Farr High School

NATIONAL 4 PHYSICS

Unit 3
Dynamics and Space

Question Booklet

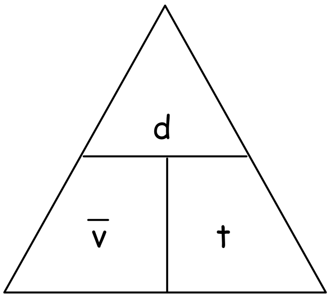
1. Average Speed

In this section you can use the equation:

$$\text{speed} = \frac{\text{distance}}{\text{time}}$$

also written as

$$\bar{v} = \frac{d}{t}$$



where **d** = distance is usually in metres (m)
$\bar{v}$ = average speed is usually in metres per second (m/s)
t = time is usually in seconds (s).

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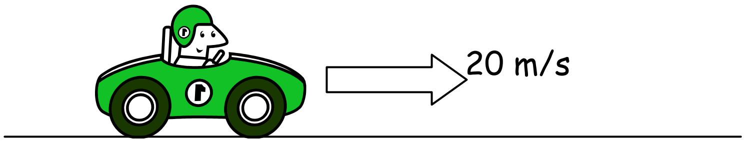
1. Copy and complete: distance = s _ _ _ _ x t _ _ _

2. A car is travelling with a steady speed of 20 m/s.

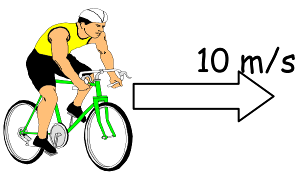


(a) How far does the car travel each second?
(b) How far will the car travel in 3 seconds?
(c) How far will the car travel in 10 seconds?

3. Nadia jogs to work every day with an average speed of 4 m/s.

(a) How far does she travel each second?
(b) How far will she travel in 5 seconds?
(c) How far will she travel in 100 seconds?
(d) It takes Nadia 600 seconds to jog to her work. What distance does she jog to her work?

4. A cyclist cycles with an average speed of 10 m/s.



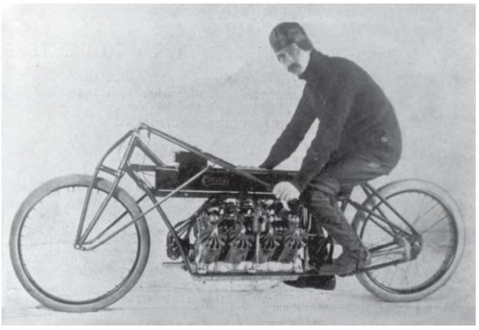
(a) How far does he cycle each second?
(b) What distance will he cover in 60 seconds?

5. A train's average speed is 200 km/h.
   (a) How far does it travel in 1 hour?
   (b) How far does it travel in 3 hours?

6. A jet aircraft flies at 400 m/s?
   (a) What distance will it cover each second?
   (b) What distance will it cover in 10 seconds?
   (c) What distance will it cover in 1 minute?
   (HINT: first you will need to change 1 minute into seconds.)

7. In 1889 the first Daimler car reached a speed of 20 km/h. How far would the Daimler car travel in $1\frac{1}{2}$ hours if it travelled at a constant speed of 20 km/h?

8. In 1907, Glenn Curtiss set an unofficial land speed record of 136 mph in a strange looking motorbike that he built himself, with a V8 aircraft engine.



   How many miles could Glenn Curtiss have covered in half an hour if he was able to maintain this speed for that long?

9. Copy and complete: average speed $= \dfrac{\text{d \_ \_ \_ \_ \_ \_ \_}}{\text{t \_ \_ \_}}$

10. A trolley travels 2m down a slope in a time of 1 second. What is the average speed of the trolley?

11. During a school sports day, Caitlin ran 60m in 10s. What was Caitlin's average speed?

12. A lorry takes 4 hours to travel 160 km. Calculate the average speed of the lorry in km/h.

13. In 2009, Usain Bolt broke the world record in the 100m sprint race with a time of 9.58s. What was his average speed?

14. Royal Airforce pilot, Andy Green, set the first "supersonic" land speed record in 1997 in Thrust SSC, a vehicle with 2 Rolls Royce turbofan engines. Andy covered 1000 m in 2.94 s. Calculate Andy's average speed.

15. During a triathlon event a competitor covers the 26 km course in 2 h.

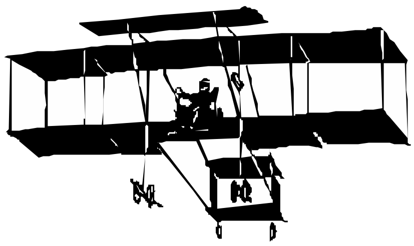
Swim 1 km

Cycle 20 km

Run 5 km

(a) Calculate the average speed of the competitor over the course.
(b) The competitor took half an hour on the cycle. What was his average speed in this section?
(c) Why is the competitor's average speed less than his cycle speed?

16. The Wright brothers were the first people to fly an aeroplane. Their first flight in 1903 lasted only 12 seconds and covered just 36 metres.



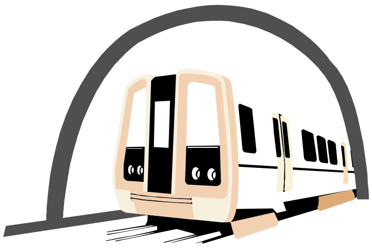
(a) Calculate the average speed of the plane during that first journey.
(b) Concorde was able to fly at Mach 2 (twice the speed of sound). How long would it have taken Concorde to travel 36 metres? (Speed of sound in air = 340 m/s)

17. Copy and complete: time = $\frac{\text{d \_ \_ \_ \_ \_ \_ \_}}{\text{s \_ \_ \_ \_}}$

18. A model train travels around 8 m of track at an average speed of $1{\cdot}6\ ms^{-1}$. How long does this take?

19. Christopher swims 50 m with an average speed of 2.5 m/s. How long does it take him to swim 50 m?

20. Calculate a hurdler's time if she completes the 400 m hurdle race with an average speed of 8 m/s.

21. 

The Channel Tunnel is approximately 50 km long.

(a) How long (in seconds) will it take a train travelling at 50 m/s to travel from one end of the tunnel to the other?
(HINT: 50 km = 50 000 m)

(b) What is this time in minutes?

22. A hill walker walks at an average speed of 4 km/h. How long will it take her to cover a distance of 20 km?

23. The French TGV train is one of the fastest commercial trains ever to operate. Its maximum speed is 270 km/h.

The TGV takes 2 hours to travel the 425 km between Paris and Lyon. Calculate its average speed for this journey in km/h.

24. Five pupils run a 200 m race. Their times are shown in the following table:

Pupil	**Time (s)**
Dave	28
Sarah	34
Frank	40
Eve	36
Lara	32

(a) Which runner had the greatest average speed over the 200 m?
(b) Calculate Frank's average speed.
(c) What would you use to measure the times taken?

25. The cheetah is the fastest mammal on earth. It can run at an average speed of 40 m/s but can only maintain this speed for short periods of time.

Calculate how far a cheetah could run in 12 seconds if it maintained an average speed of 40 m/s.

2. Instantaneous Speed

In this section you can use the idea that:

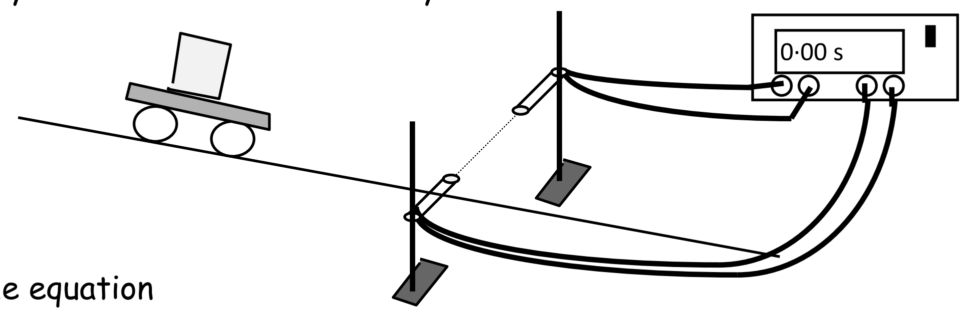
instantaneous speed = average speed over as short a time as possible

also written as

$$v_i = \frac{d}{t}$$

where v_i = instantaneous speed in metres per second (m/s)
d = object length (m)
t = time for object to pass a point in seconds (s).

