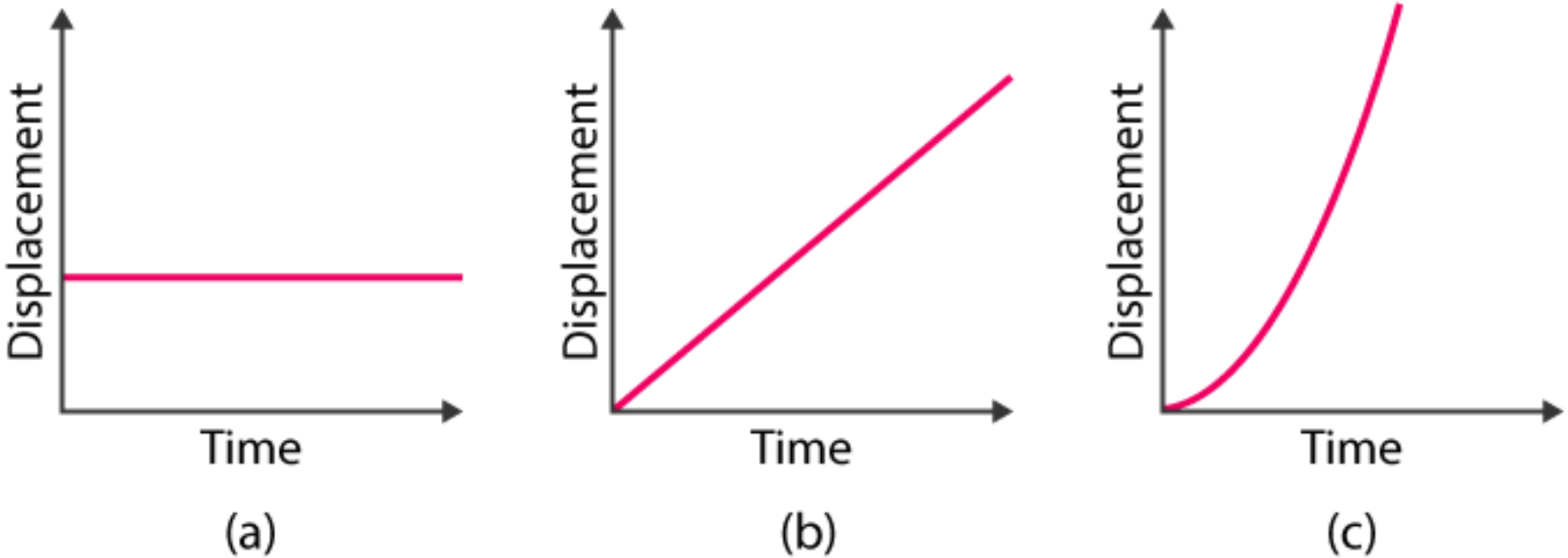
- Instantaneous acceleration is defined as velocity at a specific moment of time

$$\vec{a} = \frac{\vec{v}}{t}$$

- In calculus notation:

