Description of Motion

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Contents

- Distance / displacement
- Speed / velocity
- Instantaneous speed
- Acceleration
- Rectilinear equations of motion
- Fall under gravity
- Projectile motion

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Description of Motion

- Motion is part of us, we experience it and we see it all the time

- Galactic motion
- planetary motion
- Motion of everyday objects
- Motion of blood in our bodies
- Molecular motion etc

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The study of motion is called mechanics.

Divided into two categories:

1. Kinematics
2. Dynamics

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Kinematics

→ Kinematics – Study of motion without regard to what caused the motion.

→ Dynamics – Study of motion including what caused the motion – Force, energy

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- To study motion we first need to understand.

position

displacement

distance

Speed

Velocity

acceleration

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Position

- location of an object with respect to a chosen reference point.
- The motion of an object is completely known if the objects position is known in space.

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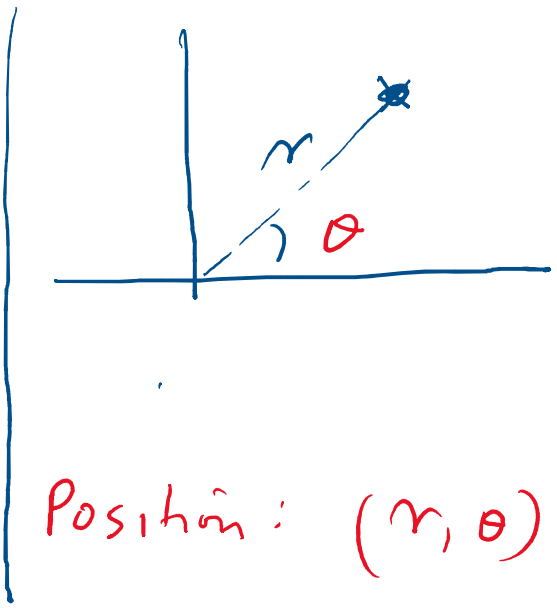
Position : (x, y, z)



Position : (r, θ)

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Distance & Displacement

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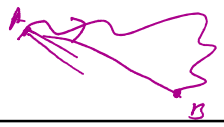
To differentiate speed from velocity we need to first understand distance & displacement:

- Distance — Scalar
- Displacement — Vector quantity

Displacement — How far the object is from the starting point



$\vec{d}$. $\Delta s = x_f - x_0$

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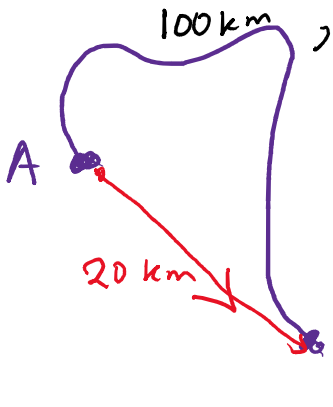
Consider a car travelling around the curve as shown.



a) average speed b) average velocity

av. Speed = $\frac{\text{Actual distance}}{\text{time taken}} = \frac{100 \text{ km}}{2 \text{ h}}$

= 50 km/hr

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average velocity $\vec{v}$

$= \frac{\text{displacement}}{\text{time}}$

$= \frac{20 \text{ km}}{2 \text{ h}} = 10 \text{ km/hr}$

in the South easterly dir.

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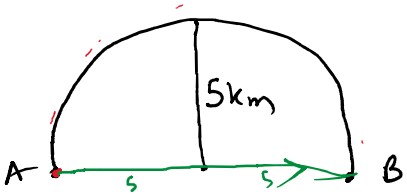
What is the average velocity & average speed of the car that travels the semi circular path as shown, if it takes 2 hrs to reach point B.



av. speed, av. velocity

$$\text{av. speed} = \frac{\text{act. dist.}}{\text{time}} = \frac{\frac{1}{2}2\pi R}{2} = \frac{\pi(5)}{2} = 7.9\ \frac{km}{hr}$$

$$\text{av. vel} = \bar{v} = \frac{\text{disp}}{\text{time}} = \frac{10\ km}{2\ hr} = 5\ km/h\ ,E$$

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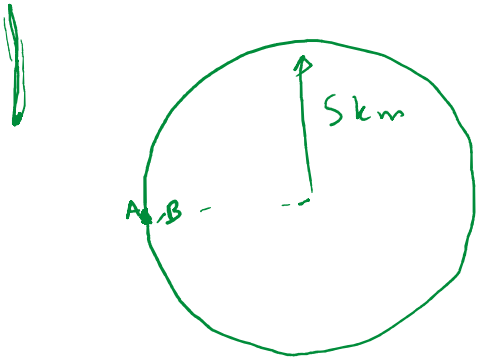

$\bar{v} = 0$

4 hr

$$\text{Av speed} = \frac{2\pi r}{T} = \frac{2\pi(5)}{4} = \frac{10\pi}{4} = \frac{5\pi}{2}\ km/h$$