1. The following experiment is used for measuring the instantaneous speed of a trolley as it travels down a runway.



Use the equation

$$\text{instantaneous speed} = \frac{\text{length of card}}{\text{time to cut beam}}$$

to find the missing values in the following table:

	instantaneous speed (ms^{-1})	*card length* (m)	*time* (s)
(a)		0·2	0·10
(b)		0·1	0·10
(c)		0·08	0.04
(d)		0.14	0·2
(e)		0.15	0·3
(f)		0·3	0.4

2. A car of length 3·5 m passes a student. The student records a time of 2·4 s between the front and the back of the car passing her.
Calculate the instantaneous speed of the car.

3. A runner decides to analyse his track performance in order to improve his overall running time during the 400 m event. He sets up light gates at six points round the track so that he can work out his instantaneous speed at each point.

$$\textbf{instantaneous speed} = \frac{\textbf{width of runner}}{\textbf{time to cut beam}}$$

The results he recorded are shown below.

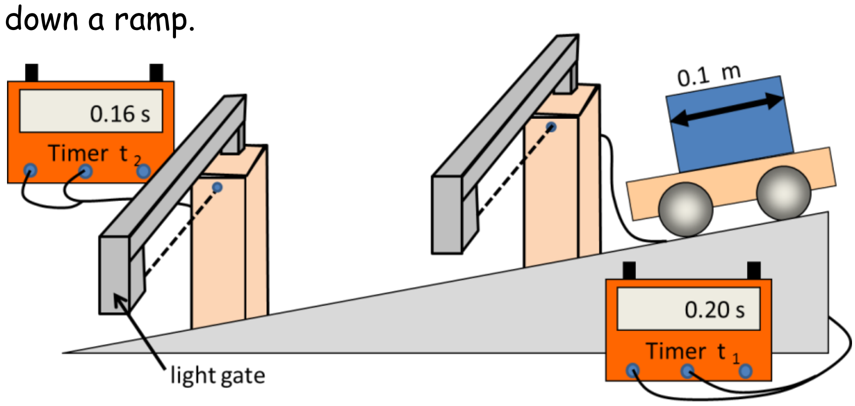
Position	*width of runner* (m)	*time* (s)	*instantaneous speed* (m/s)
A	0·2	0·025	
B	0·2	0·026	
C	0·2	0·030	
D	0·2	0·029	
E	0·2	0·025	
F	0·2	0·024	

Use the results to calculate his instantaneous speed at each position and state at which point is he running:

(a) fastest
(b) slowest

4. A train of length 150 m takes 1·42 s to enter a tunnel.
Calculate the instantaneous speed of the train.

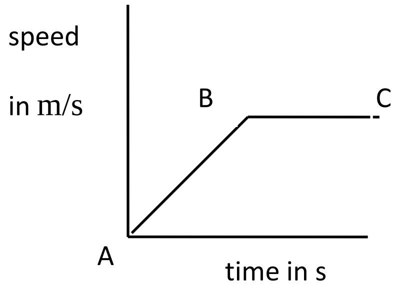
5. The following experiment is set up to investigate the change in speed as a trolley rolls down a ramp.



(a) Calculate the speed of the trolley at the top light gate.
(b) Calculate the speed of the trolley at the bottom light gate.

3. Speed - Time Graphs

Speed time graphs can be used to describe the motion of a vehicle.

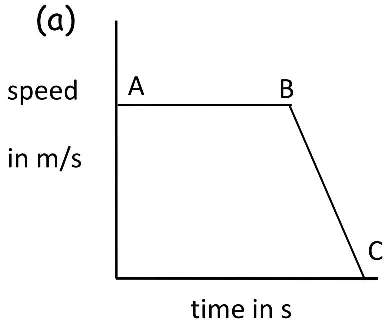


A→B: car accelerates from rest

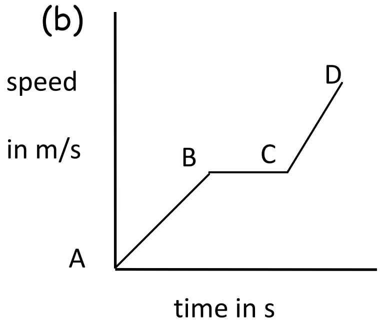
B→C: car travels at a constant speed

1. Describe the motion shown in each of the following speed – time graphs.

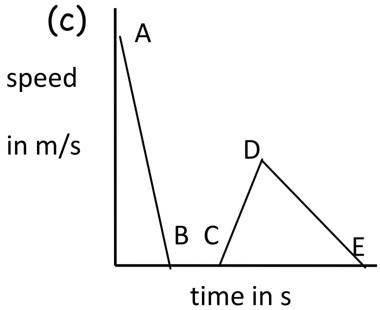
(a)



(b)



(c)



2. Draw speed time graphs to represent each of the following journeys.

(*a*)

time (*s*)	0	2	4	6	8	10	12
speed (*m/s*)	0	5	10	15	15	15	0

(*b*)

time (*s*)	0	1	2	3	4	5	6
speed (*m/s*)	0	20	40	30	30	10	0

(*c*)

time (*s*)	0	10	20	30	40	50	60
speed (*m/s*)	50	40	30	20	10	60	0

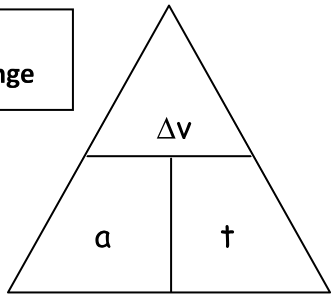
(*d*)

time (*s*)	0	5	10	15	20	25	30
speed (*m/s*)	0	100	150	175	200	200	0

4. Acceleration

In this section you can use the equation:

$$\text{acceleration} = \frac{\text{change in speed}}{\text{time taken for change}}$$



also written as

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

where

- Δv = change in speed in metres per second (m/s)
- **a** = acceleration in metres per second per second (m/s^2)
- **t** = time taken for change in speed in seconds (s).

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1. What is the missing word in the following statement:

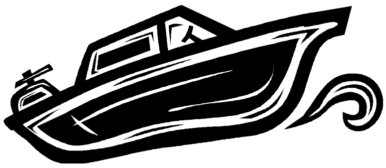
   "The change in speed of an object each second is its ___________ "

2. A car travels from 0 to 10 m/s in 3 seconds.
   A motorbike travels from 0 to 10 m/s in 2 seconds.
   Which one has the greatest acceleration?

3. A car, starting at 0m/s, gets faster by 4 m/s every second.
   (a) What is the speed of the car after 1 second?
   (b) What is the speed of the car after 2 seconds?
   (c) What is the speed of the car after 3 seconds?
   (d) What is the "acceleration" of the car?

4. A porche accelerates from 0 m/s to 20 m/s in 2 seconds.
   (a) What was its change in speed over the first second?
   (b) What was its change in speed between 1 s and 2 s?
   (c) What is the "acceleration" of the porche?

5. A motor boat accelerates from rest (or 0 m/s) to 12 m/s in 4 seconds.
   What is its change in speed each second?

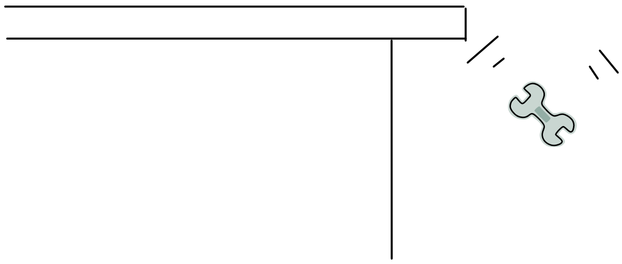


6. Car performance figures for "Feline Cars Ltd." Are shown in the table:

Model	**Time in seconds (0mph to 60mph)**
Cheetah	5.4
Leopard	6.2
Panther	6.8
Lion	8.1
Tiger	8.5

(a) Which model has the greatest acceleration?
(b) How long did it take the lion to reach 60 mph?
(c) How long would it take the Panther car to reach 120 mph from rest if it kept accelerating at the same rate?
(d) Which car would take 16.2 s to go from 0 mph to 180 mph?

7. Gravity causes falling objects to get faster by 10 m /s each second.
A spanner is blown off the top of a high building as shown.



(a) What is the speed of the spanner after it has been falling for 1 second?
(b) What is the speed of the spanner after it has been falling for 4 seconds?
(c) Why do you think the spanner might not actually reach this speed after 4 s?

8. Find the missing values in the following table .

	Acceleration **(m/s^2)**	***Change in Speed*** **(m/s)**	***Time taken*** **(s)**
(a)		12	6
(b)		20	5
(c)		9	180

9. A car, starting from rest, reaches a speed of 15 m/s in a time of 30 seconds. Calculate the acceleration of the car.

10. A sprinter in a race crossed the finishing line with a speed of 14 m/s. If her sprint time was 16 seconds, what was her acceleration?

11. A ball is dropped from the roof of a building. What is the acceleration of the ball if its speed is 30 m/s after 3 seconds?