$$\vec{a} = \lim_{t \to 0} \frac{\vec{v}}{\Delta t}$$

Motion Diagram – Displacement VS Time

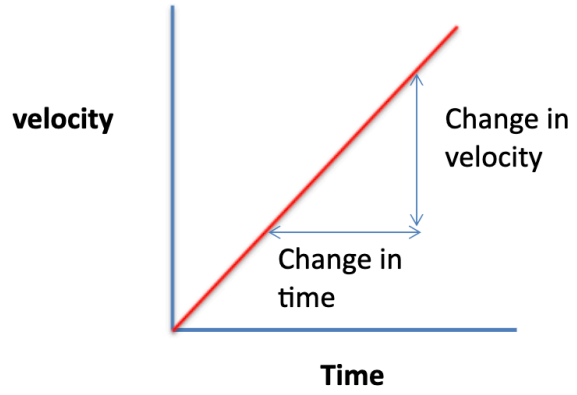


Motion Diagram – Velocity VS Time

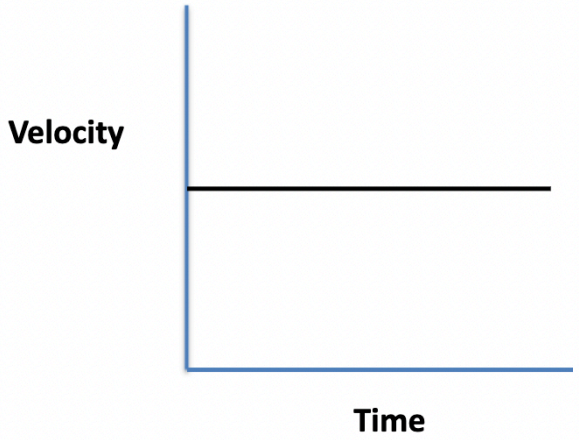
Finding the acceleration

We know that acceleration $= \frac{\text{change in velocity}}{\text{time}}$

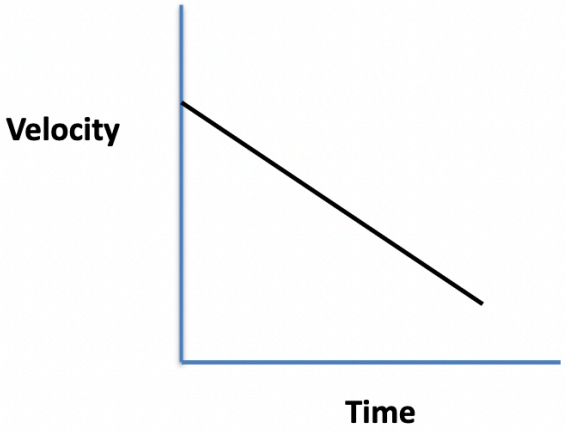
Gradient of a graph $= \frac{\text{change in y values}}{\text{change in x values}}$



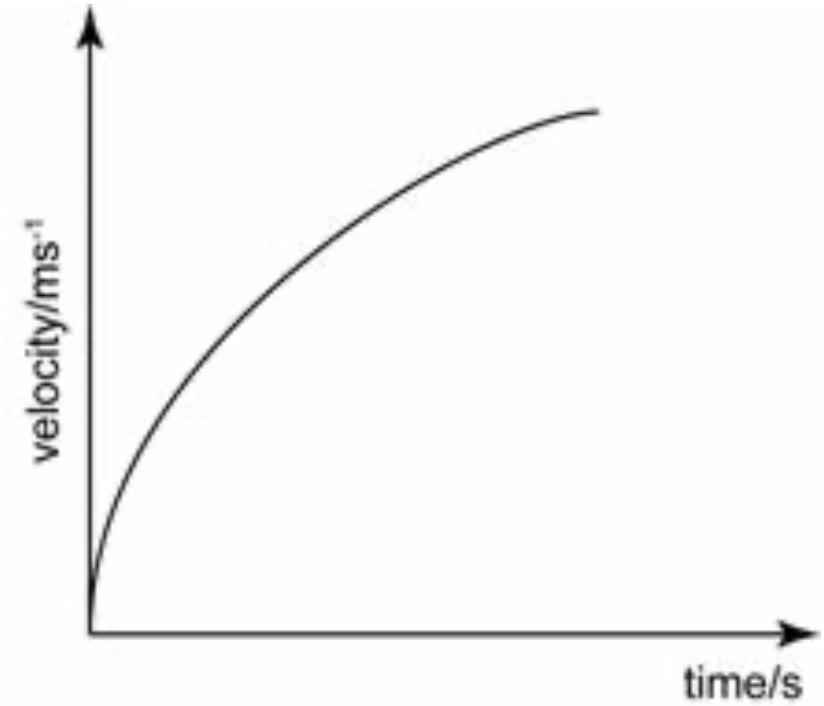
So the gradient of a velocity time graph gives the acceleration

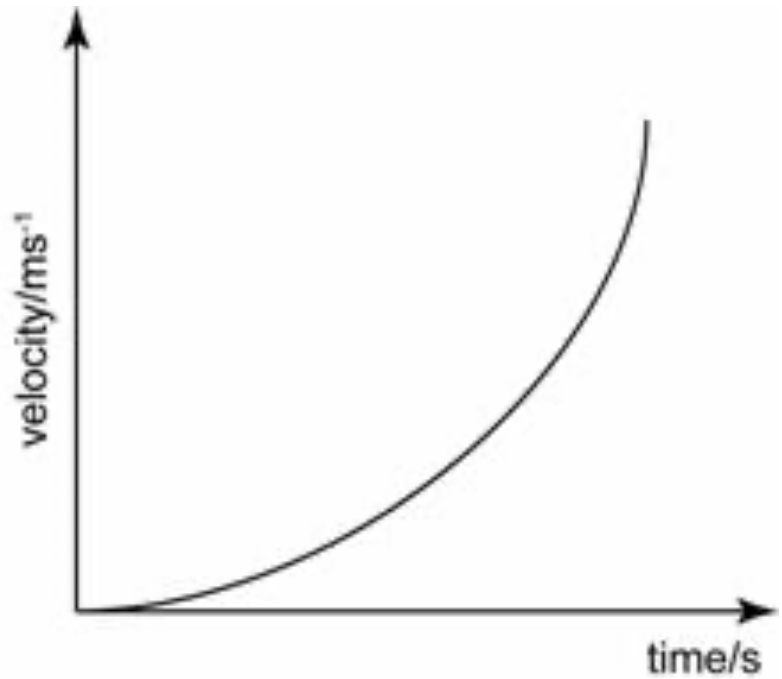


A horizontal line means that the object has a constant (or uniform) velocity.



