# Chapter 9 - Kinematics (Constant Acceleration)



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Personal notes:

# 9.1, 9.2 - Displacement-time & Velocity-time graphs

**Notes**

- Two classes of quantities : Scalar and Vector

- Motion of an object can be represented on two types of graphs
  i) Distance-time graph (learnt in GCSE)

  ii) Velocity-time graph

Velocity-time graph

# 9.1, 9.2 - Displacement-time & Velocity-time graphs

Example

A car is moving off from a traffic light and accelerates from rest to a speed of $10ms^{-1}$ in 20s when the lights turn green. The speed is then maintained for 30 seconds.

a) Sketch a velocity-time graph
b) Find the distance travelled.

Example/Practice Q1

An athlete runs along a straight road. She starts from rest and moves with constant acceleration for 5 seconds, reaching a speed of $8ms^{-1}$. This speed is then maintained for *T* seconds. She then decelerates at a constant rate until she stops. She has run a total of 500 m in 75 seconds.
a. Sketch a speed-time graph to illustrate the motion of the athlete.
b. Calculate the value of *T*.

Exam Practice

A racing car starts from rest at the point *A* and moves with constant acceleration of $11ms^{-2}$ for 8 seconds. The velocity it has reached after 8 s ks then maintained for *T* s. The racing car then decelerates from this velocity to $40ms^{-1}$ in a further 2 s, reaching point *B*.

(a) Sketch a velocity-time graph to illustrate the motion of the racing car. Include the top speed of the racing car in your sketch. **(5 marks)**

(b) Given that the distance between *A* and *B* is 1404 m, find the value of *T*. **(3 marks)**

# 9.3 - Suvat formulae 1

Terminologies and Units

Suvat formulae

Example
A particle Q is moving from point A to B with constant acceleration $3ms^{-2}$. Its speed at A is $2ms^{-1}$ and it takes 8 seconds to move from A to B. Find:
a) The speed of particle at B
b) The distance from A to B.

# 9.3 - Suvat formulae 1

Example

A particle moves in a straight line from A to B with constant deceleration $1.5ms^{-2}$. Its speed at A and B is $8ms^{-1}$ and $2ms^{-1}$ respectively. Find:

a) the time taken from A to B

b) the distance from A to B

After reaching B, the particle keeps moving and reach point C. It takes 6 seconds to move from A to C. Find:

c) the velocity of the particle at C

d) the displacement from A to C

Practice Q1

A particle is moving in a straight line with constant acceleration $3ms^{-2}$. At time $t = 0$, the velocity of the particle is $2ms^{-1}$. Find the velocity at time $t = 6$.

Practice Q2

A car is approaching traffic lights. The car is travelling with velocity $10ms^{-1}$. The driver applies the brakes to the car and the car comes to rest with constant deceleration in 16 s. Modelling the car as a particle, find the deceleration of the car.

# 9.4 - Suvat formulae 2

**Notes** (Suvat Formulae)

- $v = u + at$
- $s = \frac{(u+v)t}{2}$
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Example

A particle is moving horizontally from A to B with acceleration $5ms^{-2}$.The particle's velocity at A is $3ms^{-1}$ and at B is $18ms^{-1}$. Find the distance between A and B.

Example

A particle is moving horizontally with constant deceleration $4ms^{-2}$. At time t = 0, particle passes through point O with speed $13ms^{-1}$ is travelling towards point A where OA = 20m.

a) Find the times when the particle passes through A
b) Find the velocities of the particle at A.
c) Find the value of t when the particle returns to O.

# 9.4 - Suvat formulae 2

Practice Q1

A particle moves along a straight line, with constant acceleration, from a point *A* to a point *B* where *AB* = 48 m. At *A* the particle has velocity $4ms^{-1}$ and at *B* it has velocity $16ms^{-1}$. Find:
a) the acceleration of the particle
b) the time the particle takes to move from *A* to *B*.

Exam Practice (M1 May 2013 Q4)

A lorry is moving along a straight horizontal road with constant acceleration. The lorry passes a point *A* with speed $u\ ms^{-1}$ , $(u < 34)$, and 10 seconds later passes a point *B* with speed $34\ ms^{-1}$. Given that *AB* = 240 m, find

(a) the value of $u$, **(3 marks)**

(b) the time taken for the lorry to move from *A* to the mid-point of *AB*. **(6 marks)**

# 9.5 - Vertical motion under gravity

**Notes**

- Famously, when the Apollo 15 landed on the moon, astronaut David Scott conducted a famous demonstration in which a hammer and feather were released at the same time. As anticipated, they hit the ground at the same time!

- If there is **no air resistance**, then the **acceleration** of objects under gravity, regardless of mass, **is constant**.

- Acceleration due to gravity ($g\ ms^{-2}$) =

Example

A ball B is projected upwards from a point O with speed $12ms^{-1}$. Find

a) the greatest height B can reach
b) The total time before B returns to O

Example

A particle is projected vertically upwards from a point O with speed $\boldsymbol{u}\ ms^{-1}$. The greatest height reached by the particle is 62.5m above O. Find

a) The value of $\boldsymbol{u}$.
b) Total time for which the particle is 50m above O.

# 9.5 - Vertical motion under gravity

Summary about signs of suvat - positive or negative?

Practice Q1

A ball is projected upwards vertically with speed $24ms^{-1}$. Find:
(a) the greatest height above the point of projection reached by the ball
(b) the time taken to reach this height
(c) the times that the ball is 10m above the point of projection.

Exam Practice

A ball is thrown vertically upwards with speed $u\ ms^{-1}$ from a point *P* at height *h* metres above the ground. The ball hits the ground 0.75 s later. The speed of the ball immediately before it hits the ground is $6.45ms^{-1}$. The ball is modelled as a particle.

(a) Show that $u = 0.9$ **(3 marks)**
(b) Find the height above *P* to which the ball rises before it starts to fall towards the ground again. **(2 marks)**
(c) Find the value of *h*. **(3 marks)**