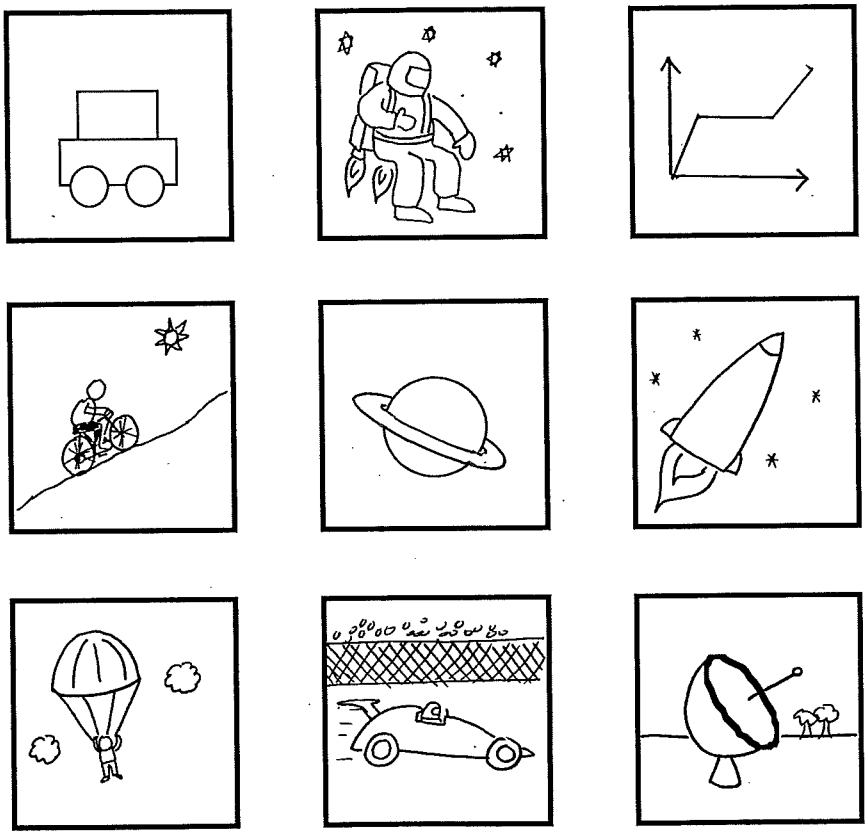
St. Maurice's High School	Physics Department

NQ 5 Physics

Unit 2

Dynamics and Space



Tutorials

Tutorial 1	Average Speed

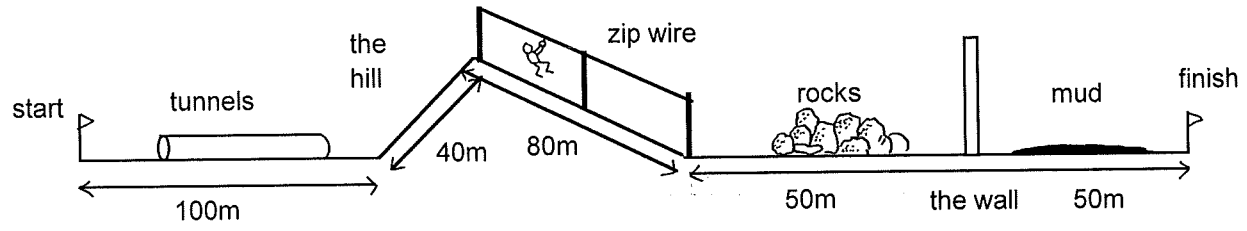
(1) A man runs 100m in a time of 15s. Calculate his average speed.

(2) The average speed of a car is $27ms^{-1}$. How long would it take him to travel 380m?

(3) How far will a sparrow flying at an average speed of $8ms^{-1}$ travel in 25mins?

(4) A car travels 240km in a time of 2.5hours. Calculate its average speed in kmh^{-1}

(5) The diagram shows a soldier completing an assault course in a time of 6mins..