A negative slope means that the object delerates constantly


velocity/ms-1
time/s

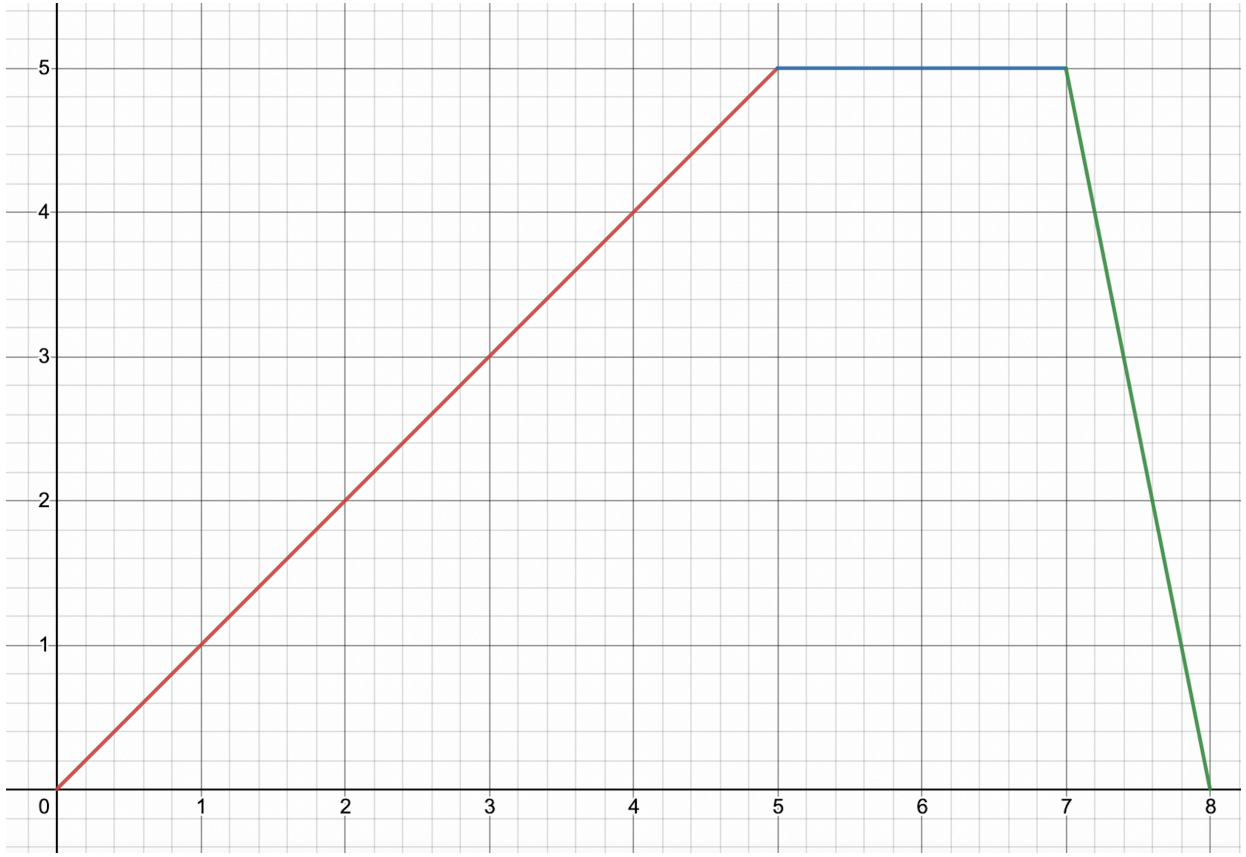

velocity/ms-1
time/s

Velocity Versus Time Graph Summary

- Gradient represents acceleration
- Area under the curve (with negative and positive signs) represents displacement
- Area under the curve (without negative and positive signs) represents diistance

