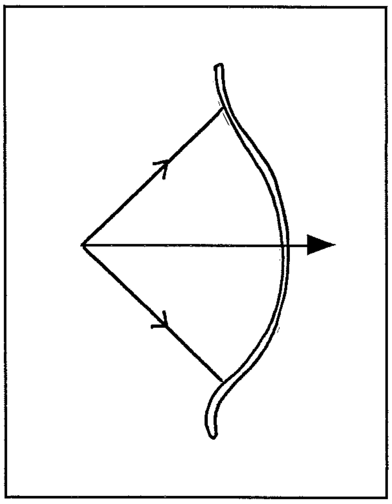
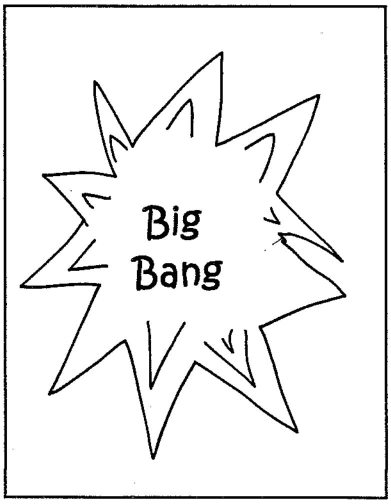
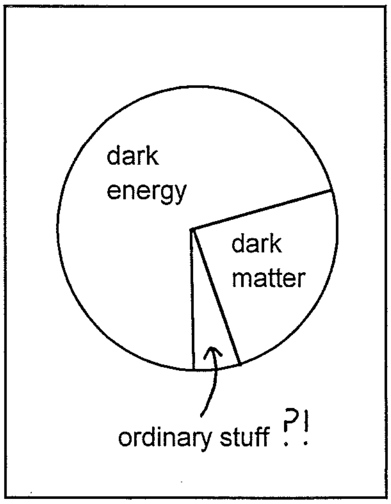
Higher Physics

Unit 1

Our Dynamic Universe







Summary Notes

1. A Bit of NQ5 Revision

Scalars - Quantities defined only by their S________ Ex - M_______, T________
Vectors - Quantities defined by their S________ and D____________ Ex - F________

Distance d = total L__________________of a journey

Displacement s = shortest distance from a starting point to an end point in a given D________________ from the start

Speed v = D________________ / time

Velocity v = D____________________ /time

Acceleration - the change in the velocity of an object in ___ second. ie
a = $4 ms^{-2}$. The objects velocity increases by ________ each second
a = - $4 ms^{-2}$ The objects velocity decreases by ________ each second

2. Equations of Motion

Equations of motion allow us to study the motion of **any** object moving with a constant A____________________ in a straight L__________________.

u = i__________velocity v = f_________ velocity a = a____________________
s = d___________________________ t = t________________ taken

Convention Because **u,v,a** and **s** are vector quantities it is important to specify their direction by placing a + or a - in front of them.

In St Maurice's we take To the right = +ve direction
Upwards = +ve direction

But this is just a convention. Be aware some questions may have the opposite convention.

Ex1 A car starts from rest and accelerates at $2.5ms^{-2}$ for 6s. Calculate its final velocity

Ex2 A cyclist starts from rest and accelerates at $1.8ms^{-2}$ until she reaches $17ms^{-1}$. How far did she travel?

Ex3 A speed boat travels 400m while accelerating uniformly from $2.5ms^{-1}$ for 10s.What was its acceleration?

Ex4 A speed boat travelling at $14ms^{-1}$ accelerates at $4.5ms^{-2}$ until its speed reaches $30ms^{-1}$. How far did it travel during the acceleration?

Ex5 A plane travelling at $300ms^{-1}$ decelerates at $7ms^{-2}$ for 5s. How far did the plane travel during the deceleration?

Free fall

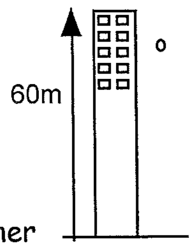
Free fall describes the motion of an object when it is acted on by the force of gravity alone. So its acceleration is determined by the gravitational field strength at that point

On the surface of Earth $g = 9.8Nkg^{-1}$ so acc due to gravity = $9.8ms^{-2}$

On the surface of the moon $g = 1.6Nkg^{-1}$ so acc due to its gravity = $1.6ms^{-2}$

In free fall examples - If we take the convention - up is positive then acceleration upwards is __________ and the acceleration downwards is also ___________.

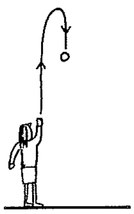
Ex A man drops a spanner from the top of a 60m high block of flats



(a) What is final velocity?

(b) How long did the spanner take to hit ground?

Ex A girls throws a ball up in the air. It leaves her hand with a speed of $18ms^{-1}$.



(a) Calculate the time to reach the highest point

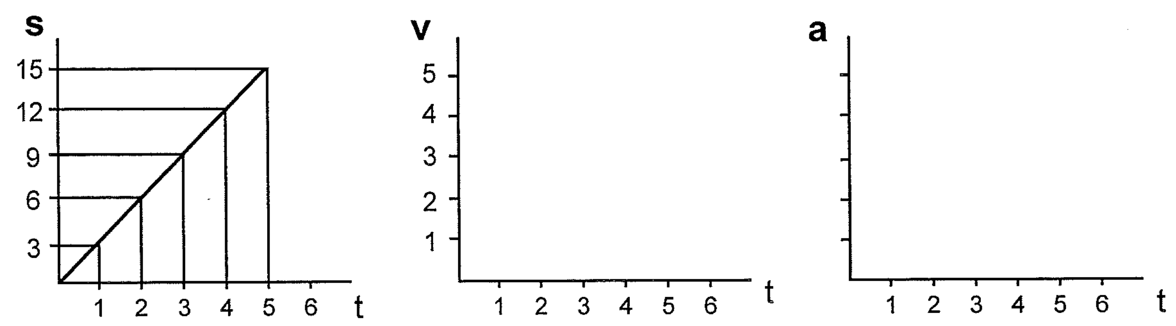
(b) Calculate the maximum height.

(c) Calculate the velocity of the ball when she catches it

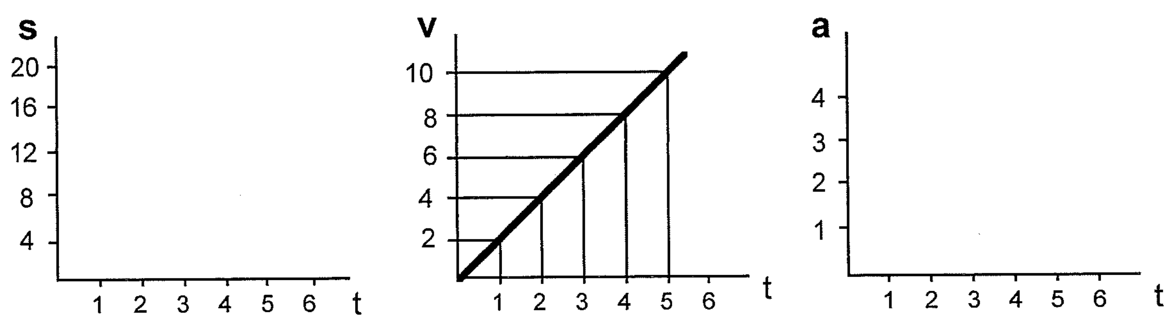
Remember in these examples when you are measuring height you are actually measuring the D______________________ of the object after time t.