12. A lorry increases its speed from 5 m/s to 15 m/s in 40 seconds.
    (a) What is the change in speed of the lorry?
    (b) Calculate the acceleration of the lorry.

13. A train increases its speed from 15 m/s to 25 m/s in a time of 8 seconds.
    (a) What is the change in speed of the train?
    (b) Calculate the acceleration of the train.

14. Calculate the acceleration of a bus that takes 10 s to go from 5 m/s to 20 m/s.

15. Calculate the acceleration of a jet that takes 10 s to go from 0 m/s to 90 m/s.

16. A downhill skier takes 3 s to go from 20 m/s to 26 m/s. What is the acceleration of the downhill skier?

17. A truck starts to **"decelerate"** at a rate of 2 m/s^2. If the truck was moving at 15 m/s, what do you think its speed will be after
    (a) 1 second of deceleration?
    (a) 3 seconds of deceleration?

18. A skateboarder travelling at 8 m/s starts to decelerate as he moves up a ramp. What is his deceleration if it takes him 2 seconds to stop?

19. A ball rolling up a hill slows down at a rate of 3 m/s^2. If the ball's speed at the start of the hill was 7.5 m/s, what will be its speed after 2 seconds on the hill?

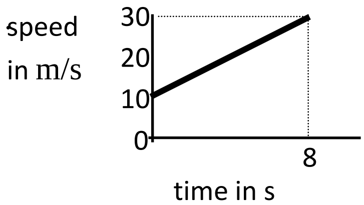
20. Explain, in your own words, the meaning of the word "acceleration".

5. Speed – Time Graph Calculations

Helpful Hint

Speed - time graphs can be used to calculate the **acceleration (a)** of an object.

e.g



From the graph: initial speed = 10 m/s

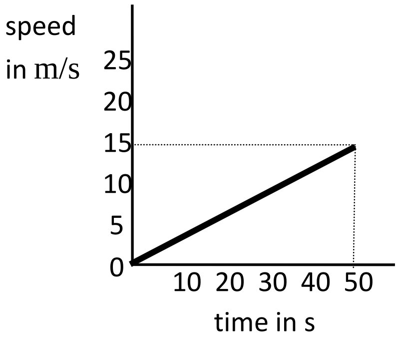
final speed = 30 m/s

time taken (t) = 8 s

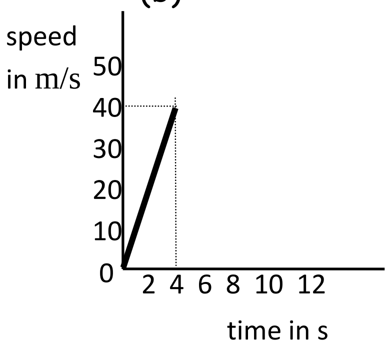
So, using: $a = \frac{\Delta v}{t}$ $\quad a = \frac{20}{8}$ $\quad = \mathbf{2{\cdot}5\ m/s^2}$

1. Use the graphs below to calculate the **acceleration** over the interval shown in bold.

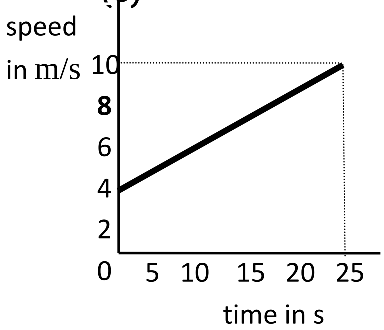
(a)



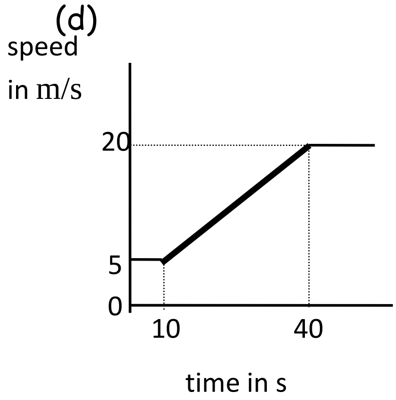
(b)



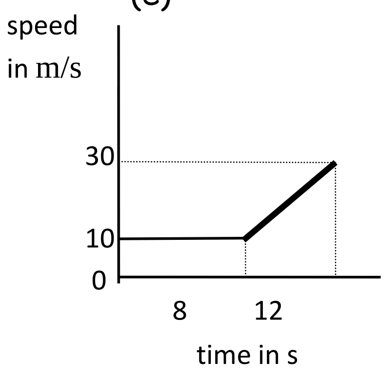
(c)



(d)



(e)



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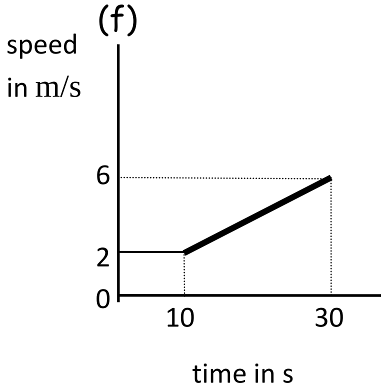
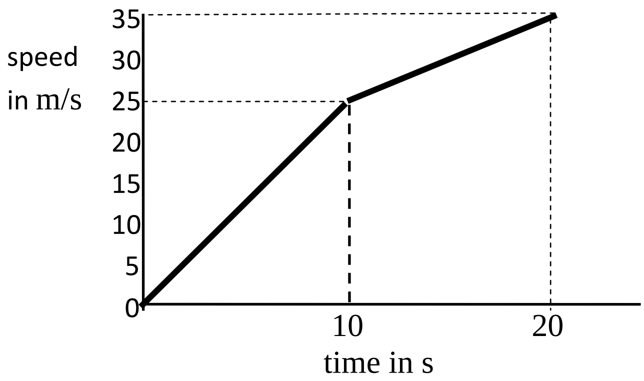


2. This graph shows the journey of a car over a 20s interval.

Calculate the acceleration of the car between:

(a) 0 and 10 seconds

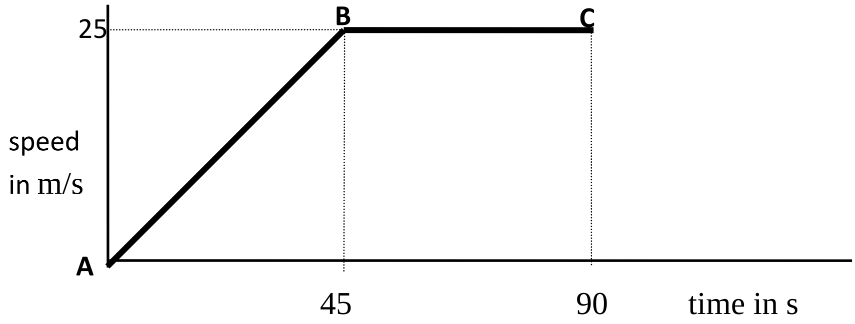
(b) 10 and 20 seconds.



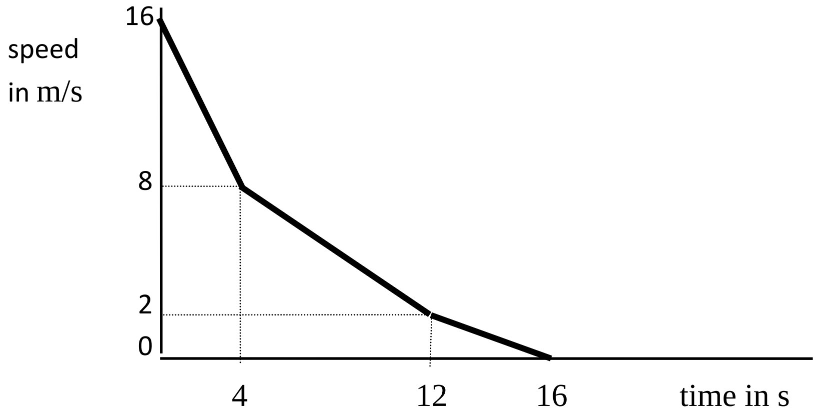
3. Use the speed - time graph below to calculate the acceleration between:

(*a*) A and B

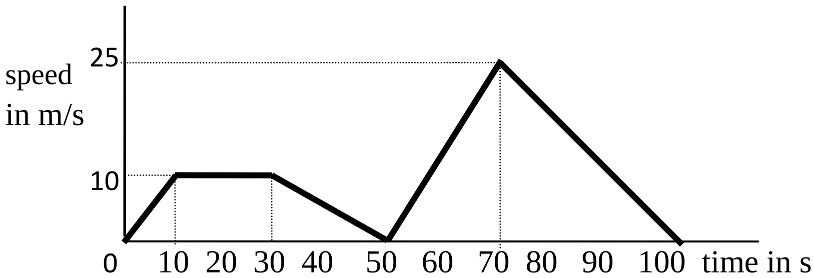
(*b*) B and C.