(a) Convert 6 minutes into seconds?
(b) How far did he run in the 6mins?
(c) What was his average speed over the course in ms^{-1}?
(d) State one part of the course he'd be travelling faster than this average speed?
(e) State one part of the course he'd be travelling slower than this average speed?

(6) A man runs along a flat course of distance 4200m in a time of 700s.

(a) Calculate his average speed?
(b) A bird flies the same distance with a constant speed of $6ms^{-1}$. How long would it take the bird?

(7) A train travels 45km in 35minutes. What is its average speed in ms^{-1}?

(8) At the top of a slope the speed of a ball is zero. At the bottom of the hill the ball's speed is $12ms^{-1}$. Estimate the average speed of the ball

(9) A long distance lorry driver has 3 hours to travel 210km to get to the cross channel ferry

(a) Calculate the average speed she would have to travel at to make the ferry in kmh^{-1}
(b) Due to heavy traffic the average speed over the first 100km was $60kmh^{-1}$. Calculate how long this part of the journey took.
(c) At what speed must he travel at for the rest of the journey to catch the ferry

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(1)$6.7ms^{-1}$ (2) 14.1s (3) 12,000m (4) $96kmh^{-1}$ (5)(a) 360s (b) 320m (c) $0.89ms^{-1}$ (6)(a) $6ms^{-1}$(b) 700s (7) $21.4ms^{-1}$ (8) $6ms^{-1}$ (9) (a) $70kmh^{-1}$ (b) 1.67h (c) $82.7kmh^{-1}$

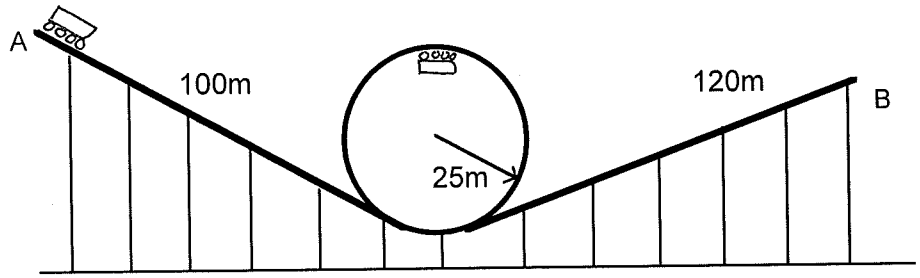
(10) A supersonic plane can fly at Mach 2 (twice the speed of sound). How long would it take a supersonic plane to travel the length of a football pitch - 100m?

(11) This table shows the train timetable for a journey between Glasgow and Aberdeen.

Route	Distance covered	departure time	arrival time
Glasgow to Stirling	40km	9.00	9.45
Stirling to Perth	60km	9.48	11.00
Perth to Dundee	40km	11.04	12.20
Dundee to Aberdeen	100km	12.12	1.30

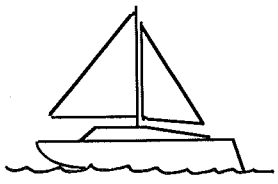
(a) What was the total distance travelled in km?
(b) What was the total time taken in hrs?
(c) Calculate the average speed for the whole journey in $kmhr^{-1}$.
(d) What was the average speed between Stirling and Perth in $kmhr^{-1}$?
(e) Just by looking at the numbers - on which part of the journey do you think the train was travelling much slower than the average speed?

(12) This diagram shows part of a roller coaster ride including a circular loop. The travels from A to B in a time of 8.5s.



(a) Use the information to work out the average speed of the journey? (hint - circumference)
(b) When would it have been travelling slower than the average speed?
(c) When would it have been travelling faster than the average speed?

(13) Bob's sailing boat travels a distance of 20km from one port to another on a day when the wind was very variable. It took the boat 3hrs to make the trip.



(a) Calculate his average speed in ms^{-1}
(b) Bob's brother Dave makes the same journey in his motor boat. At what constant speed would Dave have to travel at to get to the port at exactly the same time as Bob.
(c) Later, Dave travels back the same distance in his motor boat with an constant speed of $4ms^{-1}$. How long will it take Dave to cover the 20km this time?