3. Graphs of motion - Constant speed

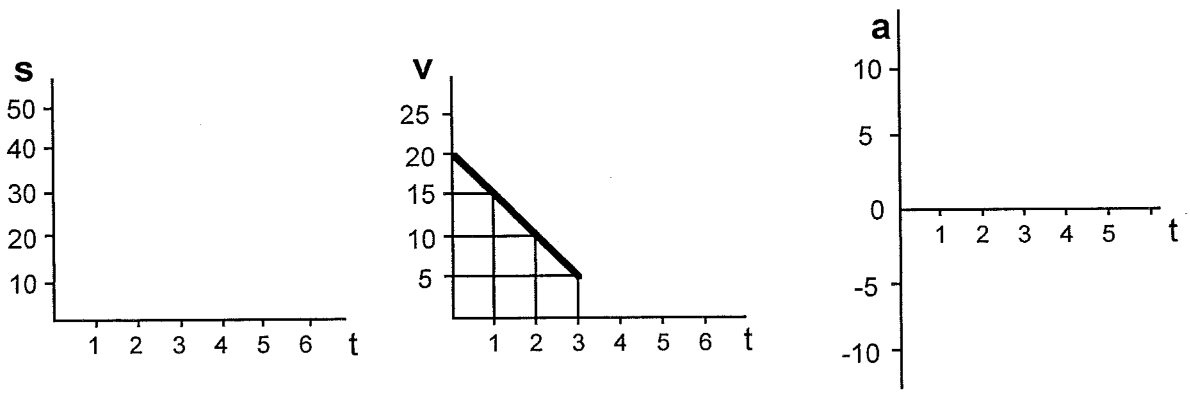
These are the graphs of motion of an object travelling at a constant velocity to the right.



Graphs of Motion II - Constant acceleration in positive direction



Graphs of motion III - Constant deceleration in positive direction.

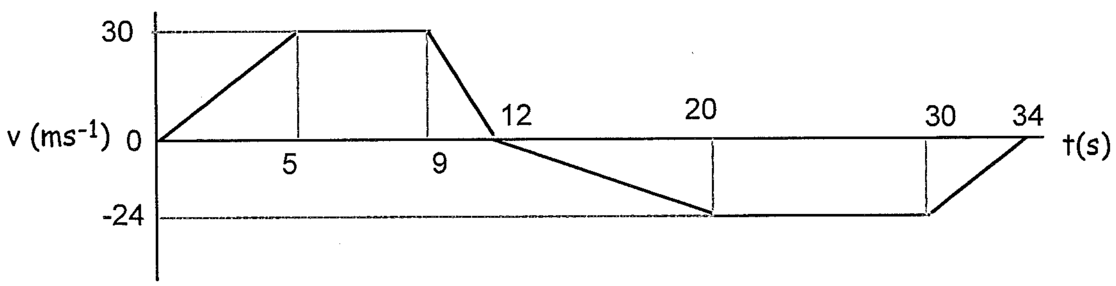


The area under a velocity time graph gives you the D____________________ of the object over that time frame.

Acceleration Time graphs.

We are familiar with the shapes of velocity time graphs. Here we draw the acceleration time graphs associated with the velocity time graph.

This velocity time graph shows a car accelerating in the +ve direction then travelling at a C________________ velocity of ________ before D____________________ to rest. At 12s it changes D________________ and A________________________ back the way it came, for ______s. It then travels at a constant velocity of _________ for ______s before decelerating to R__________.



0-5s $a = \frac{v - u}{t} = \frac{30 - 0}{5} = \frac{30}{5} = 6ms^{-2}$

5- 9s $a = 0ms^{-2}$

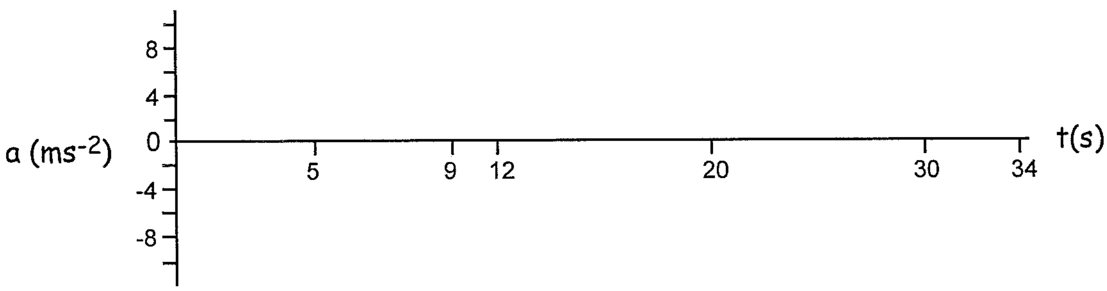
9 - 12s $a = \frac{v - u}{t}$ = ________ = _____ =

12 - 20s $a = \frac{v - u}{t}$ = ________ = _____ =

20 - 30s $a = 0ms^{-2}$

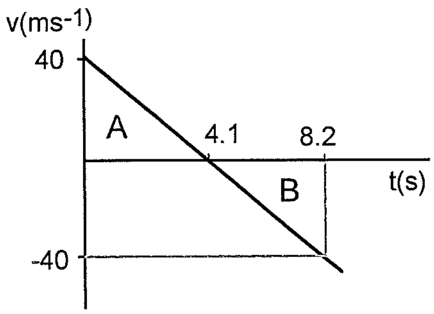
30 -34s $a = \frac{v - u}{t}$ = ________ = _____ =

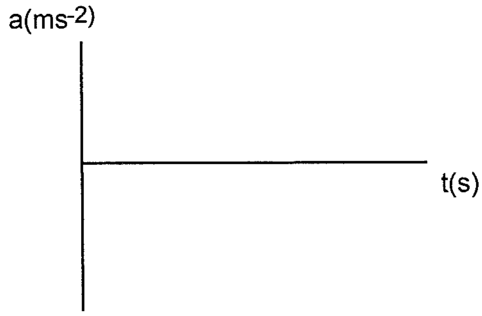
Now draw the acceleration time graphs. All these accelerations are constant so the lines will be straight.



Note the relationship between gradients on vel vs time graph and accelerations

Special Case 1 - **Object thrown vertically upwards**. In this case we make upwards positive so the ball leaves the person's hand with a velocity of $+40ms^{-1}$





Area ____ = height ball rises to =

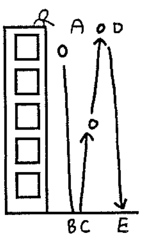
Area ____ = Distance ball falls =

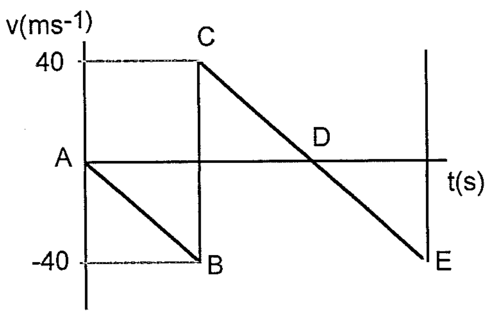
Total distance travelled = ___________

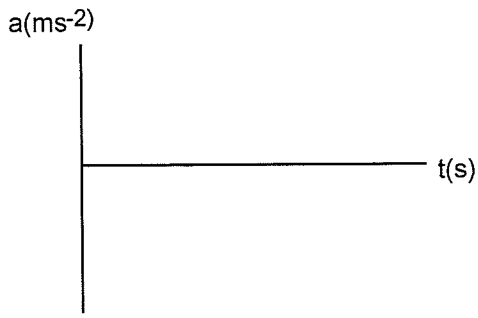
Displacement from start = ___________

As the ball is in freefall at all points the acceleration will be __________

Special case 2 - **Ball dropped from a height and bounces**. (No energy losses)
Take upwards as positive.







A-B Ball is F______________ vertically D______________________

B - C Ball is in contact with the G_____________. In this time the ground decelerates the ball from $-40ms^{-1}$ to R_________ then starts to accelerate it upwards so that its velocity is $+40ms^{-1}$ just as it leaves the G______________ at point _____.

C- D Ball leaves ground and D_________________ as it travels upwards until v = 0

D-E Ball starts F_________ again.

During A-B and C-D and D-E the ball is in freefall so its acceleration will be ________.

Rule of thumb - If the velocity time graph slopes upwards from left to right =
P_________________acceleration
If velocity time graph slopes down from left to right =
N_________________ acceleration.

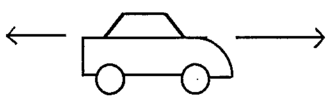
4. Forces

Newtons 1st Law - Balanced forces are equivalent to N__ forces acting at all. So the motion of an object will not C____________________.