Worked Examle 1

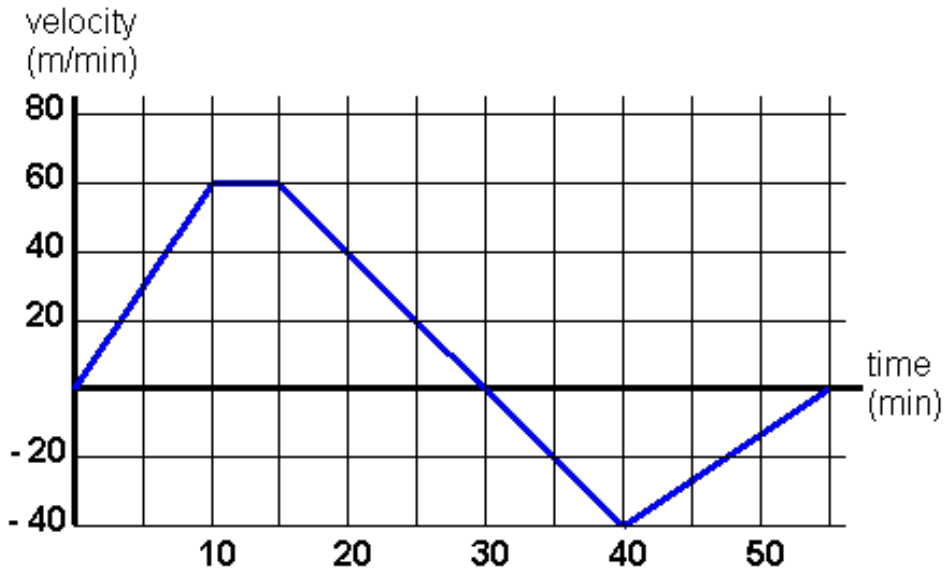
- Calculate the total displacement if the -aixs represent velocity and x-axis represent time



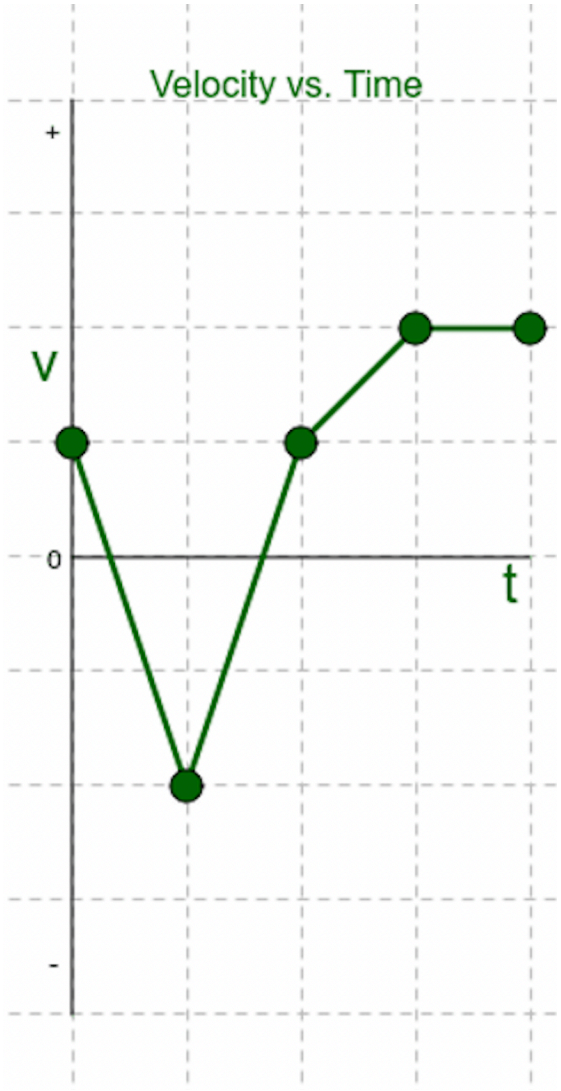
https://www.desmos.com/calculator/tgknfg8biz