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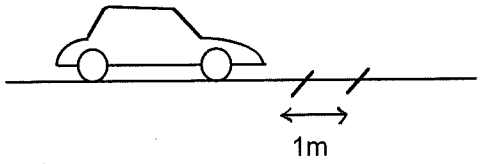
(10) 0.15s (11) (a) 240km (b) 4.5hrs (c) $53.3kmhr^{-1}$ (d) $50kmhr^{-1}$ (12)(a) $44.4ms^{-1}$
(13)(a) $1.85ms^{-1}$ (b) $1.85ms^{-1}$ (c) 5000s

Tutorial 2	Instantaneous Speed

(1) What do we call the speed at one particular point on a journey.

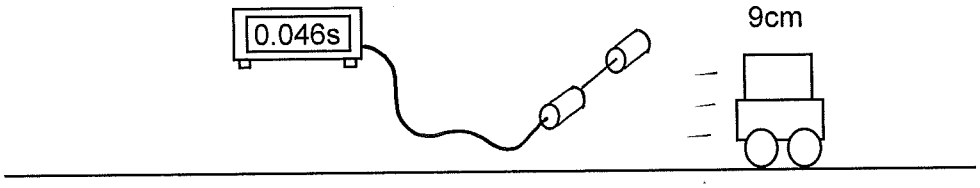
(2) A boy tries to measure the speed of this car. He measures the time for the front wheels to travel the 1m from X to Y.



(a) If the time he measured was 0.12s calculate the instantaneous speed of the car.

(b) Why is this not a very accurate way of measuring the instantaneous speed of the car?

(3) A girl sets up a light gate attached to a timer to measure the instantaneous speed of the trolley.

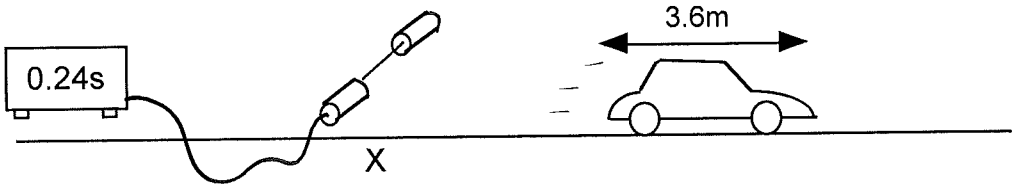


(a) How long did it take the trolley to cut the light beam?

(b) How far did the trolley travel in this time?

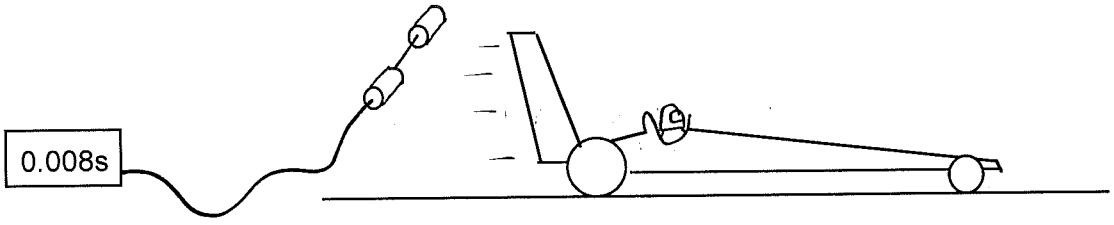
(c) Use the data to calculate the instantaneous speed of the car in ms^{-1}.

(4) He now uses a light gate to help him measure the instantaneous speed of the car at point X.



(a) Calculate the instantaneous speed of the car at point X

(5) A light gate was used to measure the instantaneous speed of a dragster as it crosses the finish line. The tail fin, which has a breadth of 36cm, is used to cut the light beam.



(a) Use the information to calculate its instantaneous speed.