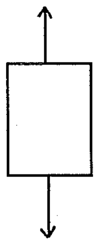
Newton's 2nd Law - If an unbalanced F_________ (F_u) is applied to a mass (m) it will accelerate at (a) Summed up in equation F_u = ______

Friction is a force which O____________ the motion of an object. The faster the object moves the G_________________ the force of friction acting.
Weight is the force pulling all objects D_________ towards the centre of the planet.
Tension is the force acting through cables, R__________ and connections.
Reaction is the force the G__________ applies back up on an object sitting on it.

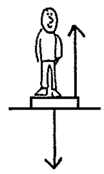
In each example note the name of the force on the diagram.



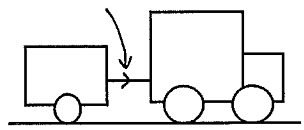
1. Car on road



2. Lift



3. Man on scales



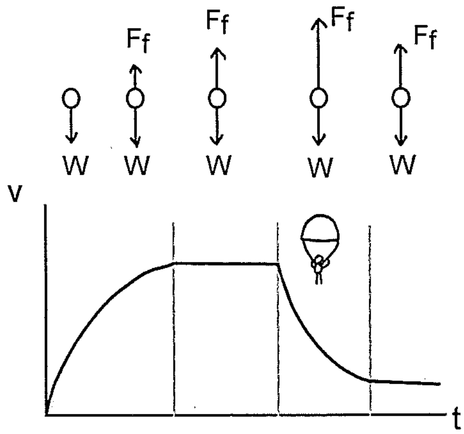
4. Lorry pulling trailer

In diagrams 1-3 if the object is at rest the forces are B___________________.
In diagram 2 for lift to accelerate upwards Tension is ___________ than weight.
In diagram 3 the scales read the R______________ force. At rest this reaction force = the W__________. If you are accelerating upwards the reaction force is G_______________ than your weight.

Terminal Velocity

In Nat 5 when an object falls we ignore F___________ and therefore the only force is its W____________. So acceleration is constant a = Fu/m = W/m = -9.8ms-2

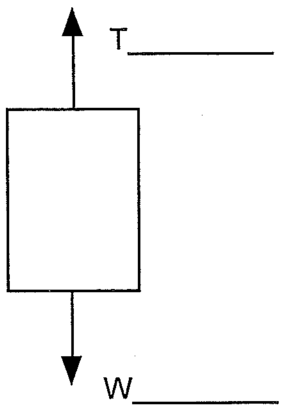
In reality a falling object gets faster so air friction I__________________.
So unbalanced force is actually $W - F_f$
therefore acceleration D_____________.
When $W = F_f$ the object falls at a constant velocity called the T________________ velocity because the forces are now B______________.
Velocity-time graph shows a skydiver releasing parachute after he reaches her terminal velocity.



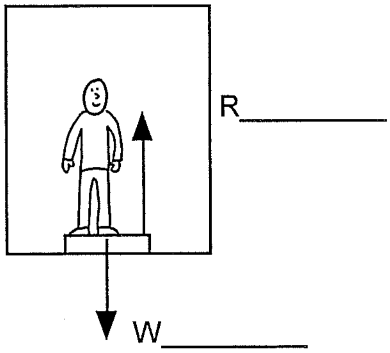
Lift Motion

These questions involve an object being accelerated up or down. The important point in each question is to identify the force acting upward and the force acting D____________________. Choose upwards as positive direction.

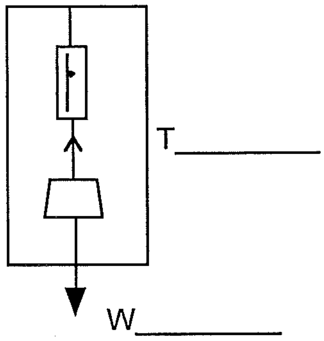
Lift



Person on Bathroom Scales

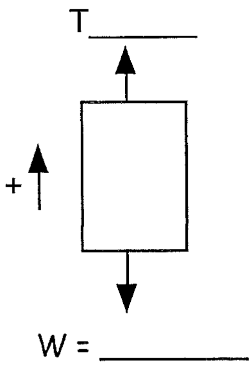


Mass on Balance



The reaction force is the force that you read on the B______________ scales. It is the force the ground applies **up** on you. The reading on the Newton balance in the 3rd diagram = the upward T_________ on the mass. In each diagram the W__________ stays the same, but the Tension and Reaction forces vary depending on the motion. The difference between these forces is the U____________________ force.

Ex A 2000kg lift accelerates upwards at $0.6ms^{-2}$. What is the Tension in the wire?



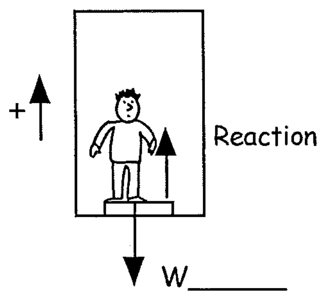
W = mg
=
=

Fu = ma
=
=

So as lift accelerates upward the Tension is B________ than the weight

Tension = W + ______
=
=

Ex A 70kg man standing on a set of scales notes the reading as 600N. Find the deceleration as he approaches the top floor



W = mg
=
=

The unbalanced force is against the motion so it will be negative

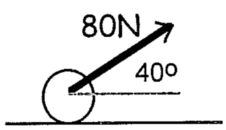
Fu = 600 - 686 = - 86N

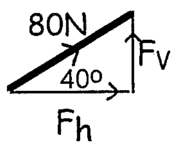
Fu = ma   a = $\frac{Fu}{m}$ = _____   =

Resolving Forces

In Nat 5 the force was always applied in the direction the object travelled.
In Higher, the forces can be at an A__________ to the direction the object travels.
In these cases we have to resolve or split the vector into its Horizontal and V________________ components, then apply the one in the direction of the motion.

Ex A gardner pulls a roller over a horizontal lawn with a force of 80N at a constant speed as shown. What is value of friction?
Friction acts in the horizontal, opposing the horizontal motion, so we need to find the H____________________ component of the Force.





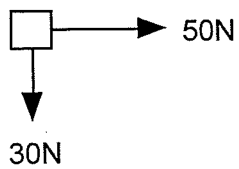
$\sin\theta = \frac{o}{h}$ = ____ F_v =

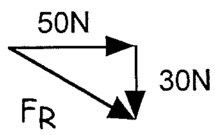
$\cos\theta = \frac{a}{h}$ = ____ F_h =

Horizontal component = ______, and as the object is moving in the horizontal with a constant velocity the forces in the horizontal are B_____________.
So force of friction = _______N

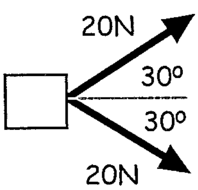
Two forces

If the forces acting on an object are at right angles we simply add the vectors together N____________ to tail to find the resultant vector

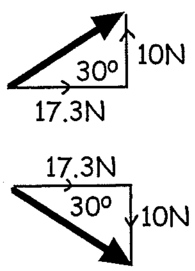




If the two forces are at an angle other than 90° - we resolve each one then add the verticals and horizontals together vectorially. The net force is called the R____________________ force



So we resolve each force vector

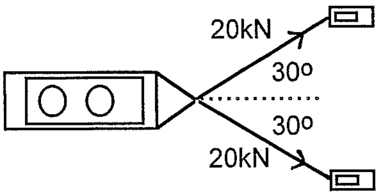


The vertical vectors C__________ out. The horizontals A_______ together

So resultant force = 2x __________

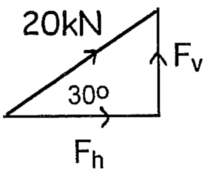
= ________

Ex1 Two tug boats are pulling a liner as shown. The tension in each rope = 20kN.



(a) Calculate the resultant force on the liner

We only have to look at one rope as the forces are applied symmetrically

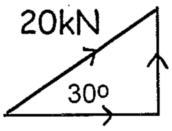


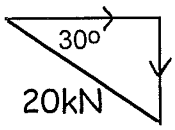
$\sin\theta = \frac{o}{h} = \frac{F_v}{\quad} = \_\_\_\_$ $F_v =$

$F_v =$

$\cos\theta = \frac{a}{h} = \frac{F_h}{\quad} = \_\_\_\_$ $F_h =$

$F_h =$



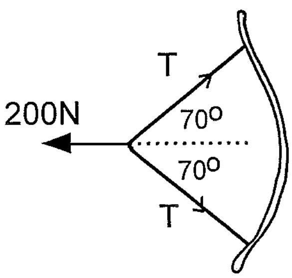


Vertical components C__________ out.

