REPRESENTING AND MEASURING MOTION

Motion is movement, thus it is technical to measure. Parameters to consider, to be able to measure motion are position, distance and displacement, speed and velocity, and acceleration.

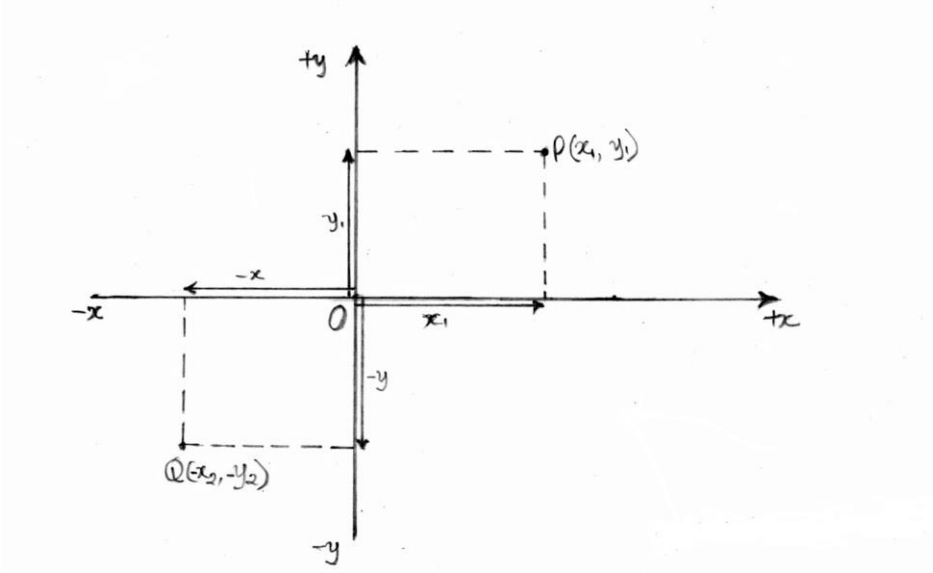
Position

The position of a point (or object) in space is determined by its distance and direction from other points. The statement of position is accompanied by means of a frame of reference or a point of reference, which is called origin.

In order to locate the position of a point in a plane (such as paper), it is customary to draw two lines intersecting at an origin *O* and perpendicular to each other. The horizontal line going across the left to right of the page is called the *x-axis* and the vertical line going up the page is the *y-axis*. By convention, points to the right of *O* are positive, points to the left are negative, points above *O* are positive, and point below *O* are negative. The position of any point such as P is

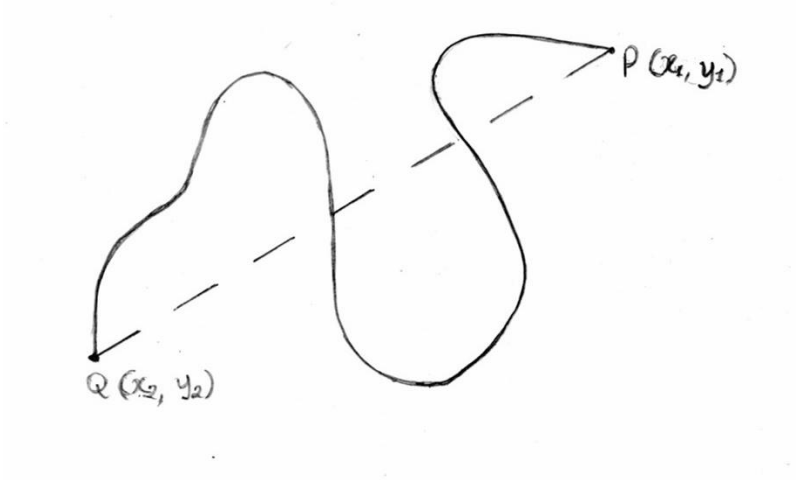
specified by two quantities or *coordinates*, the x and the y coordinates. If the position P is specified by the coordinates (x_1, y_1) it means that the distance of P from *O* in the x-direction or axis is x_1 and in the y-direction or axis, it is y_1.

The x-coordinate is called the *abscissa,* and the y-coordinate is called the *ordinate*.



Distance and Displacement

Distance is the space between two points. However, in Physics, distance is the space or ground an object has travelled. Consider the example below:



From the example above, you would notice two lines PQ; one is a broken line and the other is not. The non-broken line represents the distance travelled from P to Q. However the broken line represents the displacement. Displacement is a kind of distance. It is the distance travelled in one *direction*.