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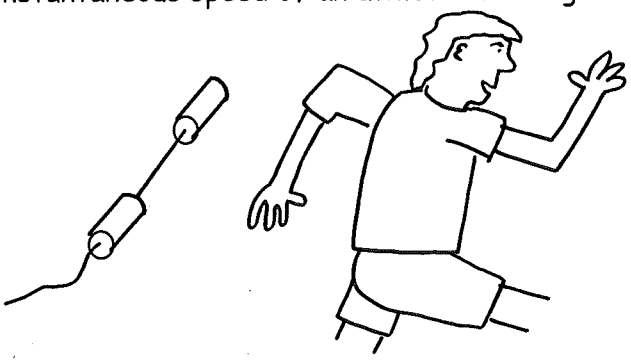
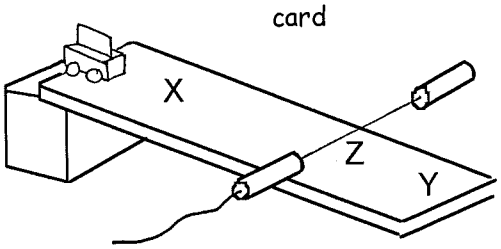
(2)(a) 8.3ms^{-1} (3)(a) 0.046s (b) 9cm (c) 1.96ms^{-1} (4) 15ms^{-1} (5) 45ms^{-1}

(6) A light gate is used to measure the instantaneous speed of an athlete crossing the finishing line of a race.



(a) Apart from the time it takes them to cut the beam what other bit of information is required to measure her instantaneous speeds?
(b) Why is this an inaccurate method of measuring her instantaneous speed?
(c) In one test the width of the athlete is 48cm and the time she took to cut the beam was 0.07s. Calculate her instantaneous speed.

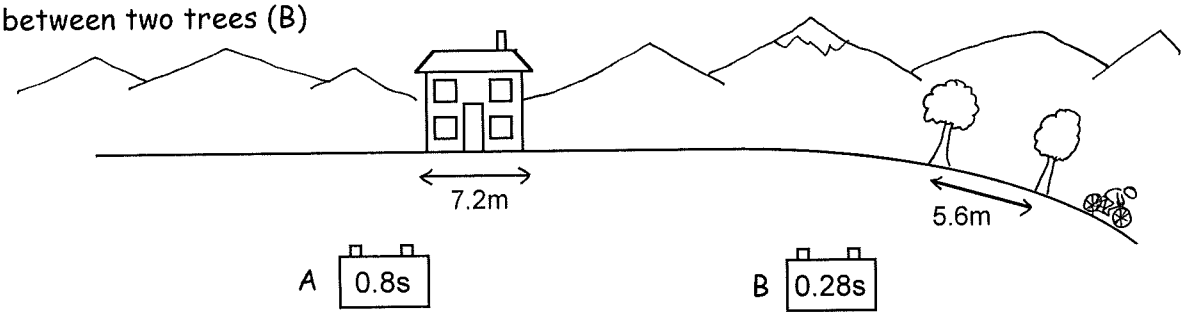
(7) A trolley travels down the slope as shown. The card cuts the light beam.
The student makes the following measurements.



distance X to Y = 1.25m
length of card = 0.1m
time for trolley to roll from X to Y = 5s
time for card to cut the light gate = 0.2s

(a) Calculate the average speed of the trolley between X and Y
(b) Calculate the instantaneous speed of the trolley at Z.

(8) Bradley Wiggins completes a 170km stage of the Tour de France in a time of 6hrs. During the route a coach measured the time he took to travel by a house (A) and between two trees (B)



(a) Measure Bradley's average speed across the whole journey in kmh^{-1}.
(b) Use the information to work out Bradley's instantaneous speed at the house and the trees.

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(6)(c) $6.9ms^{-1}$ (7)(a) $0.25ms^{-1}$ (b) $0.5ms^{-1}$ (8)(a) $28.3kmh^{-1}$ (b) $9ms^{-1}$ / $20ms^{-1}$

Tutorial 3	Vectors and Scalars

(1) What do we call quantities which are defined by their size?