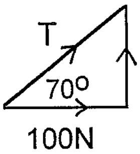
Total horizontal Force = 2 x _________

=

Ex2 An archer pulls a bow string back as shown with a force of 200N and holds the system stationary. What's the tension in each string?
This is the opposite of above question



Here we are told indirectly the resultant forward force -it must be 200N to balance the archers draw force. So the horizontal force created by **each** string must be 100N.

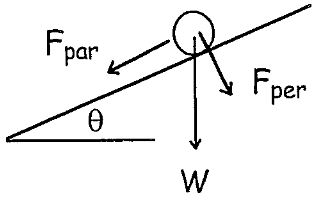


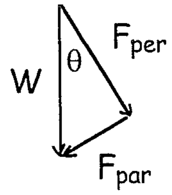
$\cos\theta = \frac{a}{h} = \frac{F_h}{\quad} = \_\_\_\_$ $T =$

$T =$

Inclined Plane

If an object is on an inclined plane then the weight which acts vertically downwards can be resolved into a component acting down or parallel to slope (F_{par}) and one acting into or perpendicular to the slope (F_{per})



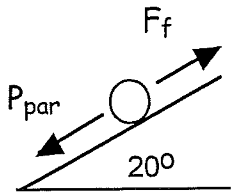


F_{par} = ____________

F_{per} = ____________

If the object is moving down the slope friction acts _____ slope. If object is moving up slope friction acts ___________ slope.

Ex A 3kg ball rolls down a slope inclined at 20° at a **constant speed**. Calculate the fictional force on the ball. First draw a force diagram



$F_{par} = mg\sin\theta$ =

As ball is travelling at constant speed the forces are balanced. So $F_{par} = F_f$

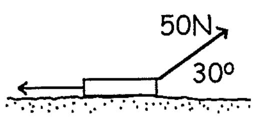
So F_f = _______

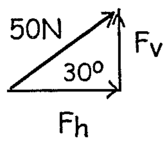
Work Done (WD or E_w) (J)

Work done is the E__________ transferred when a Force F is applied over a distance of d. The Force F must be in the direction that the object M_________.

Ex This boy pulls a sledge with a force of 50N over 4m. Friction = 30N. calculate the work done by the pulling force and frictional force.

Work out component of force in direction of motion = H_________ component.





$\cos\theta = \frac{a}{h} = \frac{F_h}{\quad} = \_\_\_$

F_h=

F_h=

So work done by boy = $WD_b = F_h \times d$ = ______ x ______ = ______N

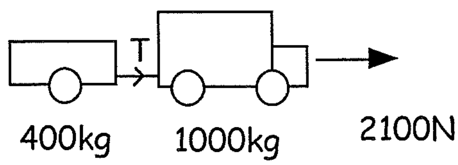
Work done by friction = $WD_f = F_f \times d$ = ______ x ______ = _______N

Multiple mass systems

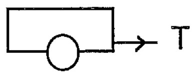
In these examples there are two separate masses moving together and we want to know the forces acting on one of them. In this example an engine force is applied to the whole system. So it all accelerates together at same rate. We want to find the force the van applies to the trailer. ie Tension in the coupling T. (Friction less surface)

1. Calculate the acceleration of system

$$a = \frac{Fu}{m} = \frac{\quad}{\quad} =$$



2. Look at the trailer as a separate body

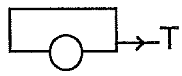


The unbalanced force on this body is

$F_u = ma = 400x$ ____ =

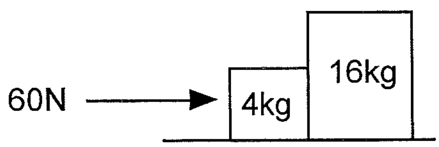
3. Now because there is only one force acting on the trailer the unbalanced force must be the Tension T.

Fu =_____



So T = _______N

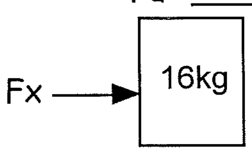
Ex A force of 60N is applied to these two boxes on a friction less surface. What force does 4kg block apply to 16kg block. Call it Fx



1. Acceleration of whole system

$$a = \frac{Fu}{m} = \frac{\quad}{\quad} =$$

Fu =_____



2. Look at the 16kg box.The unbalanced force on this body is

$F_u = ma = 16 \times$ ____ = ______

So as the there is only one force on the box the unbalanced force = the force the 4kg block applies to the 16kg block.

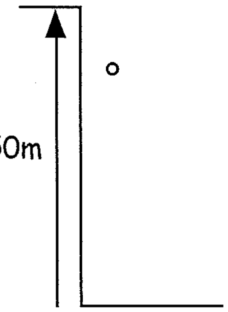
So Fx = _______

5. Conservation of Energy

Law of conservation of Energy: Energy cannot be made or d________________ but can be changed from one form to another.

1. A 2kg rock is dropped from a 50m high cliff. If we ignore friction calculate the velocity of the rock as it lands

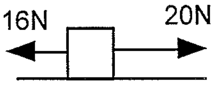
At cliff Ep = mgh = ____ x ____ X____



As it hits ground all the gravitational P____________ energy is transferred to K____________ energy.

$$mgh \text{ (lost)} = \frac{1}{2}mv^2 \text{ (gained)}$$

2. A box is pulled 5m horizontally across a floor by a pulling force of 20N force. A frictional force of 16N acts on the box.

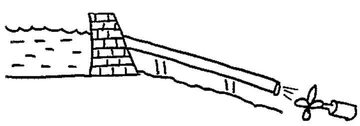


(a) Calculate the Work Done by pulling force.

(b) Calculate the Work Done by the frictional force.

(c) Calculate the kinetic energy of the box at 5m.

800kg of water flows out of a reservoir, which is 500m above a hydroelectric turbine, in a time of 5s



(a) Calculate the potential energy of 800kg of water.

Ep = mgh

Ep = ________ x ______ x _______

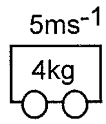
=

(b) If we ignore friction calculate the power developed at the turbine blades.

$P = \frac{E}{t}$ = ________________

6. Momentum and Impulse

Momentum (p) is the M_______ of an object multiplied by its V__________. Its units are ______________. Momentum is a V_______ quantity.



momentum p = mv = ___x___ = ______

Law of conservation of linear momentum

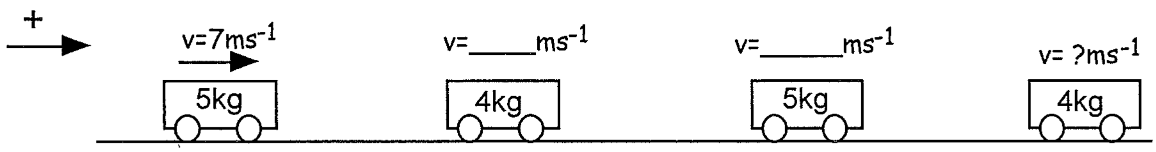
In ALL collisions the momentum of objects before the collision = the momentum of the the objects A__________ the collision. In all collisions we say that momentum is C_________________. (It is not lost).

In **elastic collisions** momentum and K_______________ energy are both conserved. (Not lost). (Air particles colliding is an example)

In **inelastic collisions** momentum is conserved but kinetic energy is lost. It is N_____ conserved. (Most collisions are inelastic as you can hear them)

Note - In all collisions the **total** energy is always C________________.