4. A car changes from 4th to 3rd to 2nd gear as it approaches traffic lights. The speed - time graph representing the car's motion is shown below. Use the graph to calculate the **deceleration** of the car in each gear.



5. Lorry drivers use tachographs to record information about their journeys. A section of one journey is represented by the the graph below.



(a) During what time interval was the lorry's **acceleration** greatest?

(b) When was the lorry stationary?

(c) Calculate the **deceleration** of the lorry before if finally stopped.

Using speed - time graphs to calculate distance.

Helpful Hint

To work out the distance travelled by an object during an acceleration or deceleration you must use:

distance = area under speed – time graph

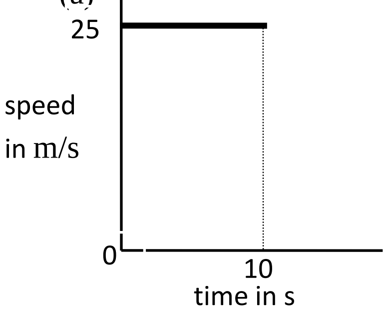
You **cannot** use:

distance = speed x time.

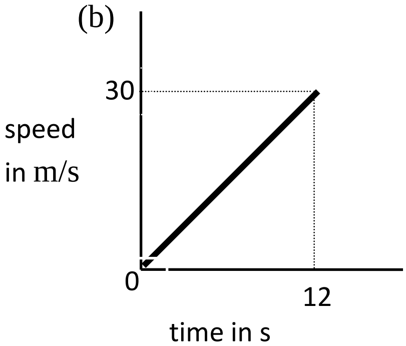
as this is **only** for objects travelling at a constant speed.

6. Use the speed - time graphs below to calculate the total distance travelled.

(a)



(b)



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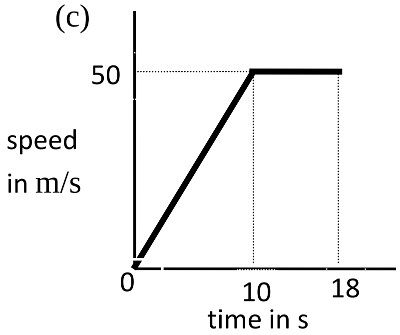

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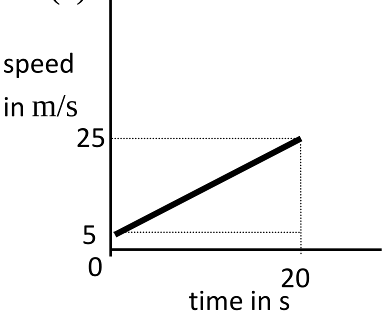

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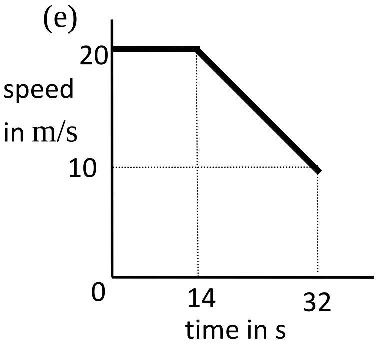
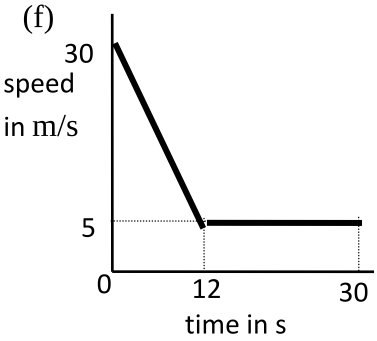


(f)



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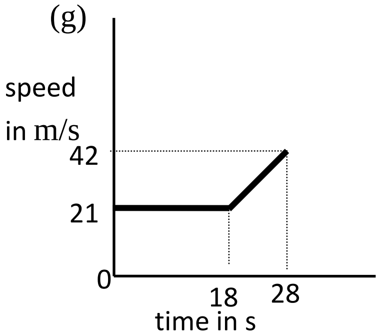

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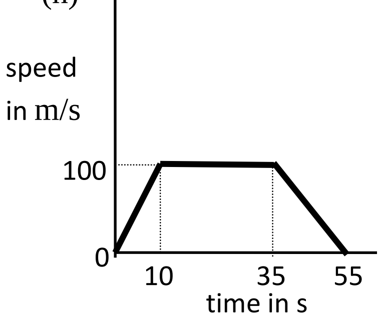
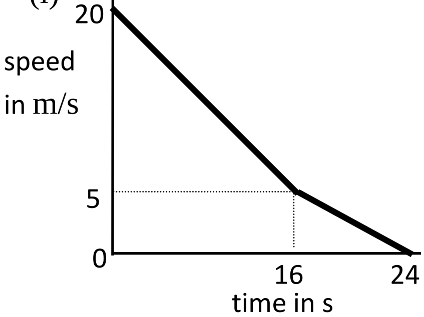
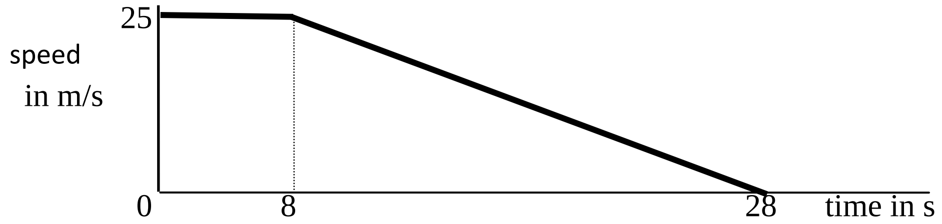


(i)



7. While driving along a motorway a driver spots an accident and brakes. The graph below represents the motion of the car from the instant the driver sees the accident.



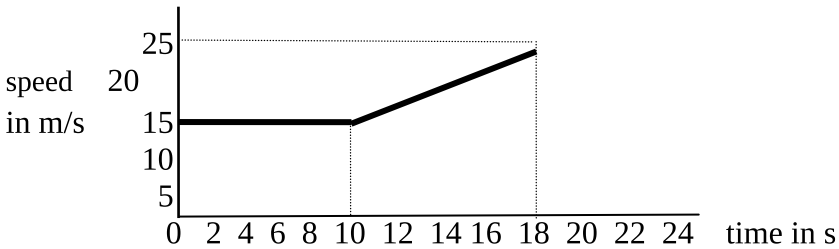
(a) When did the driver brake?
(b) Calculate how far the car travelled before braking.
(c) Calculate how far the car travelled after the driver braked.

8. Draw a speed - time graph to represent the following motion of a train leaving a station.

time (*s*)	0	10	20	30	40	50	60	70	80	90
speed (m/s)	0	5	10	15	20	25	25	25	30	30

Use the graph to calculate:
(a) the acceleration of the train during the first 50 seconds
(b) the distance travelled by the train in 90 seconds.

9. A hang glider is cruising at a speed of 15 m/s then dives.



(a) State when the dive started
(b) Calculate how far he travelled during the dive.

10. Explain, in your own words, how to find the distance travelled from a speed – time graph.

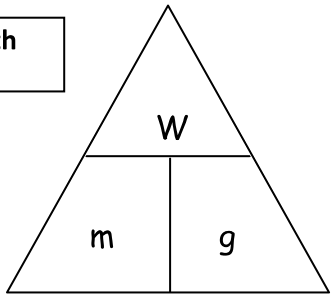
6. Mass and Weight

In this section you can use the equation:

weight = mass x gravitational field strength

also written as

W = m g



where **W** = weight in newtons (N)
m = mass in kilograms (kg)
g = gravitational field strength in newtons per kilogram (N/kg).