Distance can be measured in Physics with rule, tape, theodolite, rope, etc. The formula for calculating

the displacement between two points is a function of the coordinates of two points:

$$Displacement\ (or\ Distance) = \sqrt{(y_2 - y_1)^2 + (x_2 - x_1)^2}$$

The SI unit for measuring distance is metres. However, there are other units; they are foot, furlongs, yard, mile, etc.

Speed and Velocity

In measuring motion (which is the change of position of an object), distance and time are very important. The physical concept or quantity that relates distance with time is speed. We can say that speed is the rate of change of distance with time. Mathematically:

$$Speed\ (v) = \frac{Distance}{time} = \frac{s}{t}$$

Velocity is same as speed, only that it has a specific direction. As such, it is velocity that compares displacement with time while speed compares distance with time.

$$Velocity\ (v) = \frac{Displacement}{time} = \frac{s}{t}$$

Velocity (or speed) is measured with speedometer.

Acceleration

Acceleration is defined as the rate of change of velocity with time. Its unit is metre-per-second-per-second or metre-per-seconds-square (m/s^2 or $m.s^{-2}$).

$$Acceleration\ (a) = \frac{Velocity}{time} = \frac{v}{t}$$

Note acceleration only compares velocity with time. It does compare speed with time.

Retardation is the opposite of acceleration. Mathematically it is $-a$. The sign represents decrement in velocity.

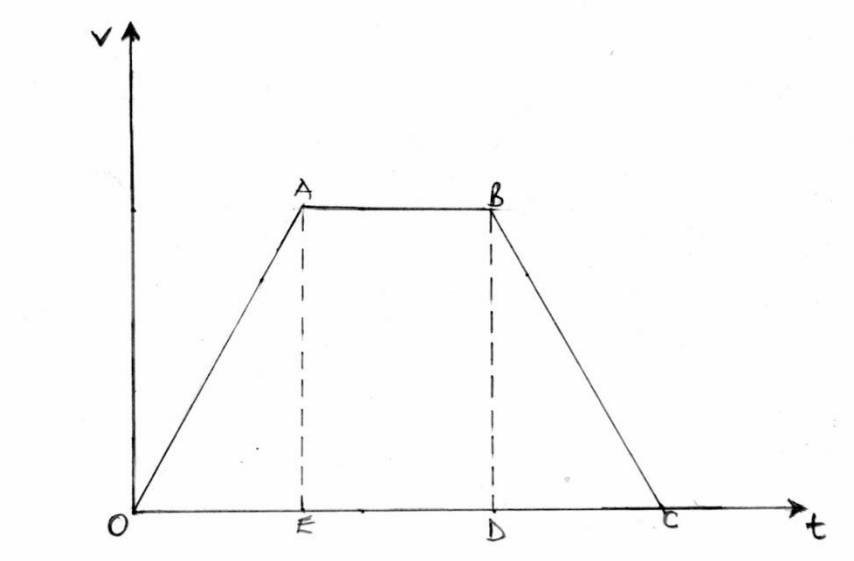
$$Retardation\ (r) = \frac{-velocity\ change}{time\ taken}$$

When a body is travelling at uniform velocity, the acceleration over such period is equal to zero (0).

Uniform acceleration is defined as the motion of an object whose velocity increases in equal amounts in equal intervals of time.

Uniform deceleration means that the velocity decreases by equal amounts in equal time intervals.

Acceleration and deceleration can be represented graphically in a *velocity-time graph*. We obtain the total distance travelled in a velocity-time graph by simplifying the area covered by the graph to the horizontal (time) axis.



$$S_1 = \frac{1}{2} \times OE \times AE = area\ of\ triangle\ OAE$$

$$S_2 = AE \times ED = area\ of\ rectangle\ ABDE$$

$$S_3 = \frac{1}{2} \times DC \times BD = area\ of\ triangle\ BDC$$

The total distance covered by the object during the time interval OC is given by

$$S = S_1 + S_2 + S_3$$

The total distance can also be obtained by finding the area of the trapezium OABC. This is given by:

$$S = \frac{1}{2}(sum\ of\ parallels) \times height$$

$$S = \frac{1}{2}(AB + OC) \times AE$$