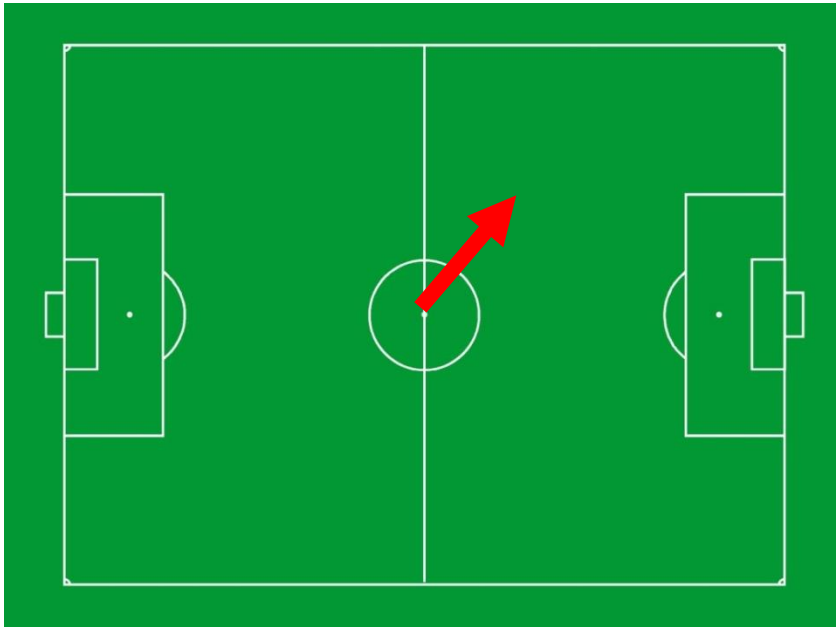
Displacement

- **Displacement** the distance moved in a stated direction (the distance and direction from the starting point). A VECTOR

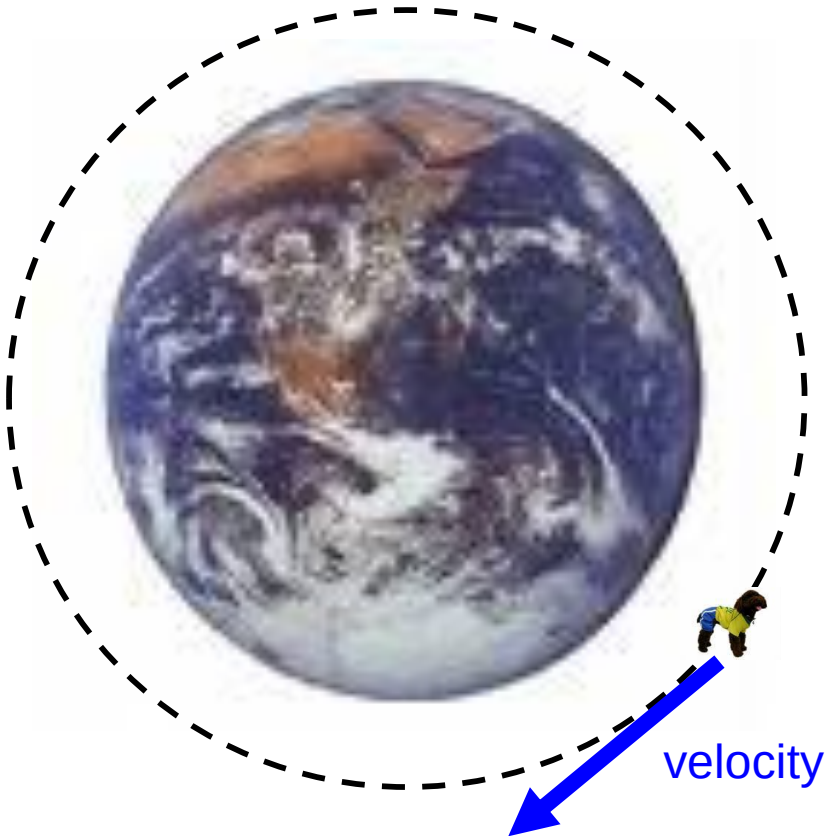


Velocity?

- **Velocity** is the rate of change of displacement. Also a VECTOR

An interesting example

We have constant speed but changing velocity.