---

1. Find the missing values in the following table.

	Weight (N)	*Mass* (kg)	*Gravitational field strength* (N/kg)
(a)		300	10·0
(b)		0·6	3·7
(c)		0·2	11·7
(d)	230		10·0
(e)	1 680		11·7
(f)	69	6·0	

2. Calculate the weight, in N, of each of the following on Earth where the gravitational field strength is approximately 10 N/kg :
   (a) a girl whose mass is 50 kg
   (b) a dog of mass 20 kg
   (c) a 9 kg box
   (d) a ball of mass 0·5 kg

3. Each of the following weights was measured on Earth where the gravitational field strength is approximately 10 N/kg. Calculate the mass, in kg, of each object.
   (a) a man who weighs 750 N
   (b) a tin of peas which weighs 4·5 N
   (c) a chair which weighs 350 N

4. The mass of a puncture repair kit is 0.03 kg. What is its weight on Earth?

5. Calculate the weight on Earth of a postcard which has a mass of 0.002 kg.

Information

Here are the approximate gravitational field strengths for various planets and the Sun and Moon.

	approximate gravitational field strength (N/kg)
Earth (major planet)	10
Jupiter (major planet)	26
Mars (major planet)	4
Mercury (major planet)	4
Moon	1·6
Neptune (major planet)	12
Saturn (major planet)	11
Sun	270
Venus (major planet)	9
Uranus (major planet)	11·7
Pluto (dwarf planet)	4·2

6. What does a 0.5 kg packet of cornflakes weigh:
(a) on Earth (b) on the Moon (c) in Space?

7. An astronaut has a weight of 800 N on Earth.
What is his mass:
(a) on Earth
(b) on the Moon
(c) in Space?

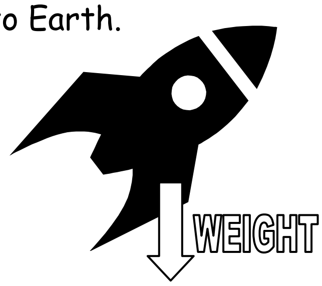
8. A question in a Physics examination asked, 'What is meant by the weight of an object?'
Two pupils, Steven and Nicola, answered as follows :

Steven - 'The weight of an object is the gravitational field strength.'
Nicola - ' The weight of an object is the force acting on the object due to gravity.'

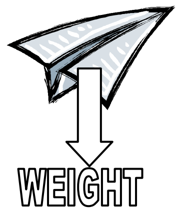
(a) Who was correct?
(b) What does the term 'gravitational field strength' mean?

9. A lift has a weight of 9 000 N on Earth.
   (a) What force, caused by gravity, acts downwards on the lift?
   (b) What is the mass of the lift?

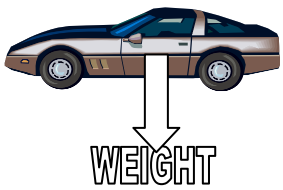
10. A rocket of mass 2 000 000 kg travels from Saturn to Earth.
   (a) What is the weight of the rocket on Saturn?
   (b) What is the weight of the rocket on Earth?



11. A paper aeroplane has a mass of 0.01 kg.
   (a) What is the weight of the paper aeroplane on Earth?
   (b) What is the force, caused by gravity, acting downwards on the paper aeroplane on Earth?
   (c) What is the gravitational field strength on Earth?



12. A car weighs 13 000 N on Earth.
   (a) What is the mass of the car?
   (b) What size is the downwards force on the car, caused by gravity?

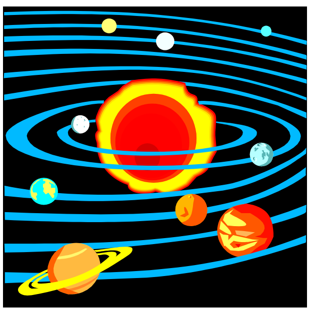


13. A small tin of oil has a mass of 0.3 kg.
   (a) What does the tin of oil weigh on Earth?
   (b) What would be the mass of the tin of oil on Jupiter?

14. A man has a weight of 700 N on Earth.
   (a) What is his mass on Earth?
   (b) What is his mass on Neptune?

15. Look at the table of gravitational field strengths on p.16.

   (a) On which major planet would you be able to jump the highest?
   (b) Which major planet has the greatest gravitational field strength?
   (c) Why is the Sun's gravitational field strength much bigger than the gravitational field strength of a planet?

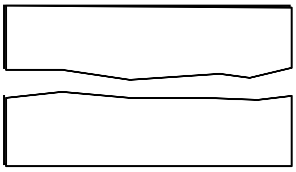


7. Friction

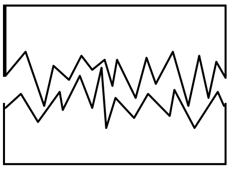
1. What do two surfaces have to do to create the force called friction?

2. Does friction try to stop surfaces moving, or make the surfaces move faster?

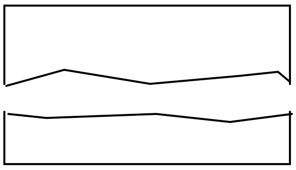
3. Here are 3 pictures of touching surfaces:



Picture 1.



Picture 2.

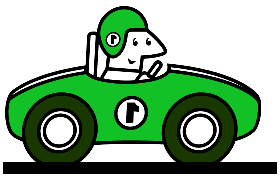


Picture 3.

   (a) Which picture shows the surfaces that would have most friction if you tried to move them over each other.
   (b) Explain your answer.

4. In these pictures, write down the surfaces which are rubbing together to create friction.

   (a)


   (b)


   (c)


5. Friction is sometimes very useful (good) and sometimes a pain (bad). For each of the following examples, state whether friction is **<u>good</u>** or **<u>bad</u>**.

   (a) Friction between car tyres and the road.
   (b) Friction between your shoes and the ground.
   (c) Friction between skis and snow.
   (d) Friction between a climber's rope and hands.
   (e) Friction between a speed boat and the surface of the water.

6. Friction can be reduced on rough surfaces by **smoothing** or **separating** the surfaces.
For each diagram below, state how friction between the surfaces is being reduced.

Diagram A

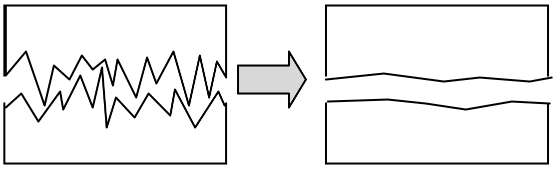
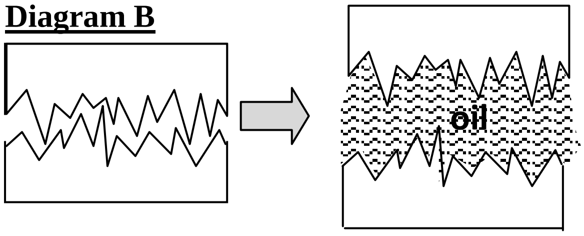


Diagram B



7. A foot in contact with the ground produces a lot of friction. How is an ice skater's boot designed to reduce friction.

8. For each of the following, suggest how friction can be reduced.

(a) A stiff door hinge.
(b) The design of a fast car.
(c) Snow boards on snow.
(d) An air hockey puck on its table.

9. For the following situations where friction is useful, suggest how friction can be increased.

(a) Cars sliding on icy roads.
(b) Vehicles having to stop at dangerous juctions.
(c) Farm vehicle tyres sliding in the mud.
(d) A gymnast's hands sliding on the bars.

10. Objects can be "**streamlined**" in order to reduce friction.

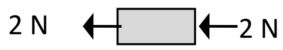
(a) State 3 ways that a vehicle can be streamlined.
(b) Describe how a cyclist can make himself streamlined.

8. Newton's First Law

An object will stay at rest or keep moving in a straight line at a constant speed if balanced forces are acting on it.

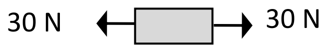
1. Which of the following diagrams show balanced forces?

(a)

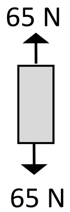


(b)

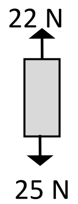
(c)



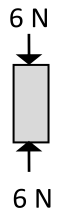
(d)



(e)



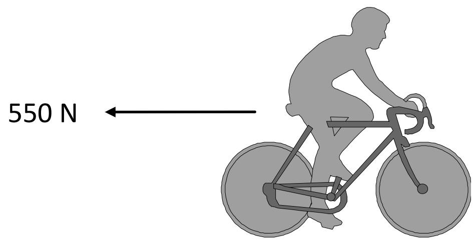
(f)



2. A fully loaded oil super-tanker moves at a constant speed of 12 m/s. It's engines produce a constant forward force of 16 000 N. What is the size of the friction force acting on the tanker?

3. A clock hangs from a peg on a wall. If the weight of the clock is 2 N what is the size of the upward force provided by the peg?

4. David cycles along the road at a constant speed of 8 m/s. The total friction force acting on David and the bike is 550 N.



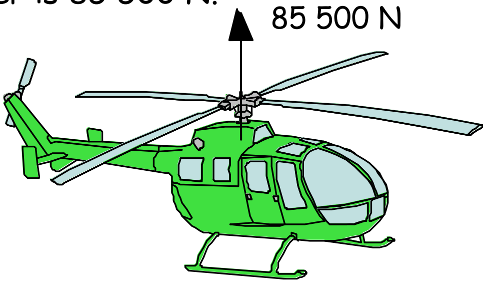
What size is the forward force provided by David pedalling?

5. A crane holds a concrete slab of mass 750 kg at a steady height while workmen prepare to position it on the building they are constructing.