Worked Examle 2

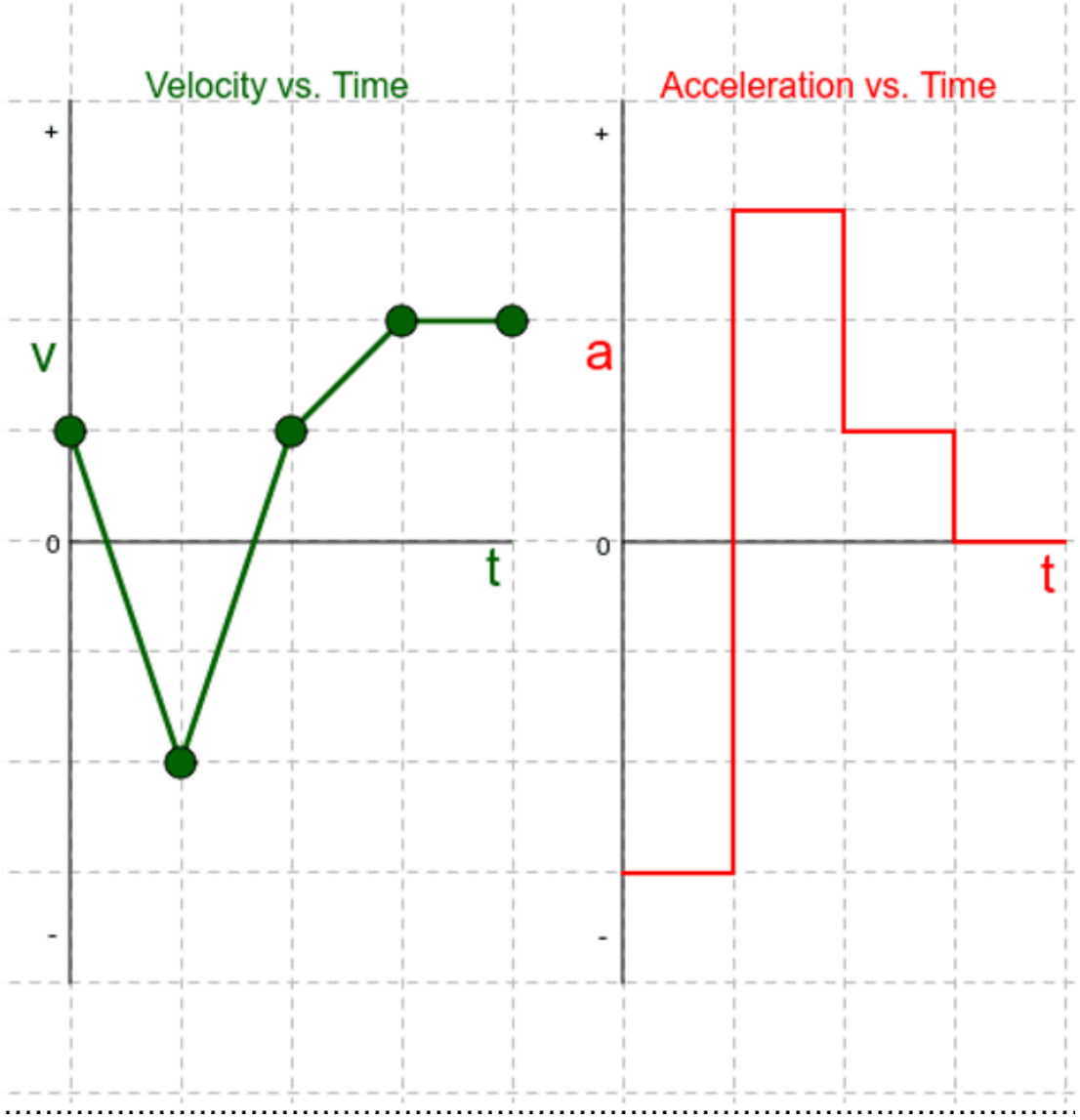
- Calculate the total displacement and distance