Ex1 A 5kg trolley travelling at $7ms^{-1}$ collides with a stationary trolley of mass 4kg. After the collision the 5kg trolley's velocity is $3ms^{-1}$. What is the velocity of the 4kg trolley after the collision

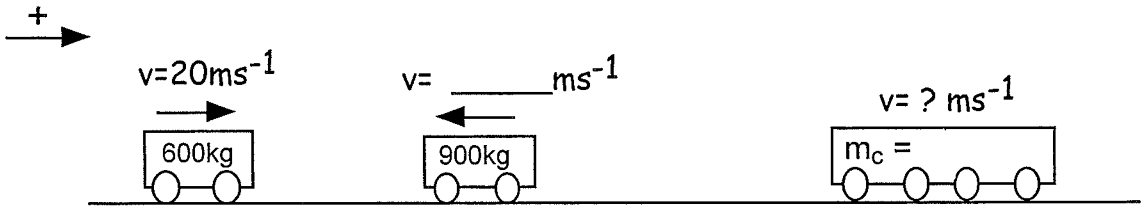


TMOBC = TMOAC

mv_A + mv_B = mv_C + Mv_D

5 x _____ + 4 x _____ = ___ x ___ + ___ x ___

Ex2 A 600kg car travelling to the right at $20ms^{-1}$ collides head on with a 900kg van travelling to the left at $32ms^{-1}$. The vehicles lock together after the collision. What is the combined velocity of the vehicles?



TMOBC = TMOAC

mv_A + mv_B = mv_C

Explosions

An explosion is a collision happening in reverse but the law still applies.

Ex3 In space a 2000kg capsule and 500kg rocket are joined and stationary. At one point the capsule and rocket explode apart. If the space capsule recoils backwards at a speed of $420ms^{-1}$ calculate the velocity of the rocket.

TMOBC = TMOAC

mv_A = mv_B + mv_C

To establish if a collision is elastic or inelastic calculate the total **kinetic** energy of objects before then A__________ the collisions. If no kinetic energy is lost the collision is E______________.

Impulse and change of momentum

In all collisions the force object A applies to object B is E__________ and O________________ to the force B applies to ____. This is known as Newton's _____ law of motion. So in a collision if one object loses X momentum then the other object will G_________ this momentum

If you apply a force F to and object m it accelerates at a. This is summarised as

$F = ma$ now $a = \frac{v - u}{t}$ so

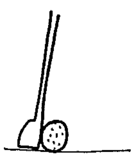
$F = \frac{m(v - u)}{t}$

or $Ft =$

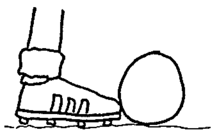
We can say that if a Force F is applied to an object for a time t then the objects momentum changes from ______ to ______. It has a change of momentum = mv - mu

Impulse of force = Ft which also = mv - mu so units for impulse could be ________ or ________.

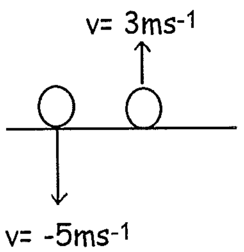
Ex A golfer hits a golf ball. The club is in contact with the ball for 18ms and the ball is accelerated to a velocity of $40ms^{-1}$. Calculate the size of the force the club exerts on the ball.



Ex A footballer kicks a 0.1kg ball with a force of 12N. If the foot is in contact with the ball for 0.2s calculate the final velocity of the ball.



Ex A 2kg ball hits the ground at a **speed** of $5ms^{-1}$ and rebounds at $3ms^{-1}$. What is its change in momentum? Careful, momentum is a vector so direction is important. Up = positive



change in momentum = Δ mv = mv - mu

= 2 x 3 - ____ x ____

= 6 + ______

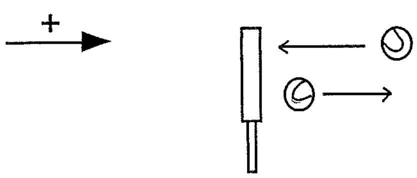
= ______kgms^{-1}

This positive change in momentum makes sense as it is changing from a negative direction to a positive direction

If the collision lasted for 8ms find the force on the ball

$F = \frac{mv - mu}{t}$ = ________________ =

Ex In a crash a driver's head of mass 3kg and travelling at $20ms^{-1}$ hits an air bag and is brought to rest in a time of 1.9s. Calculate the stopping force the air bag applies to his head.



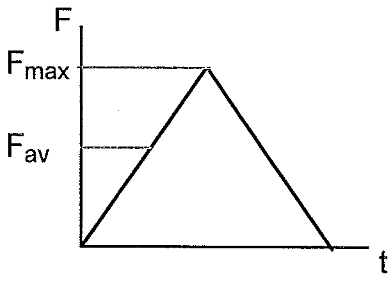
u =______

v =______

Ex In a tennis match a ball hits a racquet at $3ms^{-1}$ and is hit straight back at $14ms^{-1}$. If the ball was in contact with the racquet for 0.08s calculate the force the racquet applies to the ball.
(mass of ball = 50g)

Force - Time graphs

When a force is applied to an object we sometimes assume it is a constant force but usually when small time frames are involved the shape more resembles a triangle.



Important points:

The F_{max} is not the F used in the impulse equation Ft. This force is the average F

Area under Ft graph = Impulse = change in momentum of object

Understanding Formula

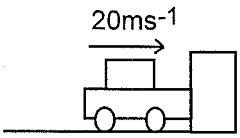
In collisions - Cars colliding, jumping off a wall and landing, a boxer being punched - we want to D______________ the stopping force. We do this by ensuring the change in momentum occurs over as big a time as possible.

$F = \frac{mv - mu}{t}$ if t is B_____ then the F is __________

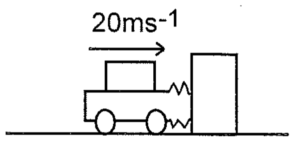
Examples - Crumple Z________ in cars. Air ______________ in cars. Padding in a boxer's _____________. Bending K_________ when you hit ground.

Ex Two identical cars hit a wall at $20ms^{-1}$ and are brought to rest. One car has no crumple zone the other has.

Car of hitting wall at $20ms^{-1}$ with no crumple zone

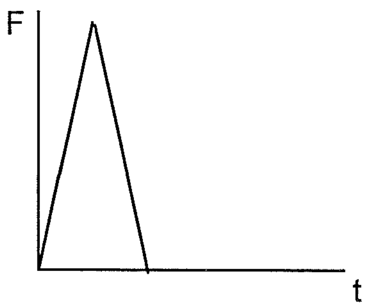


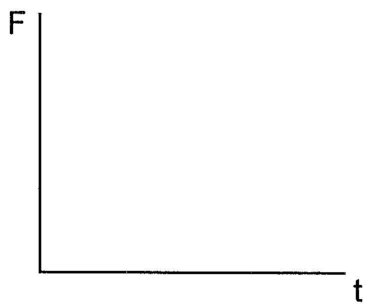
Identical car of hitting wall at $20ms^{-1}$ with a crumple zone



Cars momentum is changd over a longer time

Notice the change in momentum of both cars is the S_________ as they are identical and both decelerate from 20 to 0. So the A________ of triangles should be the same. It's just area 2 is over a larger time frame.



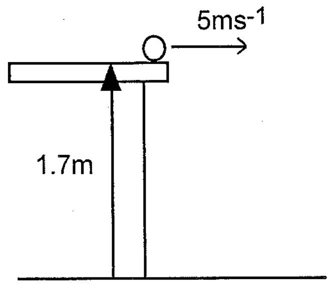


7. Projectiles and Satellites

Horizontal projectiles

This is a projectile whose initial vertical velocity is Z________. In these examples the time the object is in the air depends only on the V_________________ height it falls. (remember if height = 40m the displacement is ______m)

Ball rolls off table with horizontal velocity of $5ms^{-1}$



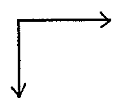
(a) Calculate the time ball is in air

(b) Calculate the horizontal distance travelled.

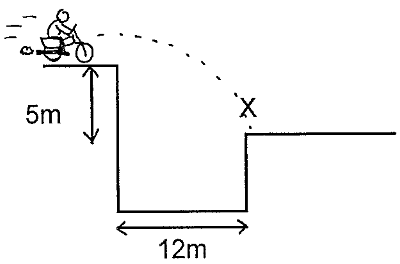
(c) Calculate horizontal and vertical component and resultant velocity when it lands

v_h =

$v_v = u_v + at$



Ex A motorcyclist rides off a cliff and wants to land at point X
What is the horizontal speed required to just land at point X.



The time the ball is in the air depends upon vertical height it falls ie s = ________m

The bike has to travel _____m horizontally in this time.