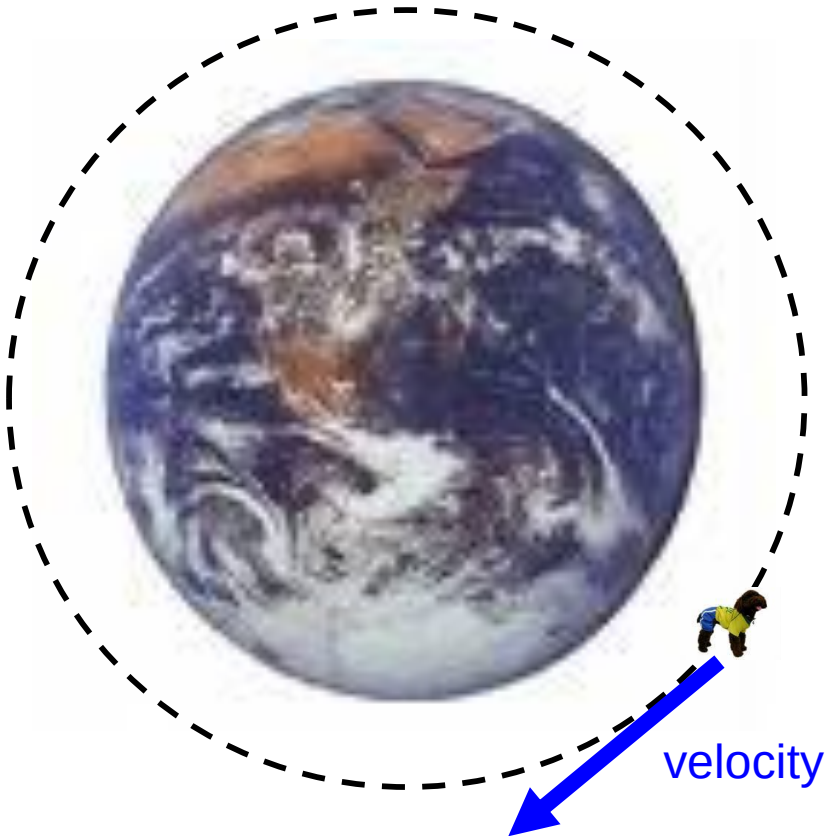


Acceleration?

- **Acceleration** is the rate of change of velocity. Also a VECTOR

An interesting example

We have constant speed but changing velocity.



Of course a changing velocity means it must be accelerating!

Average speed/velocity?

- **Average speed/velocity is** change in distance/displacement divided by time taken over a period of time.

Instantaneous speed/velocity?

- **Instantaneous speed/velocity** is the change in distance/displacement divided by time at one particular time.

The equations of motion

- The **equations of motion** can be used when an object is accelerating at a steady rate
- There are four equations relating five quantities

u initial velocity, **v** final velocity,

s displacement, **a** acceleration, **t** time

SUVAT equations

The four equations

1	$v = u + at$	This is a re-arrangement of $a = \frac{v - u}{t}$
2	$s = \frac{1}{2}(v + u)t$	This says displacement = average velocity x time
3	$s = ut + \frac{1}{2}at^2$	With zero acceleration, this becomes displacement = velocity x time
4	$v^2 = u^2 + 2as$	Useful when you don't know the time

Beware!

- All quantities are vectors.
- These equations are normally done in one dimension, so a negative result means displacement/velocity/acceleration in the opposite direction.

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v = u + at

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u = 10 ms^{-1} v = 0 ms^{-1} a = -2 ms^{-2} t = ? s

v = u + at

0 = 10 + -2t

2t = 10

t = 5 seconds

Example 2

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

$0^2 = 10^2 + 2x\text{-}2s$

$0 = 100 - 4s$

$4s = 100$

$s = 25m$, the car does not hit Jack. ☹

Example 3

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$u = 24\ m.s^{-1}$ $a = -9.8\ m.s^{-2}$ $v = 12\ m.s^{-1}$

$t = ?$

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- When is the velocity of the ball 12 $m.s^{-1}$?

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- When is the velocity of the ball 12 $m.s^{-1}$?

$u = 24\ m.s^{-1}$ $a = -9.8\ m.s^{-2}$ $v = 12\ m.s^{-1}$

$v = u + at$

$12 = 24 + -9.8t$

$-12 = -9.8t$

$t = 12/9.8 = 1.2$ seconds

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- When is the velocity of the ball -12 $m.s^{-1}$?

u = 24 $m.s^{-1}$ a = -9.8 $m.s^{-2}$ v = -12 $m.s^{-1}$

v = u + at

-12 = 24 + -9.8t

-36 = -9.8t

t = 36/9.8 = 3.7 seconds

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t = 1.2, v = 12, a = -9.8, u = 24 s = ?

$s = ut + \frac{1}{2}at^2 = 24x1.2 + \frac{1}{2}x\text{-}9.8x1.2^2$

$s = 28.8 – 7.056 = \underline{21.7\ m}$

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- A ball is thrown upwards with a velocity of 24 $m.s^{-1}$.
- What is the displacement of the ball at those times? (t = 1.2, 3.7)

t = 3.7, v = 12, a = -9.8, u = 24 s = ?

$s = ut + \frac{1}{2}at^2 = 24x3.7 + \frac{1}{2}x\text{-}9.8x3.7^2$

s = 88.8 – 67.081 = 21.7 m (the same?!)

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- What is the velocity of the ball 1.50 s after launch?

u = 24, t = 1.50, a = -9.8, v = ?

v = u + at

v = 24 + -9.8x1.50 = <u>9.3 $m.s^{-1}$</u>

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u = 24, a = -9.8, $\underline{v = 0}$, s = ?

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

$0 = 242 + 2x\text{-}9.8xs$

$0 = 242 - 19.6s$

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- What is the maximum height reached by the ball?

u = 24, a = -9.8, v = 0, s = ?

0 = 242 -19.6s

19.6s = 242

s = 242/19.6 = 12.3 m