Graph Acceleration



Answer



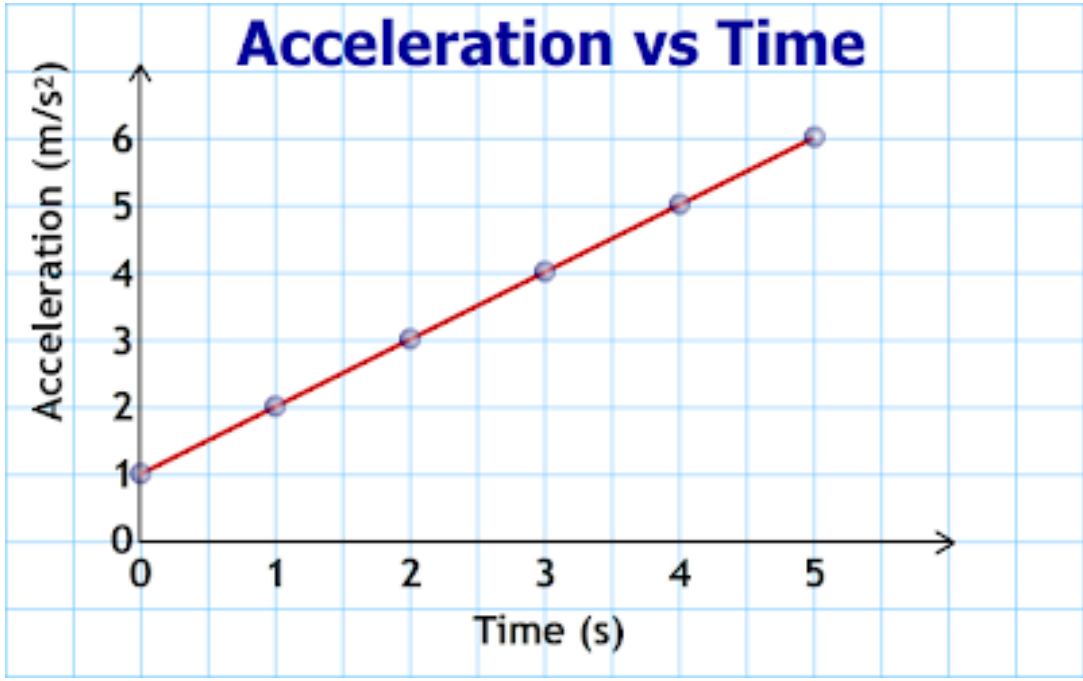
Acceleration Versus Time Graph

- Acceleration vs time graphs tells us about an object's velocity
- Slope/gradient: rate of change of acceleration

$$\text{jerk} = \frac{\Delta a}{\Delta t}$$

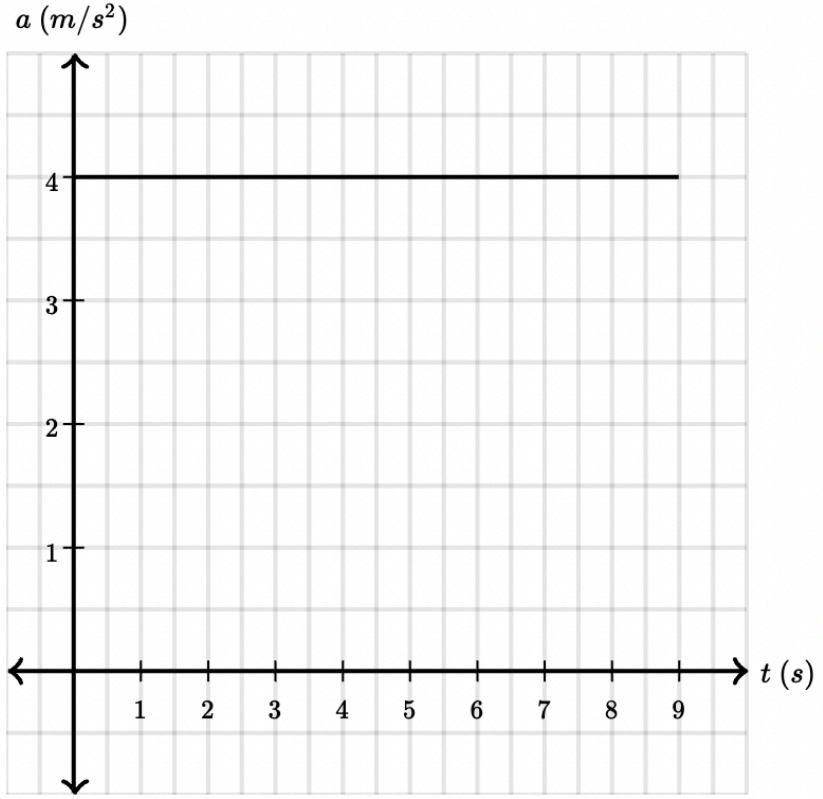
Area under the curve: change in velocity during a time interval.