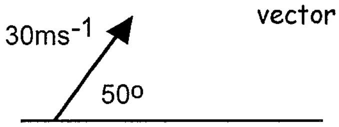
(a) Time ball is in air

(b) Horizontal velocity required

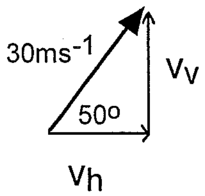
Oblique projectile

This is the type of projectile which has an initial v_____________and h_____________ component of velocity. Example - G________ shot, Jav____________throw.

Look at this golf shot



resolve vector



(a) Calculate v_h and v_v

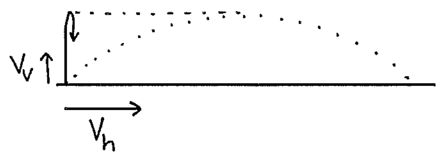
$\sin 50 = \frac{o}{h}$ = ___ = ___

v_v =

$\cos 50 = \frac{a}{h}$ = ___ = ____

v_h =

So if we project an object vertically up in the air with this vertical component it mimics the actual v___________________ position of the golf ball.



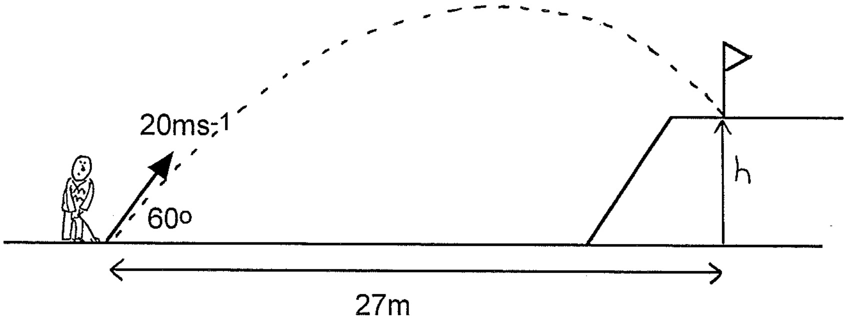
(b) Find the time the ball takes to reach the time highest point.

(c) Therefore find the time the ball is in the air.

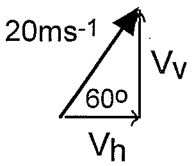
(d) Find the max height of ball.

(e) Find the horizontal distance travelled.

Ex 2 A golfer chips his ball onto a raised green as shown.



(a) Calculate the horizontal and vertical component of its initial velocity.



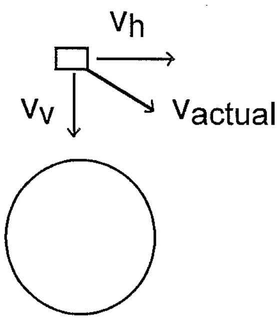
$\cos\theta$ = ―― = ―― V_h =

$\sin\theta$ = ―― = ―― V_v =

(b) How long was the ball in the air?

(c) What was the height of the green above the golfer. (Hint - what is vertical displacement after time found in b)

Satellite - projectiles in space



A satellite is an object which orbits another object. TV satellites orbit the Earth, the M______ orbits the Earth and the Earth orbits the _______. They are all satellites.

A satellite has 2 components of velocity. In the vertical the satellite is A____________________ towards the Earth.

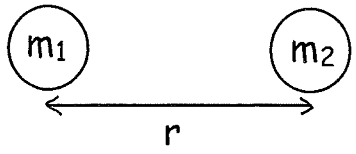
However it does not hit the Earth because it is given a H____________________ component.

The resultant motion is a projectile. If the Earth stopped moving horizontally it would fall into the sun.

8. The Universal Law of Gravitation

Although gravity is by far the weakest force in the universe it is the sculptor of the universe because, over billions of years, it managed to pull particles together to create stars, planets, and galaxies .

Newton devised a formula to calculate the gravitational force of attraction between any two objects of masses m_1 and m_2 which are a distance r apart.



$F = \frac{G\_\_\_\_\_\_\_\_}{}$

G = G__________________ constant .
( )

Gravitational force obeys the I___________ square law. ie if you double the distance between two objects the force Q__________________. NB we sometimes call this gravitational force an objects W___________.

It is important to note that these forces are not balanced forces as they are single forces being applied to different object. The reason why the Earth does not accelerate into the sun is that it is a S___________________ and therefore has a H____________________ component of velocity which means it O____________ the Sun.

Gravitational field strength g (Nkg^{-1})

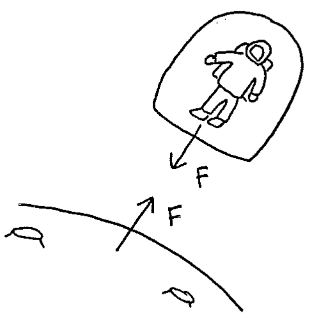
The gravitational field strength is the force acting on ___kg of mass placed at that point. So if you know the gravitational force on the object at that point and its mass you can find the force / kg or gravitational field strength. W = mg

An astronaut of mass 60kg floats around in a capsule orbiting Mars at a distance of

$r = 8.6\times10^6 m$ Mass of Mars = $6.4\times10^{23} kg$ $G = 6.67\times10^{-11} m^3kg^{-1}s^{-2}$

Find the gravitational force on him

$$F = \frac{Gm_1m_2}{r^2}$$



F = ______________________

F =

Therefore calculate the gravitational field strength at this height

W = mg $g = \frac{W}{m}$ = _______ =

9. Special Relativity

Newton's universe stated that time and space were constant and the speed of light depended on your motion. Einstein postulated that the speed of light is constant no matter what speed you are travelling at. For this to be true then T__________ and S__________ have to change to accommodate the speed of light being constant.

Einstein's special theory of relativity has 2 important points:

1. The speed of light is always measured at ____________________ no matter the speed of the observer.

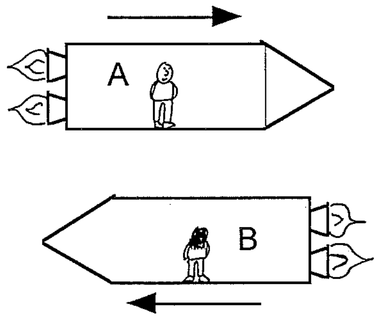
2. The laws of physics are the S_____________ for all observers.

Frames of reference

If you are stationary relative to another object **or** you are both moving together at the same velocity we say you are in the S__________ frame of reference. However if you move relative to an object you are in D________________ frames of reference

Time dilation

Two people A and B are in different frames of reference which are moving relative to each other. Both A and B will measure time passing in the other frame as longer than in their own. The time you measure in your own frame is the true time t. When you measure the time in the **other** frame this will be a longer or dilated time t'



Usually one frame is stationary and the other is moving past you at v.

$$t' = \frac{t}{\sqrt{\quad\quad}}$$

t' = D_____________time.
t = Time measured **in** observed frame B.
(T_____________ time)
v = velocity relative to observers frame
c = speed of L_______________.

A subatomic particle called a muon is created in the upper atmosphere. It travels at nearly the speed of light. The muon lasts for a fraction of a second before decaying. However a person at rest on Earth will measure its life span as L________________ because it is moving relative to the person on Earth.
So he will also measure its distance travelled as greater $d = v \times t'$. That is why we find some muons at the surface of the Earth.

Length contraction

Another implication of relativity is that objects moving relative to an observer appear S_________________ or contracted in direction of travel.

$$l' = l\sqrt{\qquad\qquad}$$

l' = C____________length
l = Length measured by observed frame.
(T___________ length)
v = velocity of observed frame
c = speed of L_____________.

These effects only become noticeable at speeds approaching the speed of L________.

Ex A spaceship's length measured on Earth is 60m long. On a mission it flies by the Earth at $2.4 \times 10^8 ms^{-1}$. On board an astronaut measures the time to finish his crossword as 30mins. Calculate the time and length measured by a stationary observer on Earth.

So true time t measured on board = ______mins

$$t' = \frac{t}{\sqrt{1 - \frac{v^2}{c^2}}} = \frac{\qquad}{\sqrt{\qquad}} = \frac{\qquad}{} =$$

So true length l measured on Earth or by astronaut on moving spacecraft = ____m

$$l' = l\sqrt{\qquad} = \_\_\sqrt{\qquad} = \_\_ \times \_\_\_\_\_\_ =$$

In 1905 Einstein included these ideas in a paper called the Special Theory of relativity. It was called special because it deals with only the special case - when objects move at constant or uniform velocity in straight lines. In 1916 he published another ground breaking paper called the General theory of relativity in which he tried to include gravity and acceleration.

