Maths for A Level Physics

Study Guide

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Mini Course

Maths for A Level Physics

This study guide contains all the Worked Example questions for the Mini Course. Watch videos with full worked solutions at ALevelPhysicsOnline.com/**maths-for-a-level-physics**

Numbers and Units

Equations

Graphs

Circles and Triangles

Logs

Standard Form

Theory:

$$300\ 000\ 000 = 3.00 \times 10^8$$

↑

$1 \leq n < 10$

Worked Examples:

A Write the following numbers in **standard form**:

a. 8 990 000 000

b. 299 790 000

c. 96 485

B Write the following numbers in **standard form**:

a. 0.002 90

b. 0.000 000 000 008 85

c. 0.000 000 000 000 000 000 000 000 000 000 911

C **Calculate** the following:

a. $2.5 \times 10^6 \quad \times \quad 3.0 \times 10^4$

b. $6.30 \times 10^4 \quad \times \quad 1.10 \times 10^{-2}$

c. $5.6 \times 10^4 \quad \div \quad 2.0 \times 10^{-2}$

Significant Figures

Theory:

0.004 560 — 4 s.f

Leading zeroes don't count

Trailing zeroes add to the significance

5600 — 4 s.f

Worked Examples:

A State the number of **significant figures** in the following:

a. 1.667

b. 0.000 082 080

c. 1 500 000

d. 1.50×10^3

B Calculate the following to an **appropriate** number of **significant figures**:

a. 30 + 50

b. 30.1 ÷ 49.97

c. 30.0 + 50.0

d. 30 x 49.97

C Calculate the **acceleration** of a ball that starts at rest and reaches a velocity of 7.823 ms^{-1} in 0.81 seconds.

Units and Prefixes

Theory:

f	p	n	μ	m	k	M	G	T
10^{-15}	10^{-12}	10^{-9}	10^{-6}	10^{-3}	10^{3}	10^{6}	10^{9}	10^{12}

Worked Examples:

A Write the following data with an appropriate **prefix**:

a. 17 200 W

b. 0.000 000 000 000 003 m

c. 750 000 000 000 J

d. 0.000 000 620 s

B Calculate the following, giving your answer in **SI units** with no prefixes.

a. The volume of a 330 ml Coke can

b. The area of a 30 SWG wire with a diameter of 0.31 mm

C Calculate the following, giving your answer in **SI units** with no prefixes.

a. The resistance of a component with 20 mV across it and a current of 12.5 μA through it

b. The density of a 26 g pebble with a volume of 10 cm^3

Converting Between Units

Theory:

$1 \text{ eV} = 1.60 \times 10^{-19} \text{ J}$

Many quantities have common alternative units

Worked Examples:

A Convert the following:

a. 3.6 eV to J

b. 8.2 MeV to J

c. 2.7×10^{-19} J to eV

B Convert the following:

a. 70 mph to m s^{-1}

b. 14.6 kWh to J

c. 3.5 TeV to kWh

C Convert the following:

a. 39.5 astronomical units to light years

b. 1.3 parsecs to light years

c. 1.2×10^{6} astronomical units to megaparsecs

1 mile = 1609 m

1 AU = 1.50×10^{11} m

1 ly = 9.46×10^{15} m

1 pc = 3.06×10^{16} m

Rearranging Equations

Theory:

Make ***a*** the subject of $v^2 = u^2 + 2as$

Do the same to both sides

$-u^2$

$v^2 - u^2 = 2as$

$\div 2s$

$$\frac{v^2 - u^2}{2s} = a$$

Neaten up

$$a = \frac{v^2 - u^2}{2s}$$

Worked Examples:

A Rearrange $v^2 = u^2 + 2as$ to make ***u*** the subject.

B Rearrange the following to make **ω** the subject:

a. $P = T\omega$

b. $v_{max} = \omega a$

c. $F = m\omega^2 r$

d. $E_k = ½I\omega^2$

C Rearrange the following to make **λ** the subject:

a. $v = f\lambda$

b. $d \sin\theta = n\lambda$

c. $w = \lambda D / s$

d. $\theta = \lambda / D$

Combining Equations

Theory:

Make **v** the subject if $E_k = \frac{1}{2}mv^2$ and $E_p = mgh$

Equate the two

$E_K = E_p$ $\quad \frac{1}{2}mv^2 = mgh$

Simplify and rearrange

$\frac{1}{2}\cancel{m}v^2 = \cancel{m}gh$ $\quad v = \sqrt{2gh}$

Worked Examples:

A Combine the equations $F = \frac{mv^2}{r}$ and $F = BQv$, then make '**r**' the subject.

B Combine the equations $F = \frac{mv^2}{r}$ and $F = \frac{GMm}{r^2}$, then make '**v**' the subject.

C Combine the equations $E = \frac{1}{2}mv^2$ and $E = \frac{GMm}{r}$, then make '**v**' the subject.

Ratios

Theory:

Plenty of examples of these can be found in real past exam paper questions

Worked Examples:

A Two wires carry different currents for different amounts of time.

Wire A carries 2.0 A for 5.0 s, wire B carries 3.0 A for 2.0 s.

Calculate the **ratio** of the total **charge** that flows through wire A to that through wire B.

B Two objects P (2.0 kg) and Q (4.0 kg) stick together after colliding.

P was initially moving at 3.0 m s^{-1} and Q was stationary.

Calculate the **ratio** of the **final velocity** of the system to P's initial velocity.

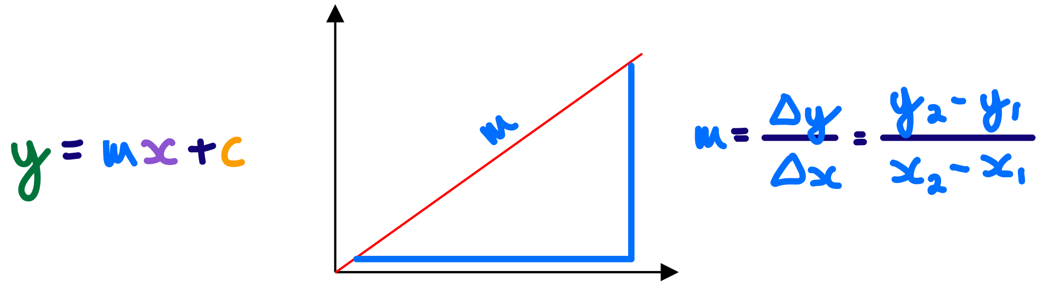
C Two identical satellites, A and B, are in circular orbits around the same planet. Satellite A orbits at a radius of 2.0×10^7 m and satellite B orbits at a radius of 4.0×10^7 m.