$$\Delta v = a\Delta t$$

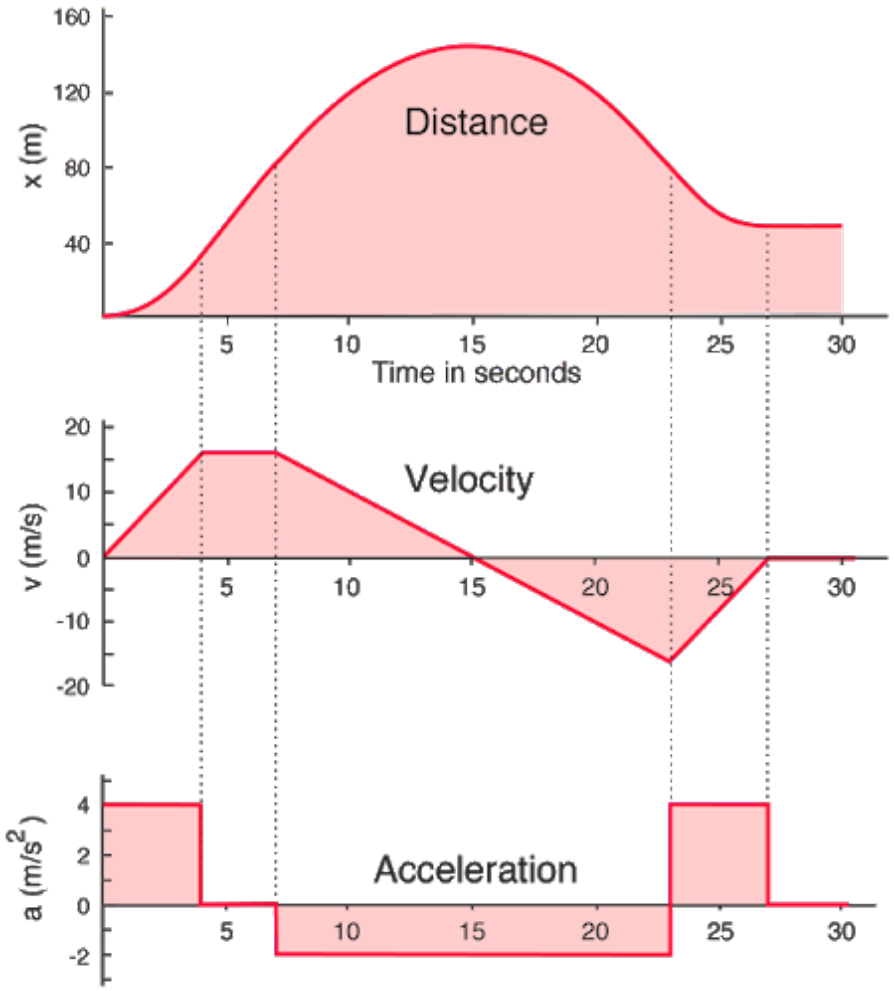


Worked Example

Find the change in velocity and jerk



Diaplcement, Velocity, and Acceleration



- Displacement to velocity: First derivative
- Displacement to acceleration: Second derivation

In Mathematical Expression

Worked Example 1-Calculus

The maximum acceleration attained on the interval $0 \le t \le 3$ by the particle whose velocity is given by $v(t) = t^3 - 3t^2 + 12t + 4$ is

(A) 9 (B) 12 (C) 14 (D) 21 (E) 40

Worked Example2 - Calculus

A particle's position is given by $s = t^3 - 6t^2 + 9t$. What is its acceleration at time $t = 4$?

(A) 0

(B) 9

(C) –9

(D) –12

(E) 12

Kinematics Equation

1. $v = v_0 + at$
2. $\Delta x = (\frac{v + v_0}{2})t$
3. $\Delta x = v_0 t + \frac{1}{2}at^2$
4. $v^2 = v_0^2 + 2a\Delta x$