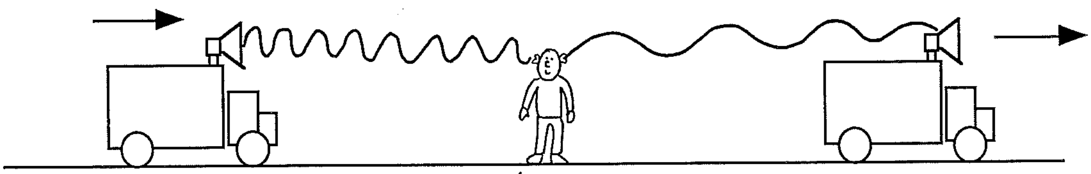
10. The Expanding Universe

The Doppler effect.

This is the effect where the frequency of the waves you observe which are being emitted from a source moving towards or away from you is different from the actual frequency the source produces. This effect is noticeable in S___________ and L___________ waves.

Doppler and Sound

An ambulance moving at a constant speed, produces a sound with a frequency of 300Hz



When an ambulance moves towards an observer the wavelength D___________ so M___________ waves enter his ear each S___________. So he hears the sound as a H_______________ frequency.

When the ambulance moves away from him the wavelength I_______________ so L___________ waves enter his ear each second. So the frequency heard D_______________

We can calculate the frequency heard by the stationary observer f_o using

$$f_o = fs\left(\frac{\quad}{\quad}\right)$$

fo = Freq heard by O_______________
fs = Freq of source if stationary.
v_s = speed of source
v = speed of sound ($340ms^{-1}$)

Ex An ambulance's siren creates a noise of frequency 800Hz. It travels past a stationary observer at a constant speed of $36ms^{-1}$. What frequency would the observer hear as it travelled away from him at this constant speed?

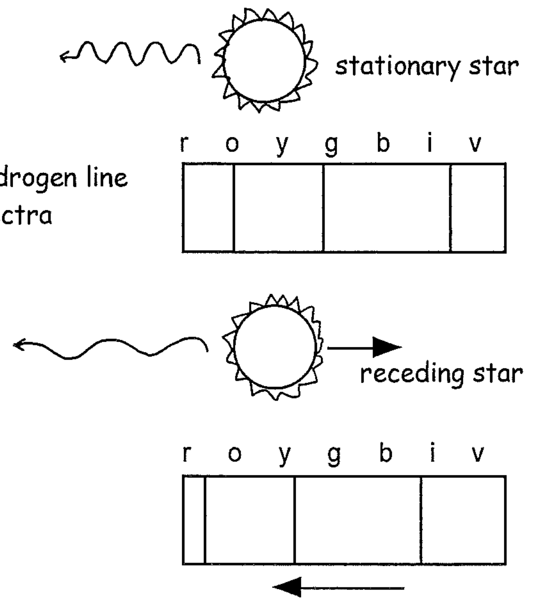
$$fo = fs\left(\frac{v}{v \pm v_s}\right) =$$

As it is moving Away from observer - use Add sign

As the ambulance travels away from observer the increase in freq stays constant as it is travelling away from him at a constant speed.

11. Red shift

If a star is moving away from us the wavelength of all the light being emitted from the star I__________. So a gas on the star may produce a photon of wavelength 500nm. But we observe it as 520nm. As the wavelengths observed are getting longer we say they are being moved or S____________ towards the longer R______ end of the spectrum. This diagram shows the line spectra for stationary hydrogen gas at the top, then the spectra for the gas moving away from you.



The magnitude of red shift is given by z the **red shift** in the equation:

$$z = \frac{\lambda_o - \lambda}{\lambda}$$

λ = actual emitted wavelength

λ_o = observed wavelength

If we know the red shift z we can find the velocity of the star relative to Earth.

$$z = \frac{v}{c}$$

v = velocity of the S__________
c = speed of L____________

When we look at the wavelengths of the light being emitted from most stars they show R_________ shift. So we can conclude that the universe must be E______________. Stars in the galaxy andromeda show B________ shift. This means that this galaxy is moving T__________________ us.

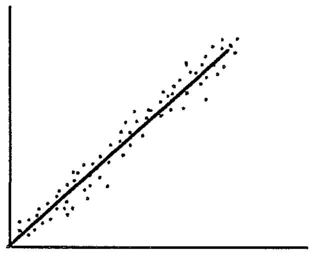
Ex The wavelength of a line in a gas spectra is 486nm. The same light is observed from a star and measured as 508nm. Calculate the recessional velocity of the star.

red shift $z = \frac{\lambda_o - \lambda}{\lambda}$ = $\frac{\quad}{\quad}$ =

$z = \frac{v}{c}$ therefore $v = z \times c$ = _____x__________ = __________

12. Hubble's Law

In the 1920s astronomer Edwin Hubble drew a graph of the receding velocity of the stars vs the distance they are from Earth and obtained almost a straight line through the origin



So Edwin concluded that the further away a star is the F____________ it is receding from us. So not only is the universe expanding but the rate of expansion is I____________________.

If you divide a velocity of a star by its corresponding distance d you will obtain a C_____________ value called the H_____________ constant H_0. A more accurate way of measuring Hubble's constant is to calculate the G__________________ of the line.

$$H_0 = \frac{v}{d}$$

v = recessional velocity of S_______.

d = D______________ of star from Earth.

H_0 = Hubble constant = $2.34\times10^{-18}s^{-1}$

Hubble also realised that if you know the rate of expansion of the universe you can rewind the clock and predict for how L_________ the universe has been expanding. Or in other words you can calculate the A________ of the universe.
Our best estimate is approximately 13.7 billion years.

Ex. A star is a distance of 12 light years from Earth. What is its recessional velocity.
First off- find the distance in m. So how far does light travel in 12 years?

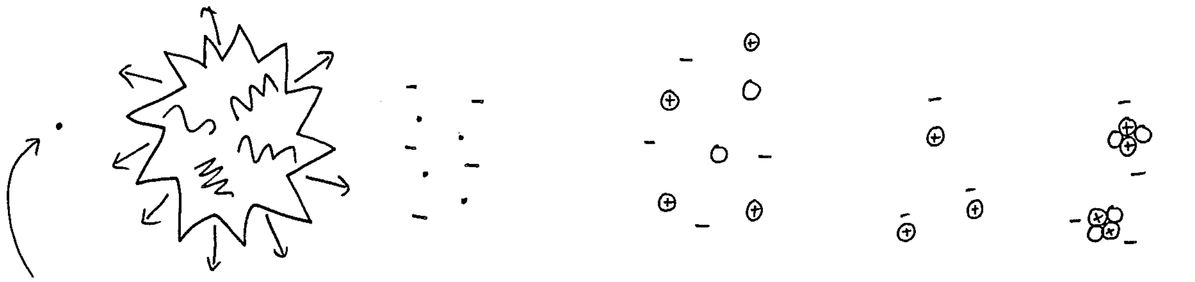
$d = v \times t = 3\times10^{8}ms^{-1} \times 12 \times 365 \times 24 \times 60 \times 60 = 378432000m$

$Ho = \frac{v}{d}$ therefore $v = Ho \times d = 2.3\times10^{-18} \times 378432000$

v = ________________

13. The Big Bang

So we know the universe has been expanding for 13.7 billion years, but from what?. Physicist believe that at one point 13.7 billion years ago all the universe we see around us (matter and light etc) was concentrated into a tiny space of Z________ volume called a singularity. Then this "point" started to rapidly expand. The initial part of the expansion was called the B_______ Bang where the universe was fantastically hot and dense. As the universe expanded it cooled and energy converted to mass. The mass started to lump together to form electrons and other subatomic particles, then protons and neutrons then H_____________ atoms then H_________ atoms......



singularity energy quarks/leptons protons/neutrons hydrogen helium

Evidence of Big Bang

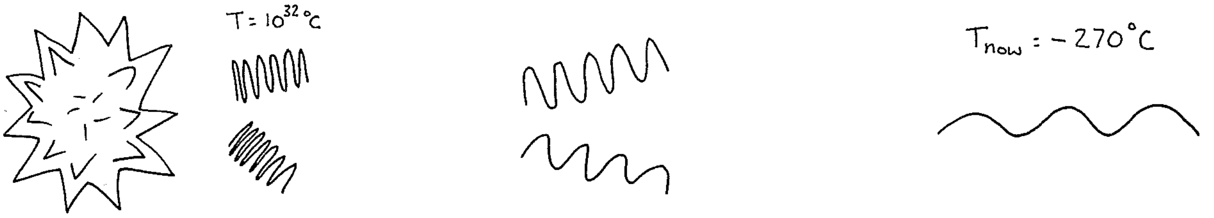
Red Shift

As we have seen, the gas from most stars exhibits a red shift in their spectra so are moving away from us, indicating that the U__________________ is expanding and therefore must have originated from a tiny P_________.