(a) What is the weight of the concrete slab?

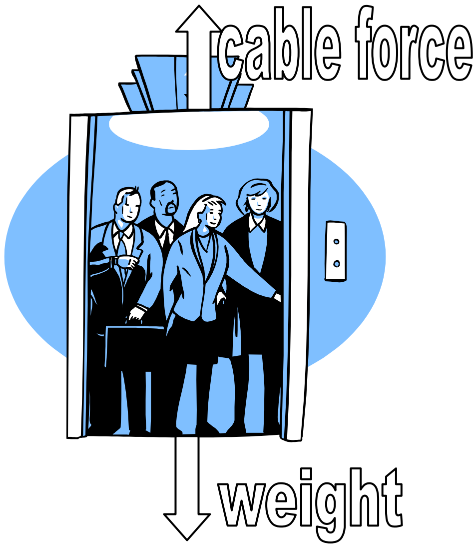
(b) What is the upward force produced by the crane cable?

6. A helicopter is hovering at a constant height of 35 m. The upward lift force on the helicopter is 85 500 N.



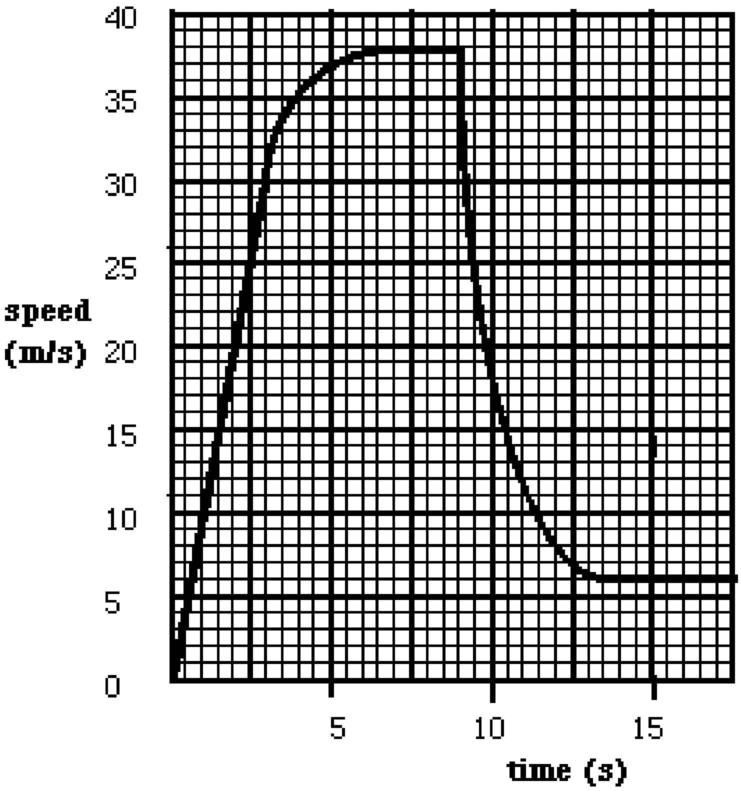
(a) What is the weight of the helicopter?
(b) Calculate the mass of the helicopter.

7. A lift travels upwards at a constant speed of 4 m/s. The mass of the lift is 800 kg and it is carrying a total mass of 153 kg.



(a) Calculate the total mass of the lift and its load, in kg.
(b) Calculate the total weight of the lift and its load, in N.
(c) Determine the upward force from the lift cable as the lift travels upwards with a steady speed?
(d) Determine the upwards force from the lift cable when the lift is stopped at the second floor?
(e) The maximum force the lift cable can provide is 16 400 N. What is the maximum possible weight of lift and passengers?
(f) What is the maximum mass the cable can hold?
(g) If an average person has a mass of 70 kg what is the maximum number of people the lift can carry?

8. David is doing a parachute jump to raise money for charity. The graph below shows his speed at different points in his journey. Use this graph to answer the questions below.



(a) During what times was David travelling at a constant speed?

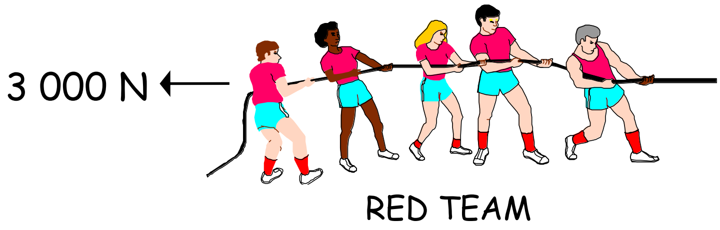
(b) At what time did David open his parachute?

(c) Describe the forces acting on David 15 seconds after he jumped out of the plane.

(d) 15 seconds after jumping out of the plane the friction force acting on David was 745 N, upwards. Calculate David's weight in Newtons.

(e) Calculate David's mass in kg?

9. In a tug of war game, the red team pull the blue team with a force of 3 000 N to the left. The two teams remain stationary.



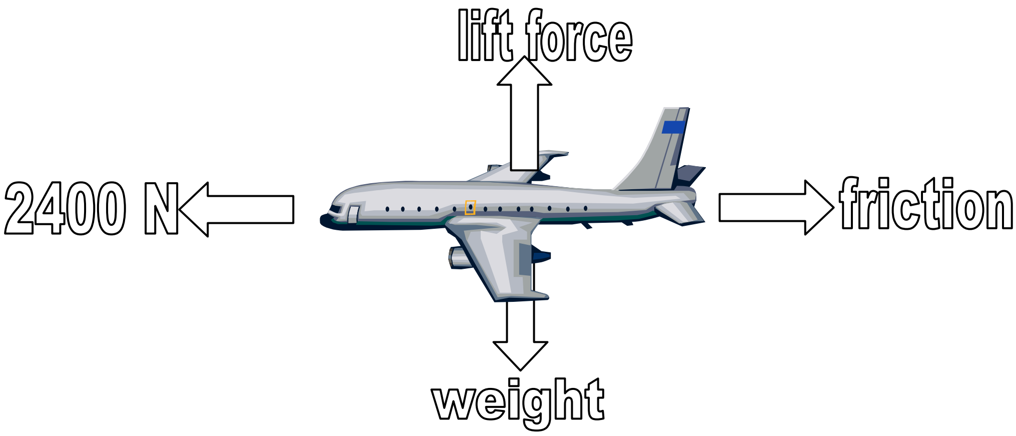
(a) What is the size and direction of the force exerted by the blue team on the red team?

(b) Each member of the red team can pull with an average force of 250 N. Calculate how many people there are in the red team.

(c) One of the members of the red team sprains her ankle and has to leave the game. What would be the force exerted by the red team now?

(d) What would happen now?

10. An aeroplane travels with a constant speed of 300 m/s at a height of 10 000 m. The mass of the aeroplane is 58 000 kg and the engine provides a forward force of 2 400 N.



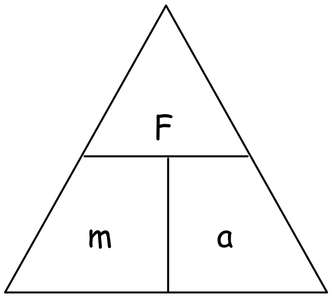
(a) Calculate the weight of the plane.

(b) What size is the frictional force acting on the aeroplane?

(c) What size is the lift force acting on the plane at this height?

9. Newton's Second Law

In this section you can use the equation:



force = mass x acceleration

also written as

F = m a

where **F** = unbalanced force in newtons (N)
m = mass in kilograms (kg)
a = acceleration in metres per second per second (m/s^2)

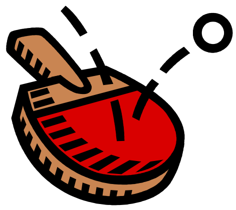
---

1. Copy and complete: force = m _ _ _ x a _ _ _ _ _ _ _ _ _ _ _ _ _

2. Calculate the force required to accelerate a mass of 12 kg at 2 m/s^2.

3. Calculate the force required to accelerate a 1 000 kg car at 5 m/s^2.

4. A table tennis ball of mass 0.03 kg is found to accelerate at 150 m/s^2 when hit with a bat. Calculate the force causing the ball to accelerate.



5. A car of mass 1 200 kg is accelerating at 3 m/s^2. Calculate the unbalanced force acting on the car.

6. What engine force must be produced by a rocket of mass 3 000 000 kg in order to produce an acceleration of 1·4 m/s^2 in space?

7. Copy and complete: acceleration = $\frac{f\_\_\_\_}{m\_\_\_}$

8. If an unbalanced force of 500 N is applied to a mass of 20 kg, calculate its acceleration.

9. A man pushes a trolley of mass 25 kg with a force of 25 N. Calculate the acceleration of the trolley.

10. A fork lift truck applies a force of 200 N to move a crate of mass 400 kg. Calculate the acceleration of the crate.

11. Calculate the acceleration of a steel ball bearing of mass 0.1 kg when fired with a force of 1·5 N in a pin ball machine.