CONSTANT ACCELERARION

For IB

$$v = u + at \quad [1]$$

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

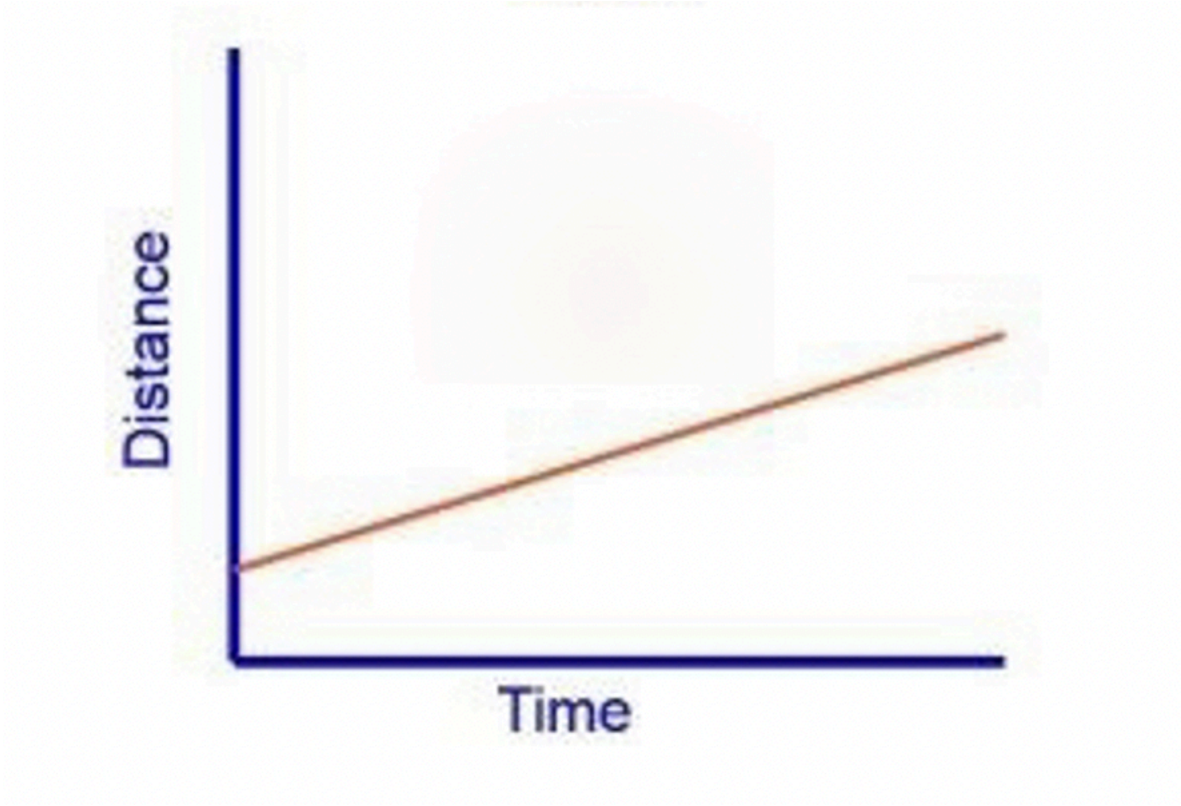
$$s = \frac{1}{2}(u + v)t \quad [3]$$

$$v^2 = u^2 + 2as \quad [4]$$

$$s = vt - \frac{1}{2}at^2 \quad [5]$$

CONSTANT ACCELERARION

Kinematic Equation From Motion Diagram



Worked Example 1

A ball rolls down a 445 m slope from rest. If it accelerates at a rate of 3.16 ms^{-2}, determine the time it takes to reach the bottom of the slope and the ball's final velocity.

Worked Example 2

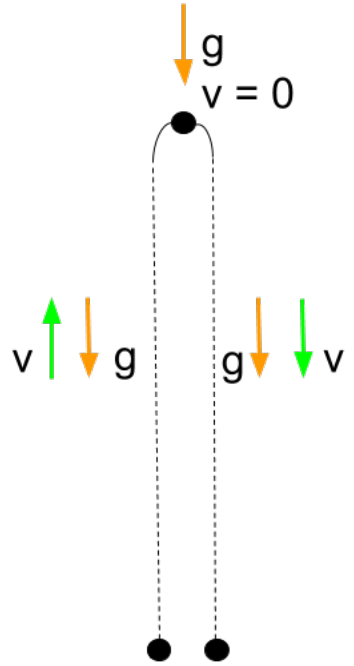
How far does a car travel in 45 seconds if it has an acceleration of 0.32 ms^{-2}? Assume that it starts from rest.

Worked Example 3

A car travels 25.0 km of a 50.0 km trip at an average speed of 40.0 kmh^{-1}. It travels the second half of its journey at an average speed of 80.0 kmh^{-1}. A truck makes the same trip but spends half of its time at an average speed of 40.0 kmh^{-1} and the other half of its time at an average speed of 80.0 kmh^{-1}. Which vehicle got there in the shortest period of time? Show your work.

Free Fall Motion: Properties

- Affected by gravity only
  - Vertical Acceleration
  - Vertical Velocity
  - Horizontal Velocity
  - Vertical Displacement
  - Formula



Worked Example 1

A construction worker accidentally drops a brick from a high scaffold.

a. What is the velocity of the brick after 4.0 s?
b. How far does the brick fall during this time?

Worked Example 2

A tennis ball is thrown straight up with an initial speed of 22.5 m/s. It is caught at the same distance above the ground.

a. How high does the ball rise?
b. How long does the ball remain in the air? *Hint: The time it takes the ball to rise equals the time it takes to fall.*

Worked Example 3

. You decide to flip a coin to determine whether to do your physics or English homework first. The coin is flipped straight up.

a. What is the velocity of the coin at the top of its trajectory?
b. If the coin reaches a high point of 0.25 m above where you released it, what was its initial speed?
c. If you catch it at the same height as you released it, how much time did it spend in the air?

Worked Example 4

. A weather balloon is floating at a constant height above Earth when it releases a pack of instruments. (Level 1)

a. If the pack hits the ground with a downward velocity of −73.5 m/s, how far did the pack fall?
b. Calculate the distance the ball has rolled at the end of 2.2 s.

References

- https://www.google.com.hk/search?q=velocity+to+acceleration+graph&newwindow=1&safe=strict&sxsrf=ALeKk01JJhg2kFuJlwKx1W7s2noB-TiFXg:1618895866606&source=lnms&tbm=isch&sa=X&ved=2ahUKEwj5tbqIiYzwAhWJad4KHW-ACTEQ_AUoAXoECAEQAw&biw=1440&bih=687#imgrc=9d6dZ-ezMEi-QM
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