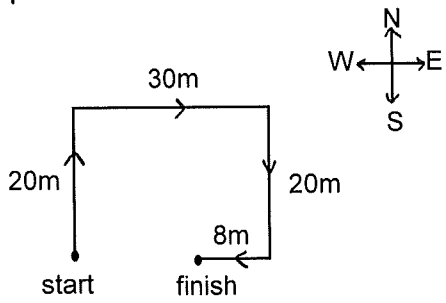
(2) What do we call quantities which are defined by their size and their direction?

(3) From the following list state the vector quantities.

temperature, distance, mass, force , time, volume, displacement.

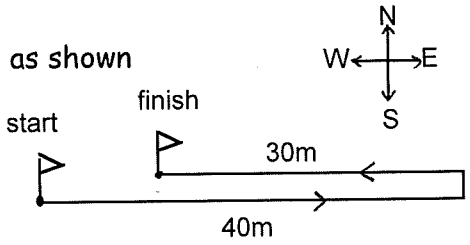
(4) A car drives round a test track as shown.

(a) Calculate the distance it travelled
(b) Calculate the displacement from the starting point.



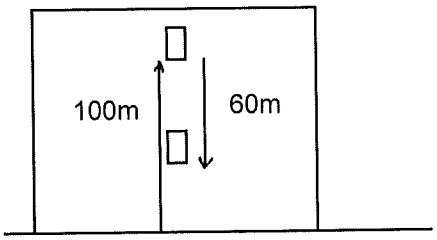
(5) A boy walks 40m east then turns and walks 30 west as shown

(a) Calculate the distance it travelled
(b) Calculate the displacement from the starting point.



(6) A man in a lift travels 100m to the top floor then 60m back down as shown

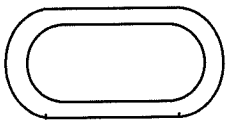
(a) Calculate the distance he travels
(b) Calculate his displacement from the ground.



(7) A car travels 8km North then 8km South

(a) State the distance the car travels.
(b) Calculate the displacement of the car from the start.

(8) A man runs **one** lap of a 400m race. Calculate
(a) the distance travelled.
(b) the displacement of the man from the start.



(9) A boat travels 400m North, then 600m South then 400m North. Calculate
(a) the distance travelled.
(b) the displacement of the boat from the start.

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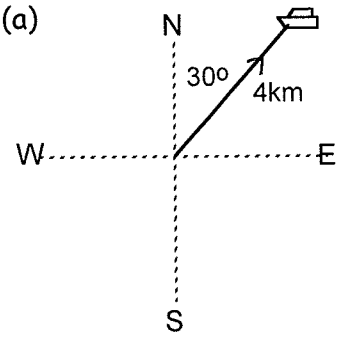
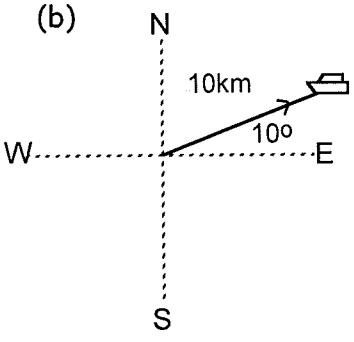
(4)(a) 78m (b) 22m (east) (5)(a) 70m (b) 10m east (6)(a) 160m (b) 40m upwards
(7)(a) 16m (b) 0m (8)(a) 400m (b) 0m (9)(a) 1400m (b) 200m (North)

(10) Look at these diagrams. Use 3 figure bearings to pinpoint the displacement of each boat from the centre.