12. The engine of a space shuttle can produce a force of 600 000 N. The mass of the shuttle is 800 000 kg. Calculate the acceleration of the shuttle in space.

13. $$\text{mass} = \frac{f \text{ \_\_\_\_}}{a \text{ \_\_\_\_\_\_\_\_\_\_\_\_}}$$

14. Find the mass of a boy and his bike if they accelerate at 1·5 m/s^2 when pushed with a force of 75 N.

15. A car experiences a force of 500 N making it accelerate at 0·25 m/s^2. What is the mass of the car?

16. A car accelerates at 0·6 m/s^2 when a force of 550 N acts on it. Determine the mass of the car to the nearest kg.

17. A ball's weight of 5N causes it to accelerate at 10 m/s^2 as it falls. Calculate the mass of the ball.

18. A trolley in a Physics lab accelerates at 2 m/s^2 when an unbalanced force of 8 N is applied to it. Calculate the mass of the trolley.

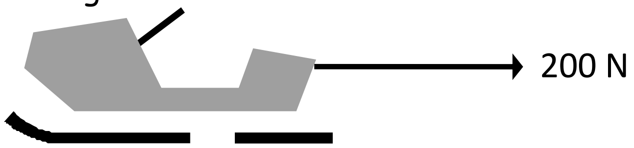
19. Find the missing values in the following table.

	***Force* (N)**	***mass* (kg)**	***acceleration* (m/s^2)**
(a)		2	4
(b)	20	0·2	
(c)	900		10

20. A ship of mass 10 000 000kg is accelerated by a force of 3 200 000N. Calculate the size of the acceleration.

21. An oil tanker of mass 150 000 000 kg accelerates at 2 m/s^2. Calculate the unbalanced force required to cause this acceleration.

22. A 70 kg sledge is pulled along as shown below



Calculate the acceleration of the sledge.

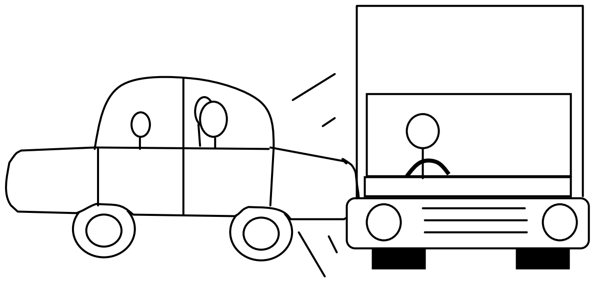
23. A car of mass 1 200 kg is accelerated from rest to 8 m/s in 8 s.
Calculate:
(a) the acceleration of the car (using $a = \Delta v / t$)
(b) the unbalanced force required to produce this acceleration.

24. A motorbike is accelerated from rest to 60 m/s in 16 seconds.
The unbalanced force required to achieve this is 1 200 N.
Calculate
(a) the acceleration of the motorbike
(b) the mass of the motorbike.

25. A bike is pushed from rest to a speed of 3 m/s in 2·5 seconds.
The total mass of the bike and rider is 100 kg.
Calculate
(a) the acceleration of the bike
(b) the force required to produce this acceleration.

10. Car Design – Safety & Speed

1. A car is travelling at 30 mph when it collides with a van that came out of a side road. A passenger in the car was not wearing a seatbelt.



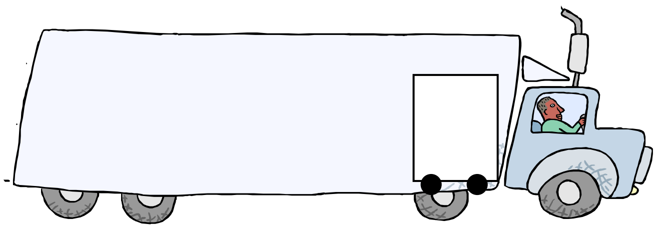
   (a) Describe the likely motion of the passenger from the moment the car hits the van.

   (b) Which law of Physics explains the fact that the passenger did not stop with the car?

   (c) Explain how a seatbelt on the passenger would have acted as a safety device.

2. It is very important that removal lorries secure goods tightly inside the lorry. This is important for moving off as well as for stopping.

   The lorry in the picture below contains a cabinet on wheels. The driver decided to put the cabinet at the front of the lorry so it would be held in place when he stopped. That way, he thought, he wouldn't need to bother tying it down.



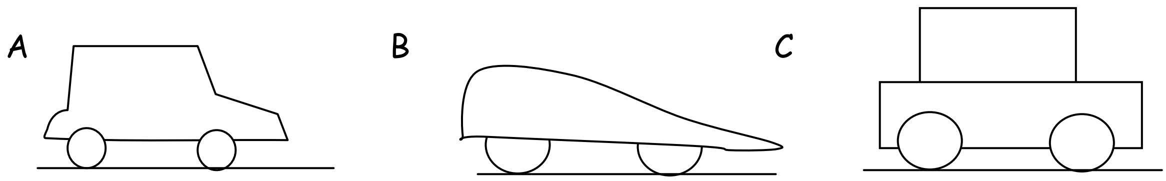
   Explain what will happen to the cabinet as the driver accelerates from rest.

3. Air bags are very common features of cars nowadays.

   (a) Explain, in terms of forces, how an air bag can help to protect lives.

   (b) Airbags should be deactivated if young children or babies are sitting in the front seat.
   Give a reason for this.

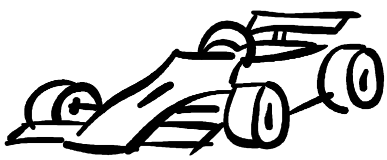
4. Look at these 3 car designs.



   (a) Which car design will cause least friction as it cuts through the air?
   (b) What word describes how this car is designed?

5. Fast cars often have “spoilers”.
   (a) Explain how a spoiler helps a car to go faster.
   (b) Does a spoiler increase or decrease friction between the road and the tyres?

6. Use the internet to research the design of fast cars.
   List as many design features as you can that help to make these cars so fast.
   For each design feature, explain how it helps to improve the performance of the car.
   Present your findings as a poster or powerpoint presentation.



11. Satellites

In this section you can use the average speed equation which you have already met:

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

Where **v** = signal speed in metres per second (m/s)
d = distance in metres (m)
t = time in seconds (s)

Helpful Hint
Radio waves, television waves and microwaves are all electromagnetic waves which travel at a speed of 3 00 000 000 m/s through space.

1. A telecommunication satellite is in an orbit 36 000 **km** above the surface of the Earth. A microwave signal is sent from a ground station directly below the satellite.

   (a) How many metres are in 36 000 km?
   (b) What is the speed of the microwave signal?
   (c) How long it would take the signal to travel this distance?

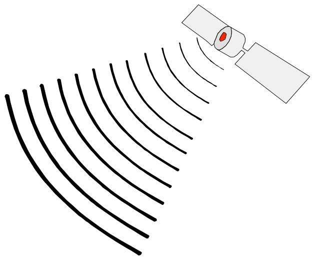
2. A dish aerial is used to transmit a microwave signal to a spy satellite. The distance to the spy satellite is 20 000 km.

   (a) How many metres are in 20 000 km?
   (b) What is the speed of the signal?
   (b) How long will it take this signal to travel to the satellite?

3. A dish aerial at a ground station collected a signal transmitted by a satellite. The signal took 0·15 s to reach the dish aerial.

   (a) What was the speed of the signal?
   (b) How far away was the satellite from the ground station in metres?
   (c) What is this distance in km?