Cosmic Microwave Background radiation

Just at the big bang the temperature of the universe was incredibly H_________, so the frequency of electromagnetic waves being emitted would be very _________. (for example G_________ and X _______ rays). As the universe expanded and cooled these high frequency waves would be stretched and the wavelengths I______________.

After 13.7 billion years physicists predicted that the freq of this background radiation would be the order of microwaves. In 1965 we discovered a radiation coming from all points in space with frequencies of the order of m________________. This must be the remnants of this first radiation produced at the big bang.



Big Bang High freq waves freq decreases and wavelengths increase as universe cools and expands today - M_________

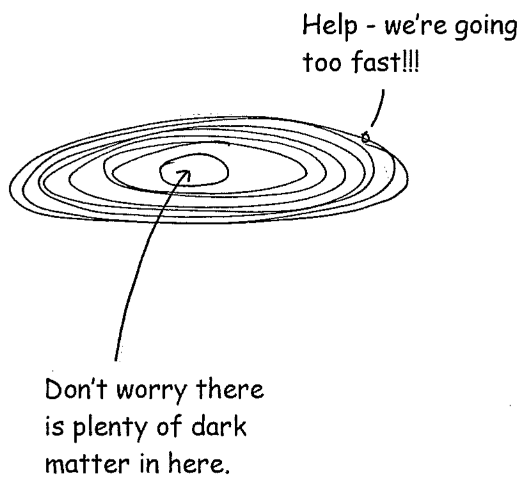
Where did all this Helium come from?

Helium is formed inside stars when H____________ atoms are squashed together due to the huge temperatures and pressures. However only 2% of the Helium we see in the universe was formed inside stars. So where was the other 98% made?
The only time and place where there was suitably high temperature and pressure to fuse hydrogen together to produce helium was during the B_____ B___________.
So all this extra H___________ in the universe is evidence of the big bang.

14. Dark matter and dark Energy

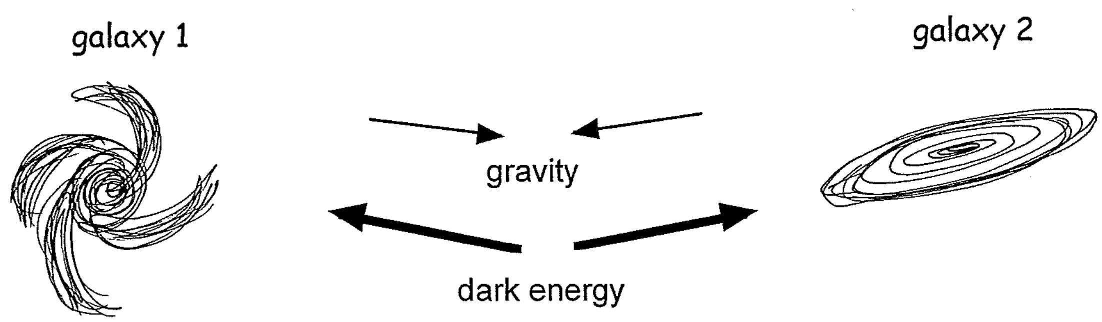
Dark Matter

The Earth orbits the sun because the sun has sufficient mass to create the gravity to stop the Earth travelling off into deep S__________. However if we look at Galaxies, there does not seem enough M_______ at the centre to create the gravity to allow the stars at the edge to spin as fast as they do.
We think the missing mass is provided by an invisible substance called D___________ matter.



Dark Energy

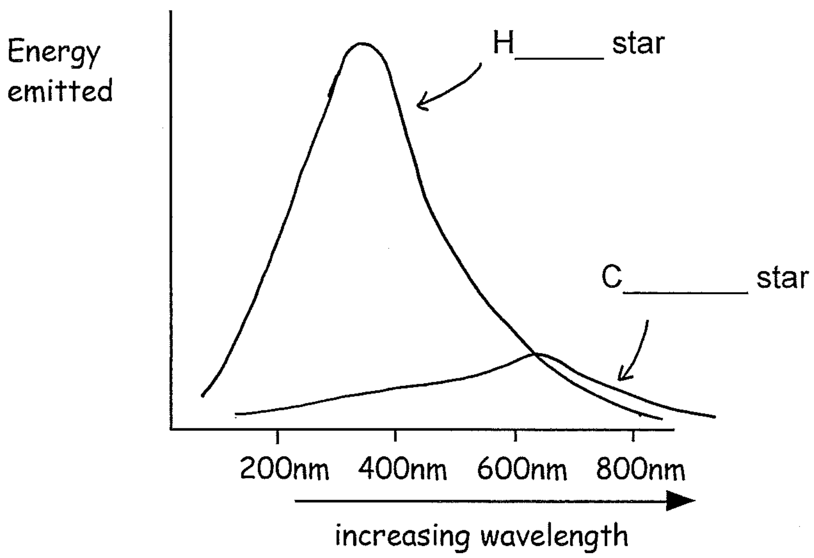
As the universe expands the gravity between the galaxies should slow this expansion down and maybe even S______ it. However from Hubble's Law the rate of expansion is increasing. We believe there is a substance called dark E______________ which exists in the space between galaxies. It has what is called a repulsive gravity. It is pushing the galaxies apart. We believe it is this Dark E___________________ which is responsible for the E____________________ of the universe.



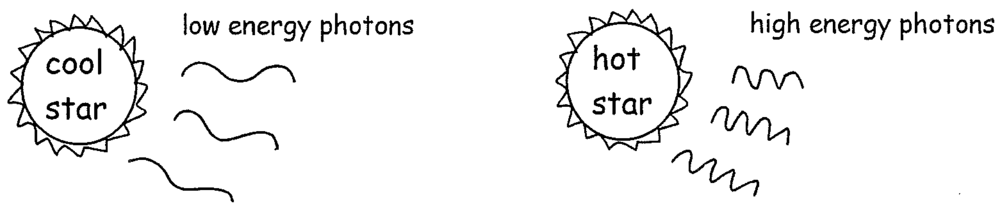
It is a sobering thought that only 4% of the universe is made from stuff we experience on a day to day basis - ordinary matter and light.
Dark matter accounts for 22% and dark energy 74% of the universe.

15. Star Radiation Diagrams

Stars give off radiation over a large range of wavelengths.
As stars get hotter they give off more of their radiation at increasingly S__________ wavelengths. So a cool star might give off more long wavelength or L______ frequency infra red radiation than anything else. However a very hot star may emit more of its radiation at short wavelength, H________ frequency UV. So as E=hf the star emitting its photons at UV will emit more energy than a star emitting the same number of photons at the low frequency infra red range. We can show this on this graph



So even if each star emits the same number of photons the total energy emitted by the hot star is greater because each of its photons have a higher frequency.. E = hf



The colour of a star tells you how h______it is. A bluey white star is very hot and uses up its fuel very Q___________. So these stars die out fairly quickly.
Our red/orange sun uses up its fuel at a slower rate and thus is not as hot and will thankfully last l________________. Red stars use fuel up so slowly they will be the last beacons of light in an increasingly black universe as galaxies expand apart.

We have an idea of the temperature at the Big Bang. Given Hubble's law and our understanding of how the universe expands and cools we can predict the T________________ of the universe today. If temperature created by all the stars in the universe today agrees with this figure we have further evidence for the B________ B__________