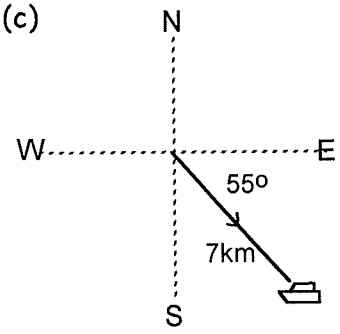
(a)



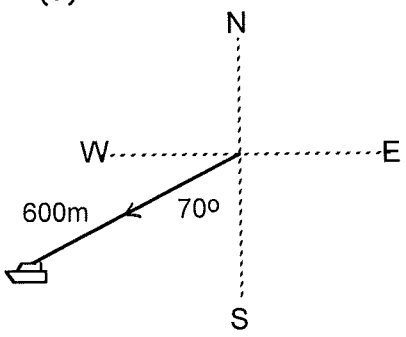
(b)



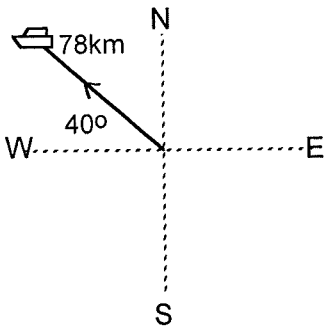
(c)



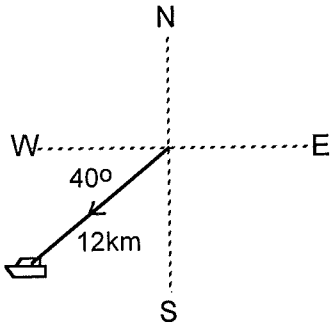
(d)



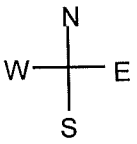
(e)



(f)

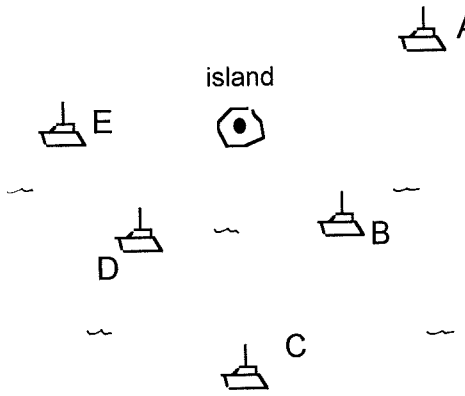


(11) Four fishing boats are fishing off the coast of a small island as shown. Use your judgment to state which boat is



(a) on a bearing 063 from the island.
(b) on a bearing 270 from the island.
(c) on a bearing 200 from the island.
(d) on a bearing 150 from the island.

(e) Suggest a bearing for boat C from the island?



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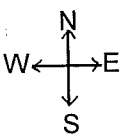
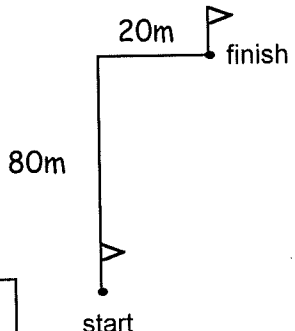
(12) A boy walks 80m North then 20m East as shown.

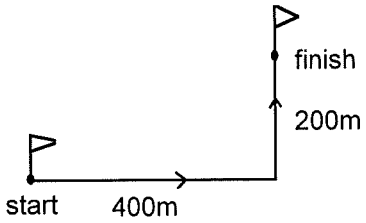


(a) Calculate the distance it travelled.
(b) Calculate the displacement from the starting point.



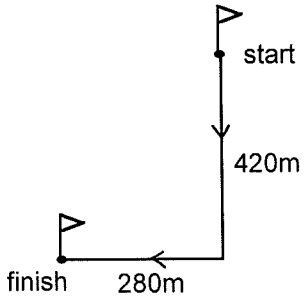
(10)(a) 4km(030) (b) 10km(080) (c) 7km (145) (d) 600m(250) (e) 78km(310) (f) 12km(230) (11)(a) A (b) E (c) D (d) B (e) 180 (12)(a) 100m (b) 82.5m(014)

(13) A boat sails 400m east then 200m north as shown.



(a) Calculate the distance it travelled
(b) Calculate the displacement from the starting point.

(14) An orienteer travels 420m south then 280m west as shown.



(a) Calculate the distance it travelled
(b) Calculate the displacement from the starting point.