Calculate the **ratio** of their **kinetic energies** $\frac{KE_A}{KE_B}$.

$$v = \sqrt{\frac{GM}{r}}$$

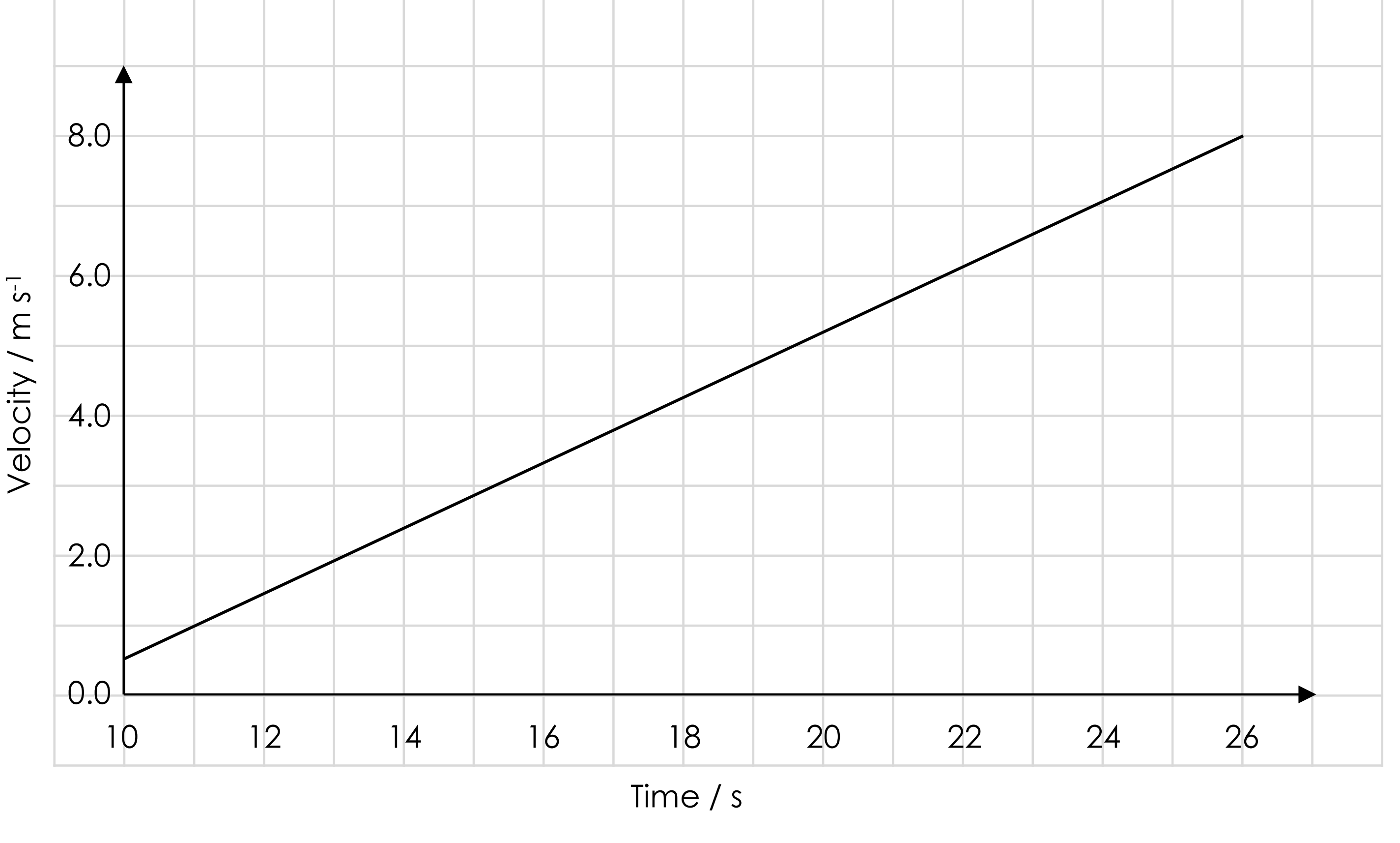
Gradients

Theory:

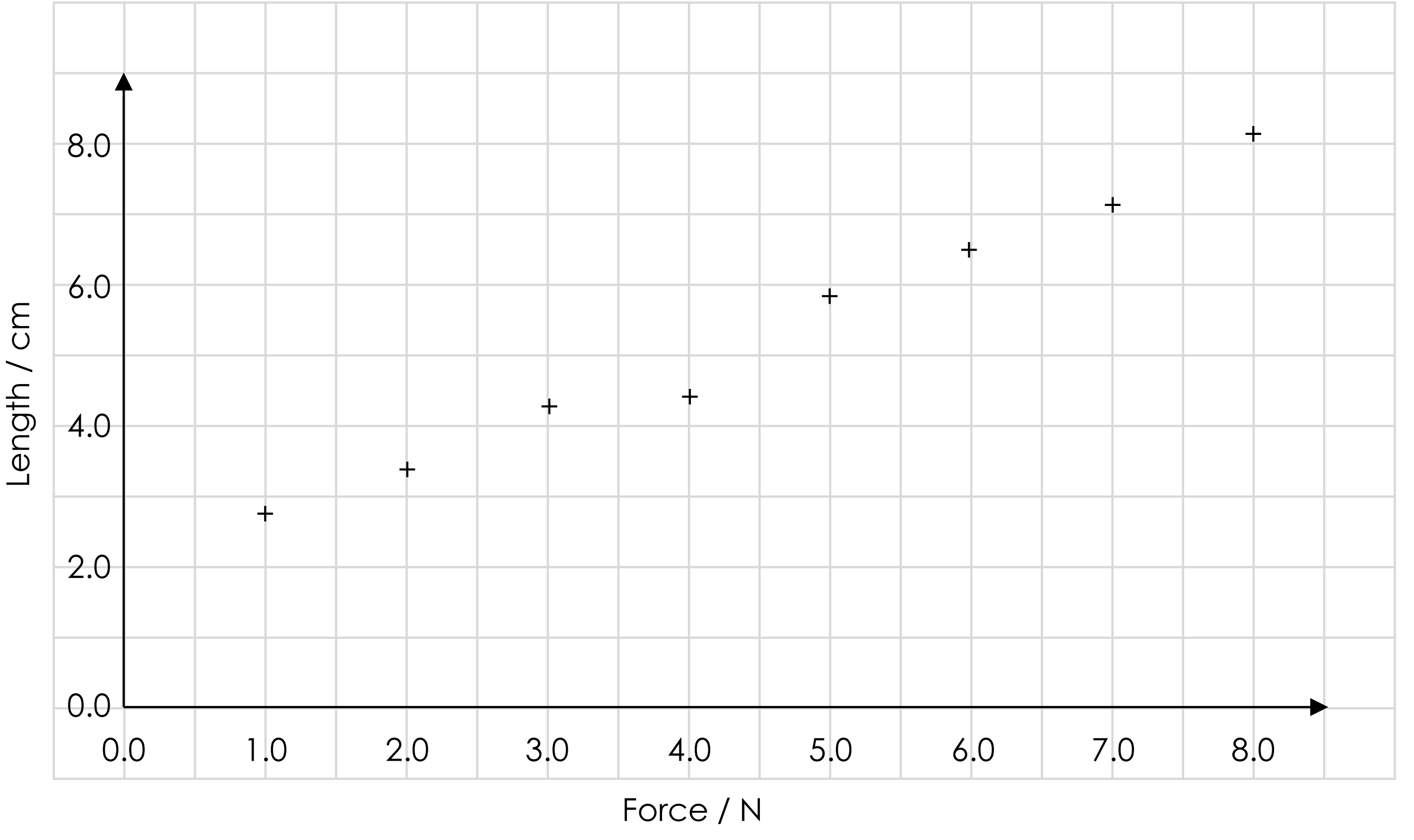


Worked Examples:

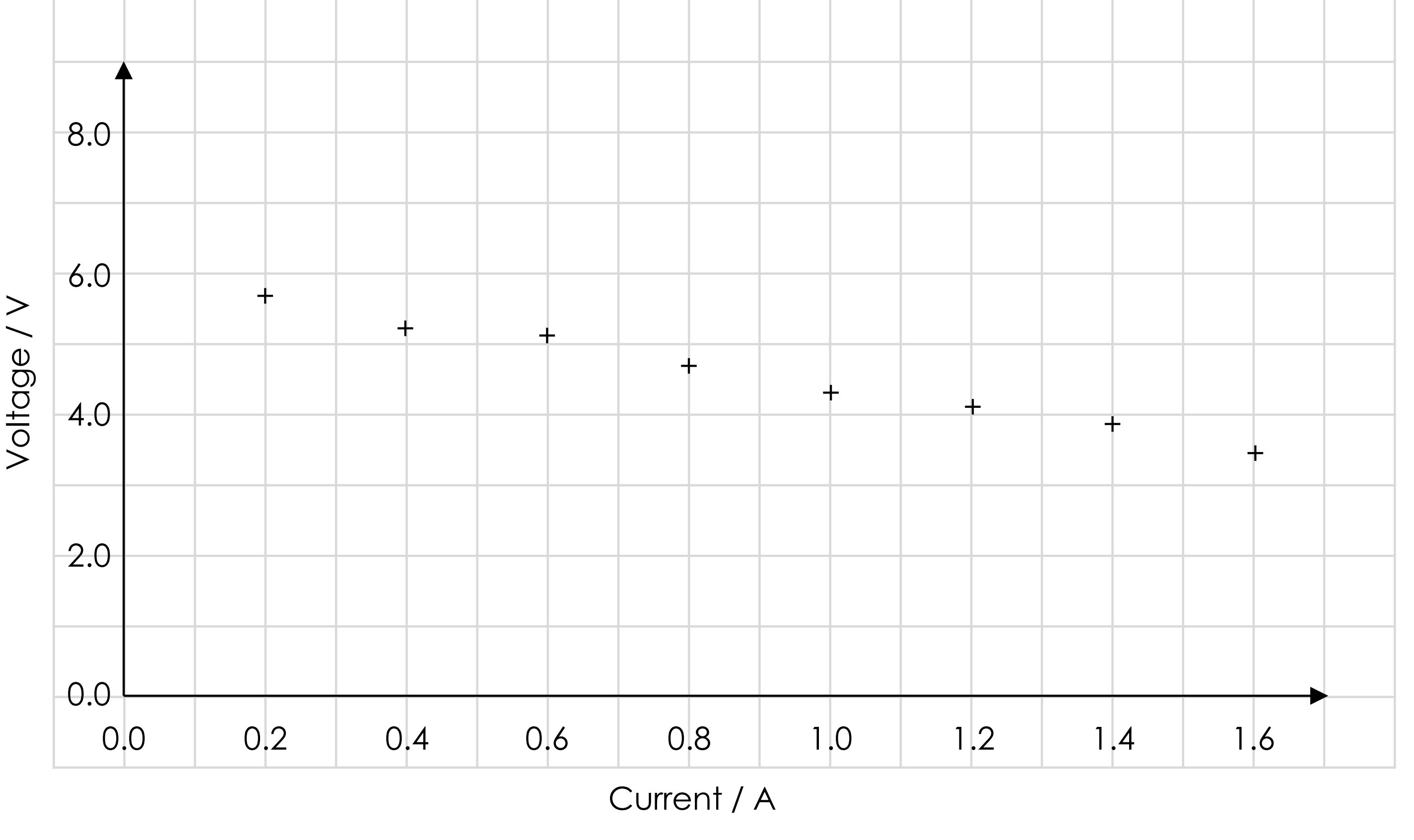
A Calculate the **gradient** of the following line, giving an appropriate unit.



B Calculate the **gradient** of the following data, giving an appropriate unit.



C Calculate the **gradient** of the following data, giving an appropriate unit.



The y-intercept

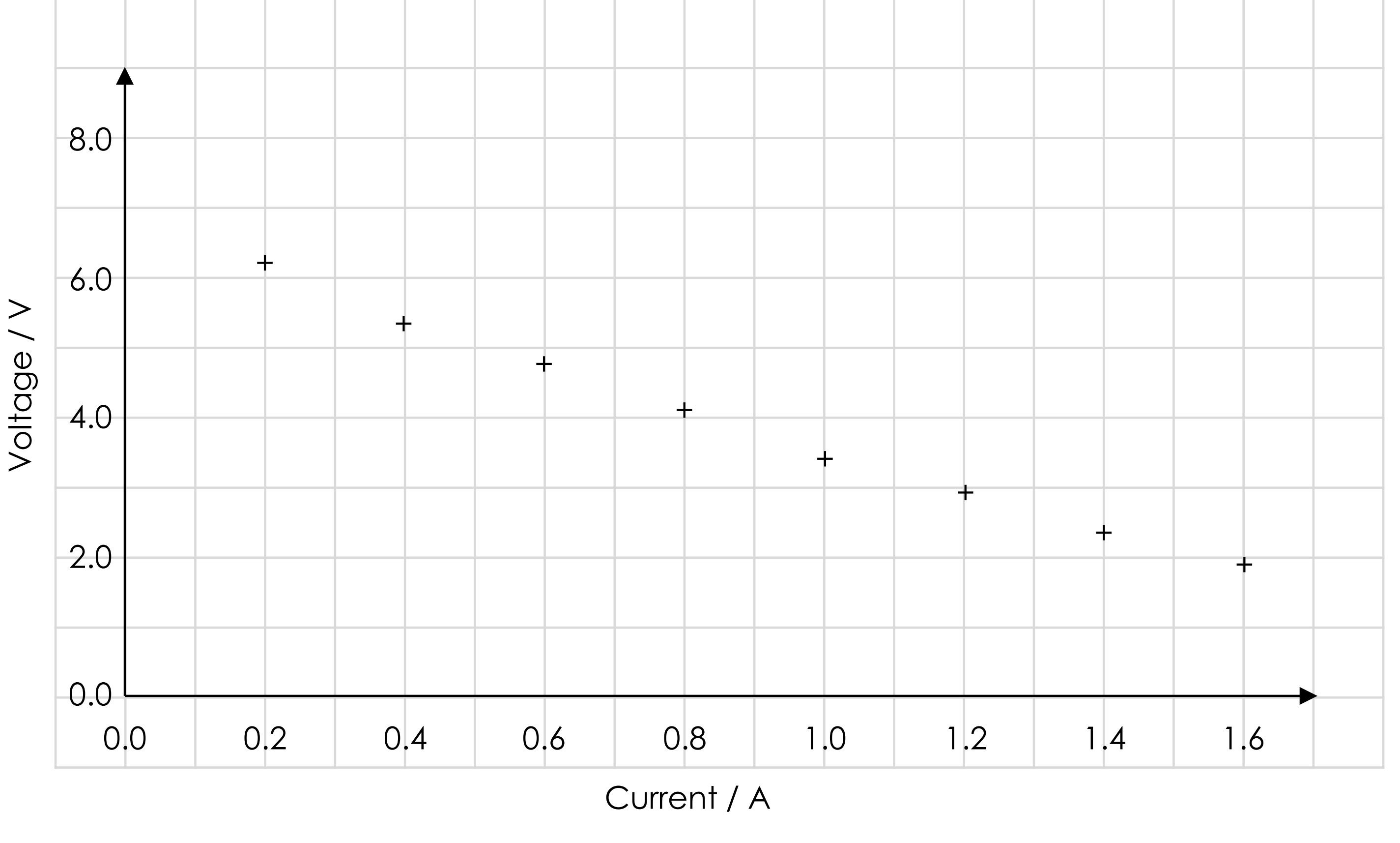
Theory:

$y = mx + c$

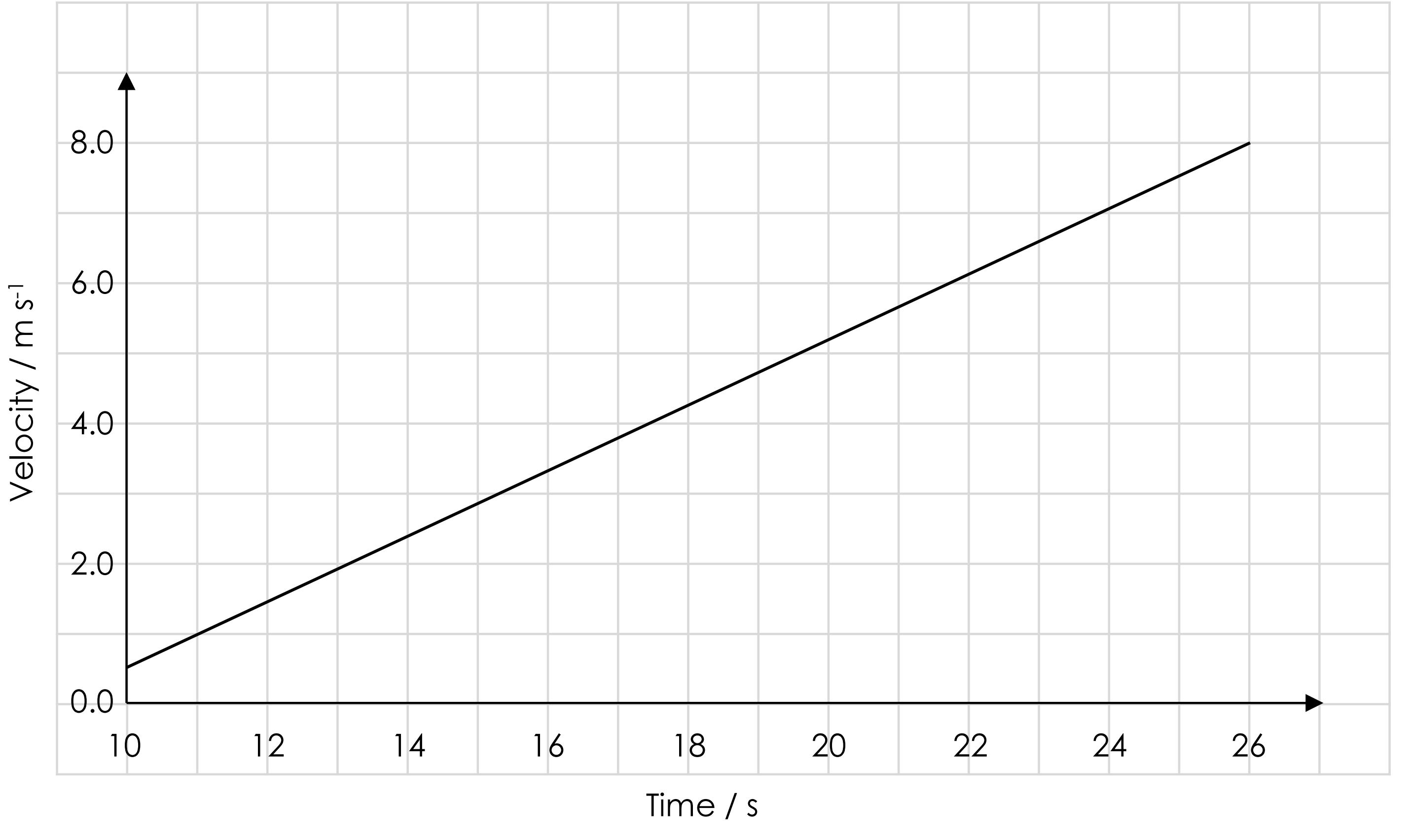
Read c when $x = 0$

Worked Examples:

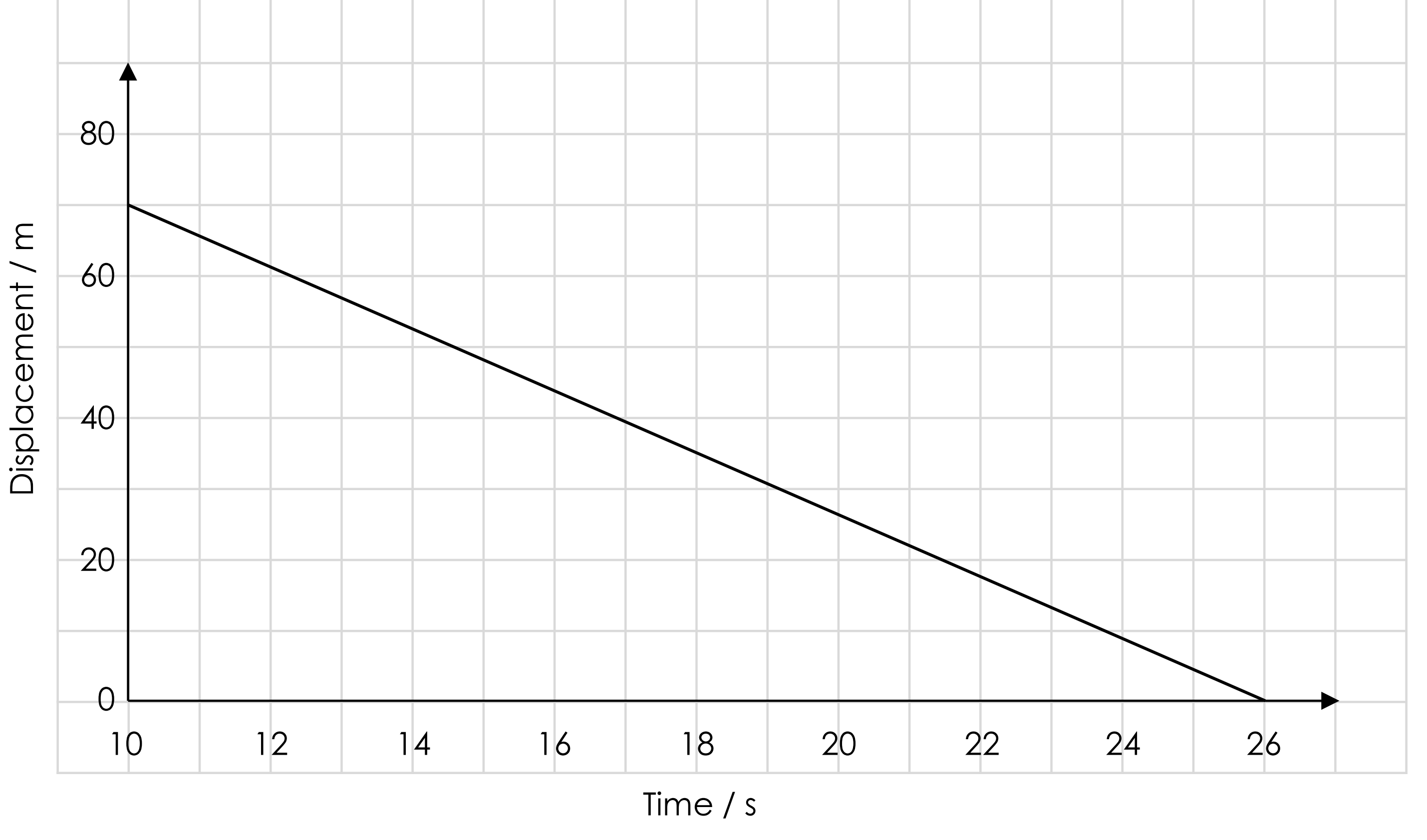
A State the **y-intercept** of the following data, giving an appropriate unit.



B Calculate the **y-intercept** of the following line, giving an appropriate unit.

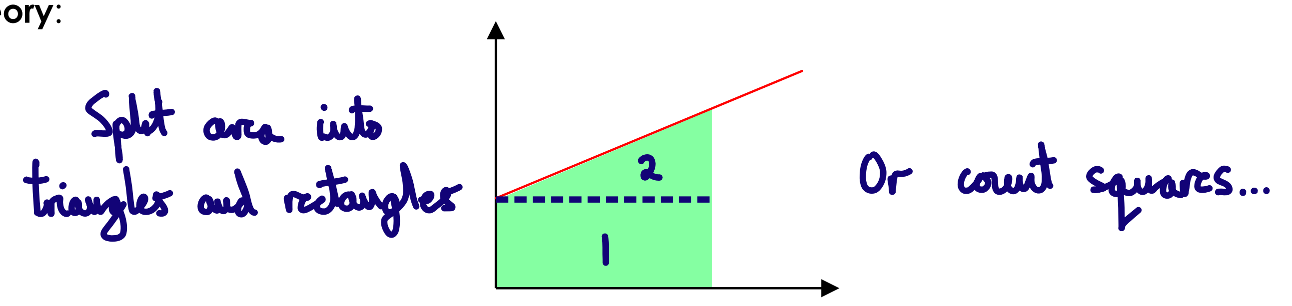


C A vehicle travels at a constant velocity. The last part of its journey is shown below. Calculate the **total distance** it travelled from t = 0.



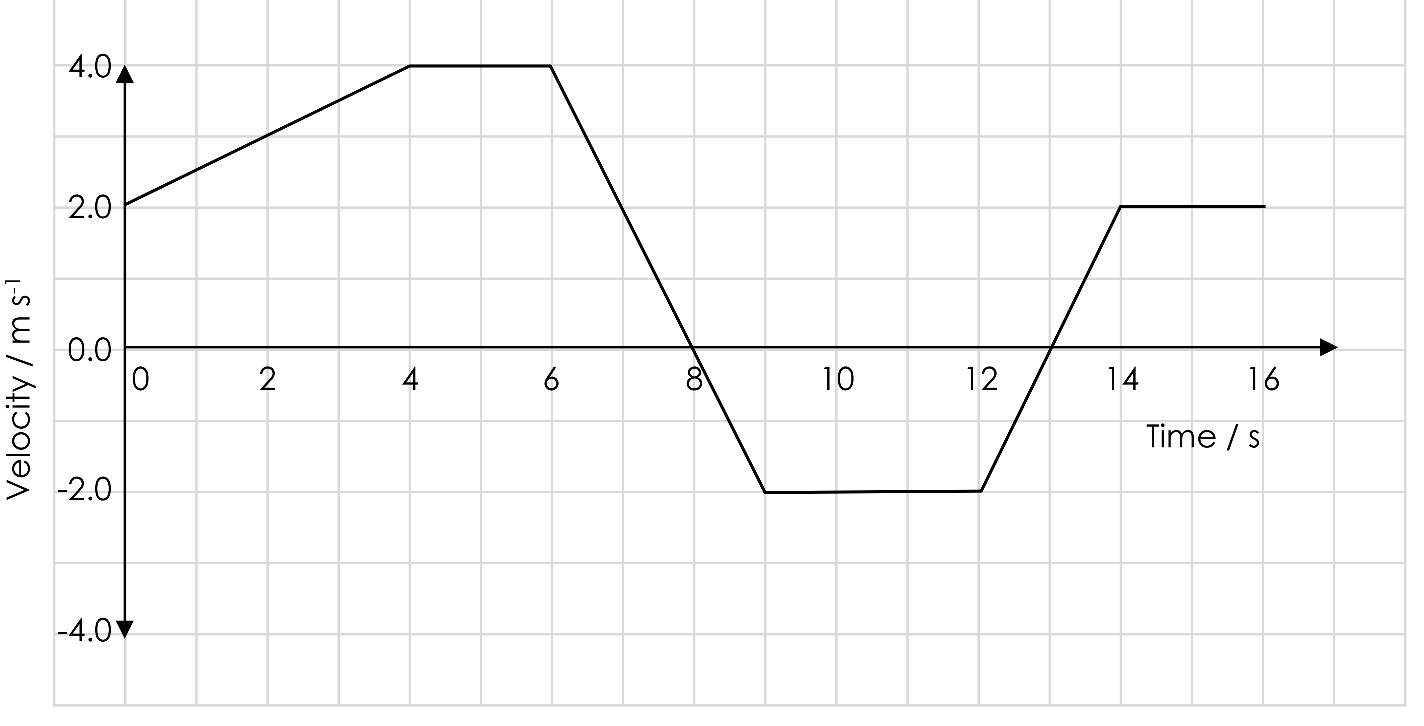
Areas Under Graphs

Theory:

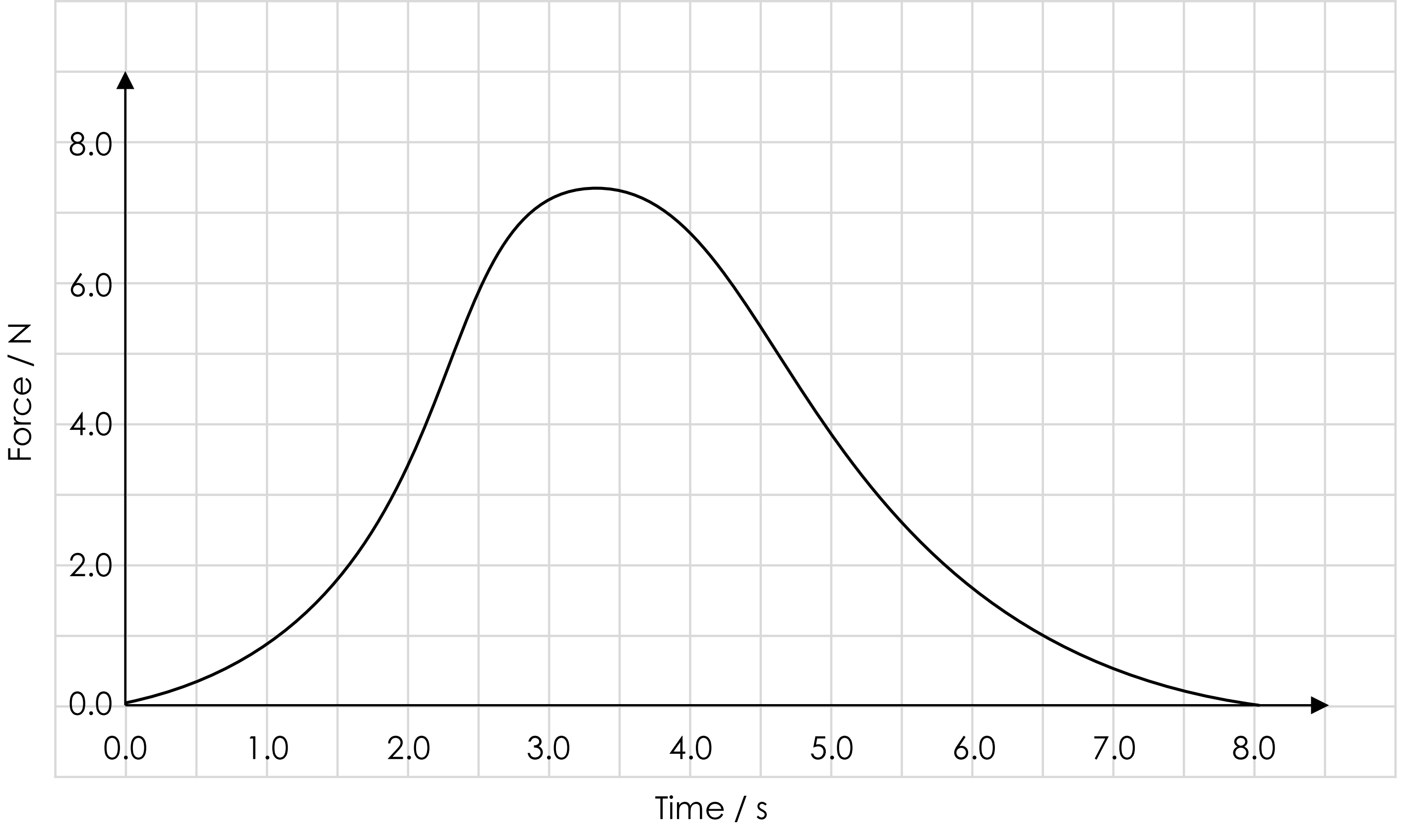


Worked Examples:

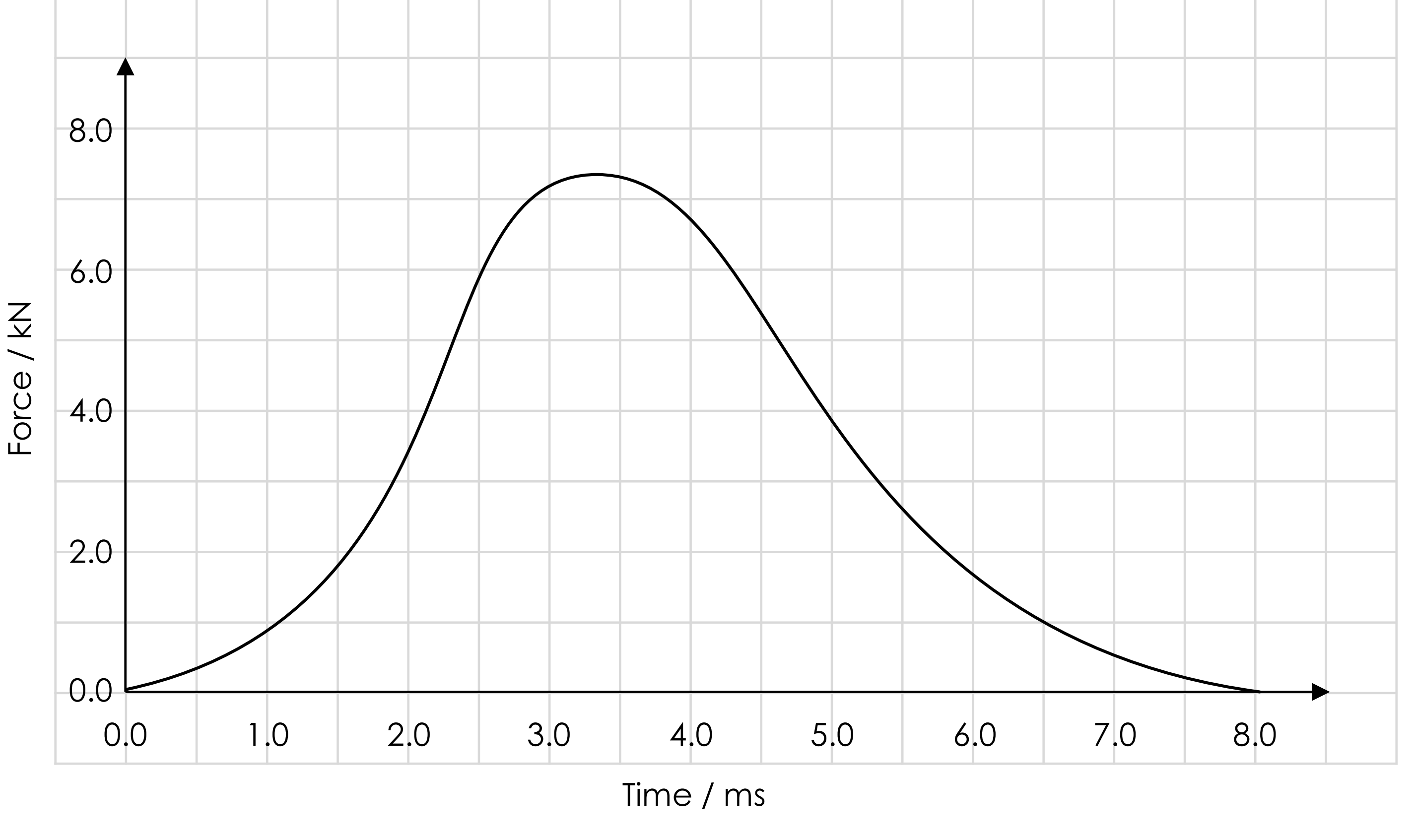
A Calculate the total **displacement** of the object after 10 s.