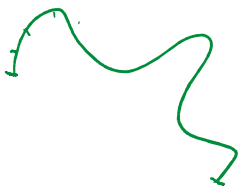

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FIGURE 2–8 Car speedometer showing mi/h in white, and km/h

Speed
or
Velocity
or
both
or
nor

displacement $= \Delta x = x_f - x_0$

average Velocity $=$ $\frac{\text{displacement}}{\text{time}}$

$\bar{v} = s/t$: $s = \bar{v}t$

$\bar{v} = \left(\frac{u+v}{2}\right)$: $s = \left(\frac{u+v}{2}\right)t$

FIGURE 2–8 Car speedometer showing mi/h in white, and km/h

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Instantaneous ~~Velocity~~ Speed

If you drive a car 100 km along straight road in one direction for 2 h, the average ~~velocity~~ speed $= 100/2 = 50$ km/h.

It is unlikely that you were travelling at 50 km/h.

- Instantaneous speed — speed/velo at a instant of time.

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Acceleration.

- Change of Speed (velocity)
- speeds up ↓ acceleration
- slows down ↓ deceleration

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Acceleration

- Suppose at a certain instant an object has velocity u, & its velocity a later time t is v,

$$\text{acc} = \frac{\text{final vel} - \text{initial v}}{\text{time taken}}$$

$$a = \frac{v - u}{t} \quad (\text{vel})$$

$m/s / s = (m/s^2)$

acceleration is the change of ~~speed~~/vel per unit time.

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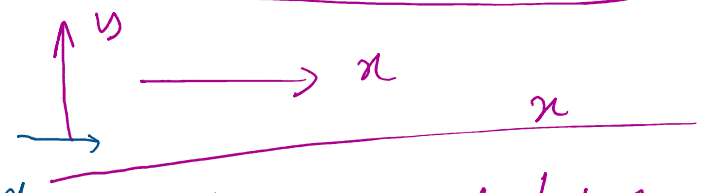
$$a = \frac{\Delta v}{\Delta t} = \frac{dv}{dt}$$

$$\Delta V = V_f - V_i$$
$$\Delta L = L_f - L_i$$
$$\Delta t = t_f - t_i$$
$$t - 0$$



s = displacement / distance
t = time take
u = initial velocity
v = final velocity
a = acceleration

a = acceleration
for free fall
$a = g = 9.8 m/s^2$

$$a = \frac{v-u}{t} \Rightarrow$$

$$v = u + at$$
$$s = ut + \frac{1}{2}at^2$$
$$v^2 = u^2 + 2as$$
$$\bar{v} = \frac{u+v}{2}$$
$$s = \bar{v}t$$
$$s = \left(\frac{u+v}{2}\right)t$$

Question or Statement	Translation
When	What value of t?
Where	What value of position x?, y? or z?
Starts from rest	Initial velocity, $u = 0$
How fast	What is the value of v?
How long does it take	What is Δt $[\Delta t = t_f - t_i]$
How far	What is the displ. or what is the value of $x_f - x_0$ or $y_f - y_0$
Comes to rest	final velocity is zero

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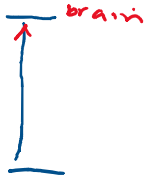
BIO The speed of a nerve impulse in the human body is about 100 m/s. If you accidentally stub your toe in the dark, estimate the time it takes the nerve impulse to travel to your brain.

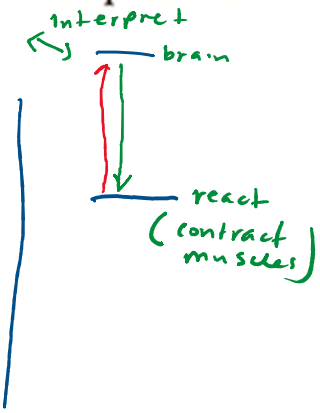
Assumptions: $h = 1.7$ m



Speed $= d/t$

$t = d/v = \frac{1.7}{100}$

$= 0.017 \approx 17$ ms



17 ms x 2

$= 34$ ms

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Ex A car accelerates uniformly from stop with a rate of 6.1 m/s². Find its speed after 0.82 second?

Data: $a = 6.1\ m/s^2$, $t = 0.82\ s$, $u = 0$, v ?

$v = u + at$

$= 0 + (6.1)(0.82)$

$= 5.00\ m/s$.

What is the distance travelled during the acc.

$t = 0.82s$, S u, v:

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

$= 0 + \frac{1}{2}(6.1)(0.82)^2$

$= 2.05m$

$S = \bar{v}t$

but $\bar{v} = \frac{u+v}{2}$

$= \frac{0+5}{2} = 2.5$

$S = (2.5)(0.82)$

$= 2.05\ m$