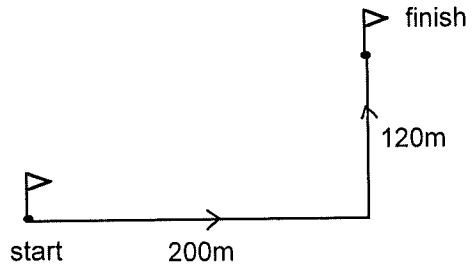
(15) A plane flies the following course. After leaving the airport it flies 800km west then it travels 460km North.

(a) Sketch a vector diagram showing the route the plane takes.
(b) Calculate the distance it travelled.
(c) Calculate the displacement from the starting point.

(16) A boat travels 400m North, 200m West then 100m South. By drawing a diagram calculate

(a) the distance travelled
(b) the displacement of the boat from the starting point.

(17) A Gillian jogs 200m east then 120m north in a time of 60s.



(a) Calculate the distance she travelled
(b) Calculate her average speed.
(c) Calculate the displacement from the starting point.
(d) Calculate her average velocity
(e) If Kate started at the starting point and ran with a constant speed of $3.9ms^{-1}$, directly towards the finish, who would arrive at the finish point first?

(18) Liam walks 100m east then 200m west then 80 east in a time of 100s.

(a) Calculate his average speed.
(b) Calculate his average velocity.
(c) Susan walk directly from the start to the finish point with a constant speed of $0.2ms^{-1}$. Who gets to the finish point first?

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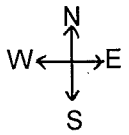
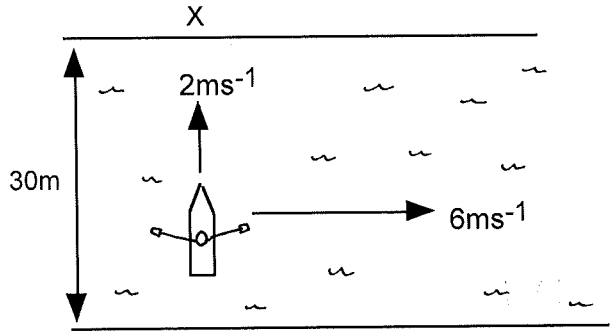
(13)(a) 600m (b) 447m (063) (14)(a) 700m (b) 504m (214) (214) (15)(b) 1260km (c) 922.8km (300) (16)(a)700m (b) 361m (326) (17)(a) 320m (b) $5.3ms^{-1}$ (c) 233.2m(059) (d) $3.9ms^{-1}$ (059) (e) both (18)(a) $3.8ms^{-1}$ (b) $0.2ms^{-1}$(west) (c) both at same time.

Tutorial 4 | Combining Velocity Vectors

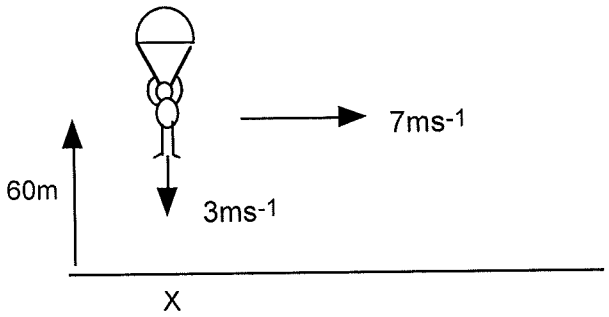
(1) A fisherman is trying to row his boat at $2ms^{-1}$ north across a river as shown. The river is flowing at a velocity of $6ms^{-1}$ to the east.





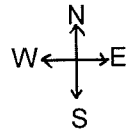
(a) Calculate the resultant velocity of the boat.
(b) How long would it take her to cross the river?
(c) How far from point X will he reach the opposite bank?

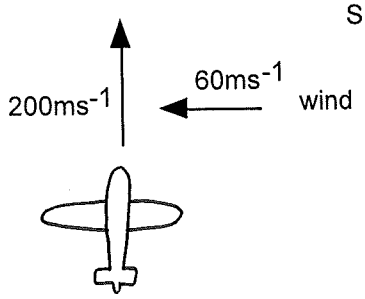
(2) A parachutist is descending at a constant vertical speed of $3ms^{-1}$. The cross wind is blowing at a speed of $7ms^{-1}$ as shown.