B Estimate the total **area** under the line, by **counting squares**.



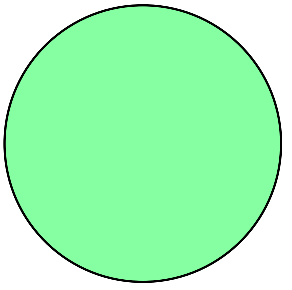
C Estimate the total **area** under the line.



Area of a Circle

Theory:

$A = \pi r^2$



$A = \frac{\pi d^2}{4}$

Worked Examples:

A Calculate the **area** of a circle with the following:

a. Radius of 0.133 m

b. Diameter of 0.366 m

c. Diameter of 0.46 mm

B Calculate the **stress** in a 1.2 mm diameter wire that has a 45 N load applied to it.

stress = force / area

C The resistance of a wire is inversely proportional to the cross-sectional area of the wire.

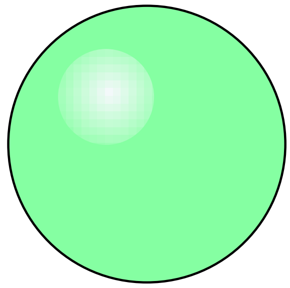
A 1.0 m long wire of diameter 0.84 mm has a resistance of 20 Ω. A second wire of the same length has a diameter 0.11 mm smaller.

Calculate the **resistance** of the second wire.

Area and Volume of a Sphere

Theory:

$A = 4\pi r^2$



$A = \frac{4}{3}\pi r^3$

Worked Examples:

A Calculate the **surface area** of a sphere with the following:

a. Radius of 0.133 m

b. Radius of 6.37 x 10^6 m

c. Diameter of 0.46 mm

B Calculate the **volume** a sphere with the following:

a. Radius of 0.133 m

b. Radius of 6.37 x 10^6 m

c. Diameter of 0.46 mm

C The area of the Hubble Deep Field image is equivalent to a 1.0 mm^2 square at a distance of 1.0 m.

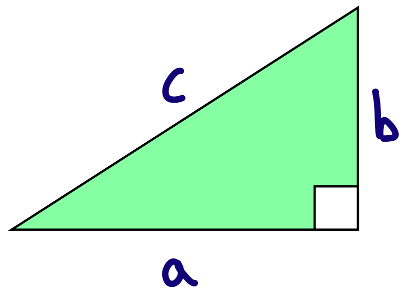
The image shows approximately 10 thousand galaxies, each with about 100 billion stars.

Estimate the **number** of **stars** in the Universe.

Pythagoras

Theory:

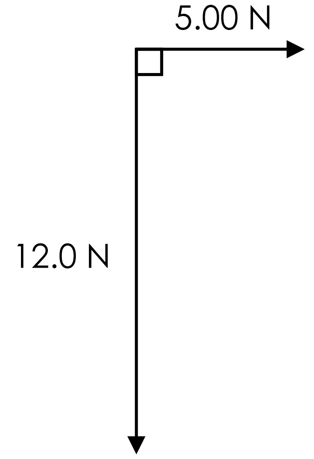
$a^2 + b^2 = c^2$



Worked Examples:

A Calculate the **length** of the side of a right-angled triangle if the hypotenuse is 10 cm and the other side is 7.0 cm.

B Calculate the size of the **resultant force** produced by these two perpendicular forces.



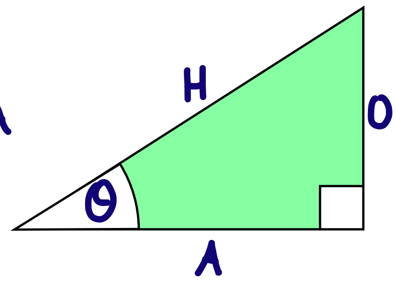
C The initial horizontal velocity of a ball that rolls off a 0.75 m high table is 1.5 m s^{-1}.

Calculate the **speed** it hits the floor, assuming air resistance is negligible.

Trigonometry

Theory:

SOH CAH TOA



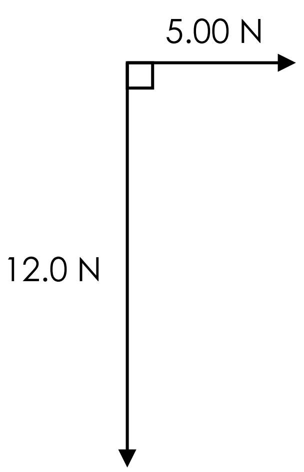
$\sin\theta = \frac{O}{H}$

$\cos\theta = \frac{A}{H}$

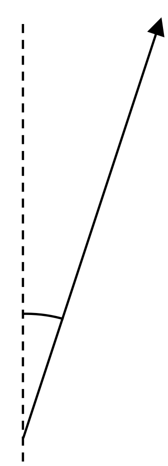
$\tan\theta = \frac{O}{A}$

Worked Examples:

A Calculate the **direction** from the vertical of the resultant force produced by these two perpendicular forces.

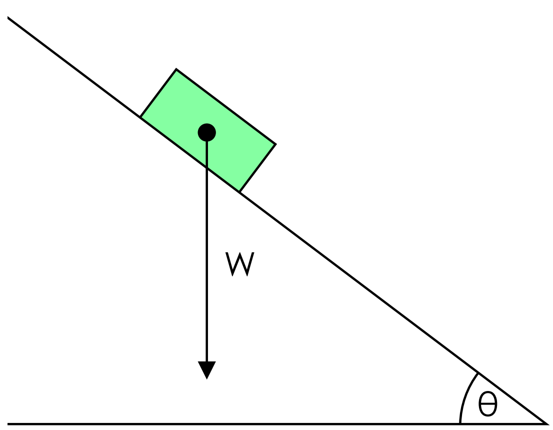


B Calculate the **horizontal** and **vertical** components of a force of 24.0 kN acting at 19˚ from the vertical plane.