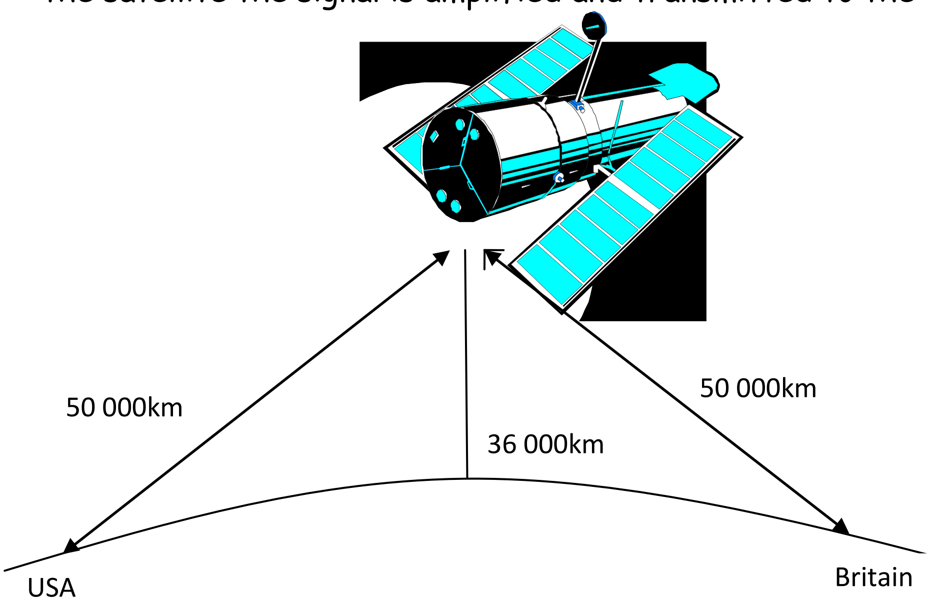
4. In 1962 the communications satellite Telstar was used to relay the first live television pictures from the east coast of the U.S.A to Britain. Telstar orbited the earth at a height varying from 320 km to 480 km.



(a) What was the speed of the signal?
(b) How many metres are in 320 km?
(c) How long would it take for a microwave signal to travel 320 km?

5. One of the first explorer satellites had an orbit height of 4 000 km above the surface of the Earth. Another satellite, Early bird, had an orbit height of 36 000 km.
Which satellite took longer to make one complete orbit of the Earth?

6. A satellite is used to send a TV signal from Britain to the USA. The TV signal from Britain is sent to the satellite on a microwave carrier wave. At the satellite the signal is amplified and transmitted to the USA.

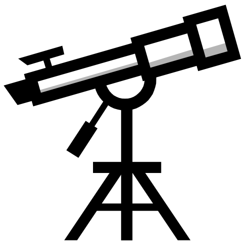


(a) State the distance travelled by the signal as it goes from Britain to USA.
(b) Calculate how long it would take for the TV signal to reach the USA from Britain?

12. Space Exploration

Use the internet to help you to answer the questions in this section.

1. Traditional telescopes based on Earth (terrestrial telescopes) detect light. What other type of signal can telescopes on Earth detect?



2. Terrestrial telescopes are limited because they cannot detect many radiations from space. Telescopes in orbit above our atmosphere can gather much more information about other parts of our galaxy and beyond.
   (a) Why are telescopes on Earth unable to detect some types of radiation from space?
   (b) Name one space telescope currently in orbit around Earth.

3. "Unmanned missions" often involve space probes being sent very long distances. On February 17, 1998, space probe Voyager 1 became the most distant human-made object in space.
   (a) When was Voyager 1 launched?
   (b) Use the internet to find out where Voyager 1 and Voyager 2 are today.

4. Space exploration has required the development of various new technologies. Some of these technologies have resulted in "spin off" developments for domestic use.
   Give 3 examples of items we commonly use that were originally developed for use in space exploration.

5. What is meant by the term "geostationary satellite"?

6. (a) What is meant by the term "period" when referring to satellite orbits?
   (b) How does a satellite's height above Earth affect its period?

7. The communications satellite INTELSAT V was launched into a geostationary orbit in 1980. It could handle 12 000 telephone calls plus two TV channels at the same time.

   How long did INTELSAT V take to make one complete orbit of the Earth?

8. Explain why satellites are useful for defence and security.

9. Explain why satellites are useful for communications.

10. Find out how many communications satellites are currently in orbit around Earth.

11. Apart from communications and defence, state 3 other uses of satellites.

12. Why does re-entry to a planet's atmosphere pose a challenge to space craft designers and engineers?

13. Our Universe

1. Read the following clues and select the answer from this list. Some answers can be used more than once.

star	**moon**	**planet**	**solar-system**
universe	**exo-planet**	**galaxy**	**ight year**

(a) The distance light travels in one year.
(b) A ball of gases continually reacting to give out heat and light.
(c) This orbits a star.
(d) Our Sun and its 8 planets.
(e) Everything?
(f) A large group of stars.
(g) A natural satellite of Earth.
(h) The Sun is one of these.
(i) The Milky Way is one of these.
(j) This orbits a star outside our solar system.

2. (a) What is meant by an "exo planet"?
(b) How can Scientists detect exo planets?

3. A planet would need to meet several requirements in order to sustain life as we know it. Some suggestions are written below.
Write down TRUE or FALSE for each one.

(a) The planet must be not too big and not too small.
(b) The planet must already have intelligent life on it.
(c) The planet surface must be liquid and gas.
(d) The planet must be in orbit around a stable, long lived star.
(e) The planet must be very close to its star.
(f) The planet must have a protective electromagnetic field.

4. Scientists widely agree that all matter was once packed into a tiny space, then the Universe was created as a result of a massive explosion.

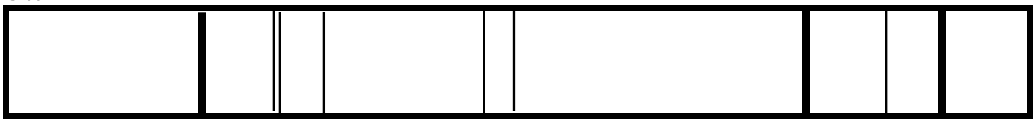
(a) What is the name of the theory that attempts to explain this origin of the Universe?
(b) By this theory, how long ago did this explosion happen?

(c) Nowadays, are our galaxies STABLE or STILL MOVING APART or MOVING CLOSER TOGETHER?

5. High frequency radiation like Ultraviolet, X-Rays and Gamma rays are given off by extreme astronomical events.
Give 2 examples of “extreme astronomical events” and explain what they are.

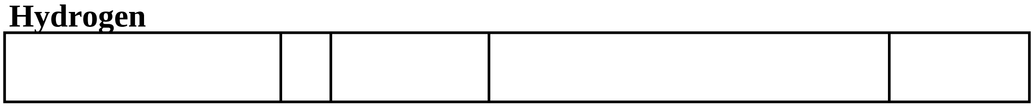
6. Frequencies of radiation from a distant star are shown below as “spectral lines”.

Star

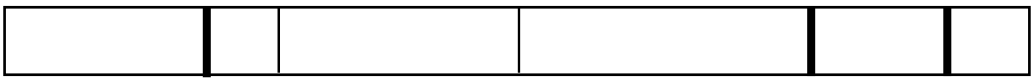


Here are the spectral lines caused by some known elements:

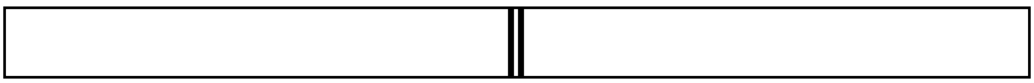
Hydrogen



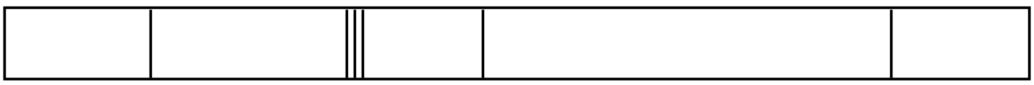
Helium



Sodium



Calcium



Look carefully at the lines caused by the star.
What elements do you think are present in the star?

7. The temperature of a star can be estimated by the frequency / colour of light that it emits.

Look at the following chart and use it to answer the questions below.

Spectral Type	Example(s)	Temperature Range	Key Absorption Line Features	Brightest Wavelength (color)
O	Stars of Orion's Belt	>30,000	Lines of ionized helium, weak hydrogen lines	<97 nm (ultraviolet)*
B	Rigel	30,000 K–10,000 K	Lines of neutral helium, moderate hydrogen lines	97–290 nm (ultraviolet)*
A	Sirius	10,000 K–7,500 K	Very strong hydrogen lines	290–390 nm (violet)*
F	Polaris	7,500 K–6,000 K	Moderate hydrogen lines, moderate lines of ionized calcium	390–480 nm (blue)*
G	Sun, Alpha Centauri A	6,000 K–5,000 K	Weak hydrogen lines, strong lines of ionized calcium	480–580 nm (yellow)
K	Arcturus	5,000 K–3,500 K	Lines of neutral and singly ionized metals, some molecules	580–830 nm (red)
M	Betelgeuse, Proxima Centauri	<3,500 K	Molecular lines strong	>830 nm (infrared)

* All stars above 6,000 K look more or less white to the human eye because they emit plenty of radiation at all visible wavelengths.

(a) Is the violet end of the spectrum the short or long wavelength end?

(b) Light from which end of the spectrum, blue or red, indicates a hotter star?

(c) Our nearest star is our Sun. Which spectral type is our Sun?

(d) Which 3 spectral types emit the strongest radiation outside of the visible spectrum?

(e) Where are some of the hottest stars?