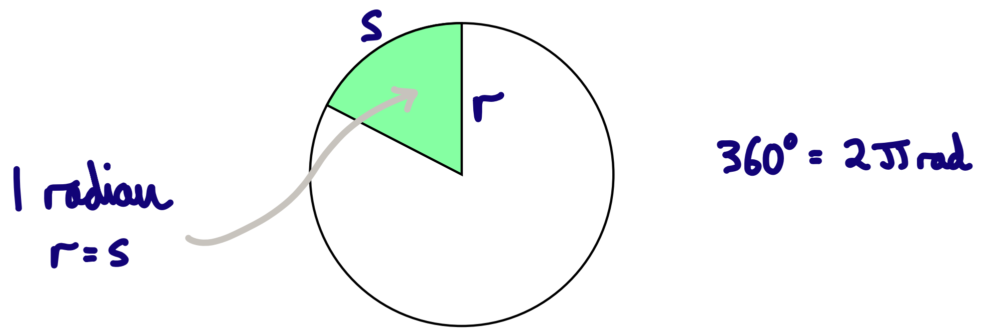
C Calculate the **component** of the block's weight **parallel** to the slope.

W = 697 N and θ = 38˚.



The Radian

Theory:



Worked Examples:

A Convert the following angles from degrees to **radians**.

Give your answer to one decimal place.

a. 90˚

b. 45˚

c. 57˚

d. 30˚

e. 196˚

B Convert the following angles from radians to **degrees**.

Give your answer to the nearest degree.

a. ¾ π radians

b. 22/7 radians

c. 6.0 radians

d. 2.4 radians

e. 0.45 radians

C Calculate the following:

a. sin θ where θ = 90˚

b. sin θ where θ = 2.3 radians

c. cos θ where θ = 40˚

d. cos θ where θ = 0.67 radians

Log to the Base 10

Theory:

log = log to the base 10 (log_{10})

$\log (AB) = \log A + \log B$

$\log (A/B) = \log A - \log B$

$\log x^n = n \log x$

Worked Examples:

A Take **logs** of both sides of these equations:

a. $A = B^3$

b. $A = B^2C$

c. $A = B/C$

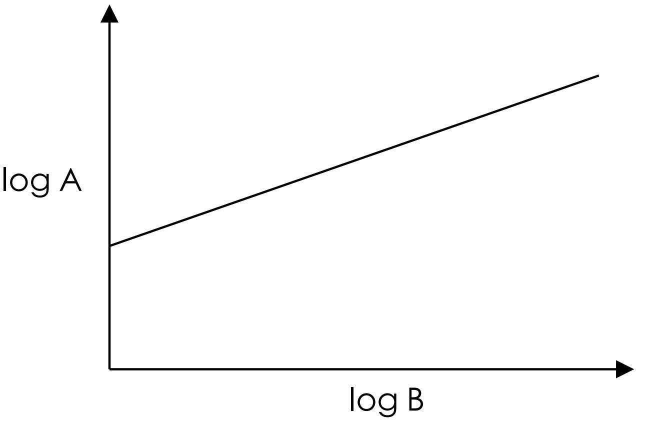
d. $A = BC/D^3$

B It can be shown that:

$A = B^C D$

In an experiment, some data is recorded and plotted, giving a straight line of best fit.

a. Take **logs** of both sides of the equation



b. **Complete** the table:

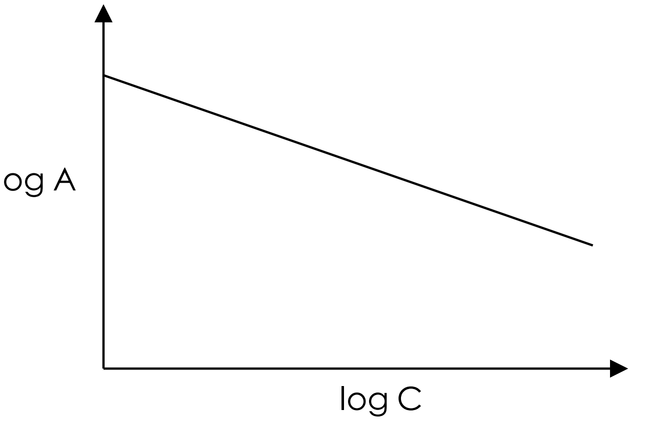
y-axis	gradient	x-axis	y-intercept

c. Describe how the value of the **constant *D*** would be calculated from the graph

C It can be shown that:

$$A = B\,C^{-D}$$

In an experiment, some data is recorded and plotted, giving a straight line of best fit.



a. Take **logs** of both sides of the equation

b. **Complete** the table:

y-axis	gradient	x-axis	y-intercept

c. Describe how the value of the **constant *D*** would be calculated from the graph

Natural Logs

Theory:

ln = natural log to the base e (log_e)

$ln\ e^{kx} = kx$

Worked Examples:

A Take the **natural log** (ln) of both sides of these equations:

a. $y = e^{-x}$

b. $y = e^{-nx}$

c. $y = Ae^{-x}$

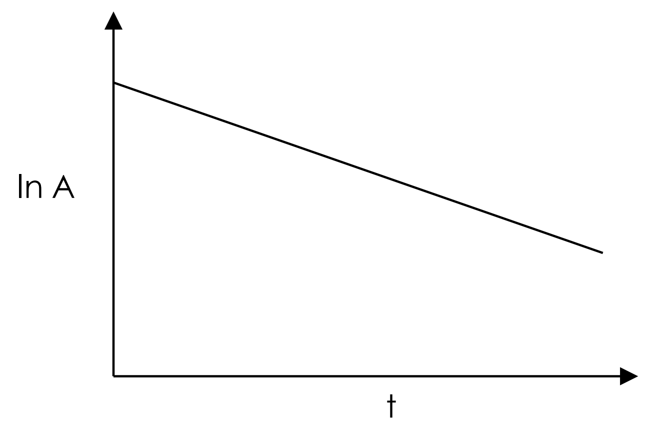
d. $A = A_0e^{-\lambda t}$

B For a radioactive sample:

$A = A_0\ e^{-\lambda t}$

In an experiment, some data is recorded and plotted, giving a straight line of best fit.

a. Take **ln** of both sides of the equation



b. **Complete** the table:

y-axis	gradient	x-axis	y-intercept

c. Describe how the value of the **constant λ** (the decay constant) would be calculated from the graph

C An equation for the discharge of a capacitor is: $Q = Q_0 \, e^{-t / RC}$

a. **Rearrange** the equation to make ***t*** the subject

When Q is equal to $Q_0/2$ the capacitor has discharged to half its original value.

The time constant for the capacitor-resistor combination is equal to RC and can be represented by the symbol τ (the Greek letter tau)

b. Using this information, **rewrite** your equation to part a. to show the time it takes to discharge a capacitor to half its original value