(a) Calculate her resultant velocity
(b) How long will it take her to land?
(c) How far from her landing point X will she actually land?

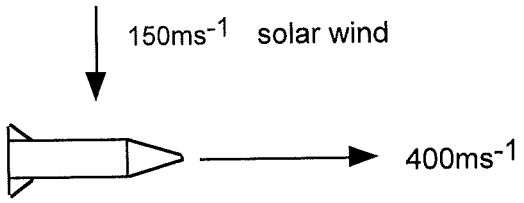
(3) A plane is flying due North at $200ms^{-1}$. The wind was blowing due west at a speed of $60ms^{-1}$ as shown.





(a) Calculate its resultant velocity.
(b) Which bearing should the pilot fly at to ensure he is travelling due North?

(4) A space probe is travelling through space with a velocity of $400ms^{-1}$
A solar flare creates a solar wind of velocity $150ms^{-1}$ as shown.



(a) What the probe's resultant velocity?

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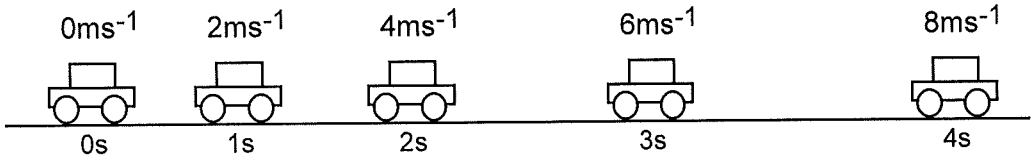
(14)(a) $6.3ms^{-1}$(072) (b) 15s (c) 90m (15)(a) $7.6ms^{-1}$(23° below horizontal) (b) 20s (c) 140m
(16)(a) $209ms^{-1}$ (343) (b) $209ms^{-1}$(017) (17) (a) $427ms^{-1}$ (20.6° below horizontal)

Tutorial 5	Acceleration

Do the questions in this tutorial in your head.

(1) This diagram shows the speed of a car each second as it accelerates along a road.



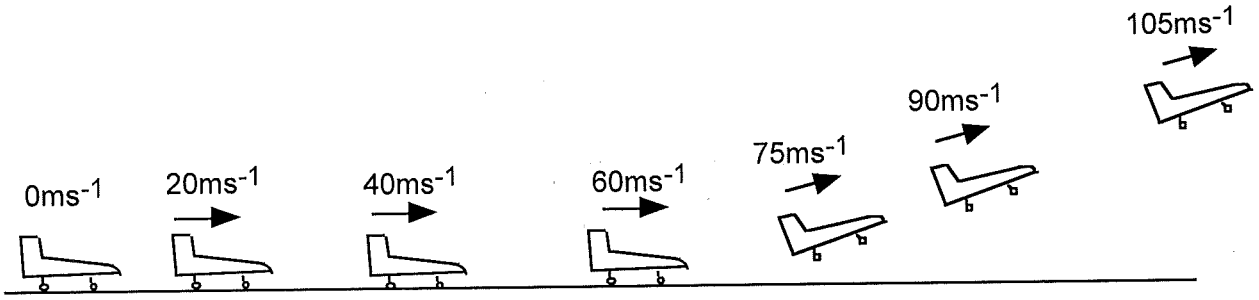
(a) What is the acceleration of the car?
(b) Is it a constant acceleration?
(c) What is the velocity after 5s if the acceleration is constant?

(2) Here are two numbers $40ms^{-1}$ and $8ms^{-2}$. Which one is an acceleration and which one is a speed?

(3) A motorboat accelerates from rest at a constant rate of $10ms^{-2}$

(a) This tells us that the speed of the motorboat is increasing by how much each second?
(b) What would be its final speed if it maintained this acceleration for 4s?

(4) This diagram shows pictures taken every second of a plane taking off



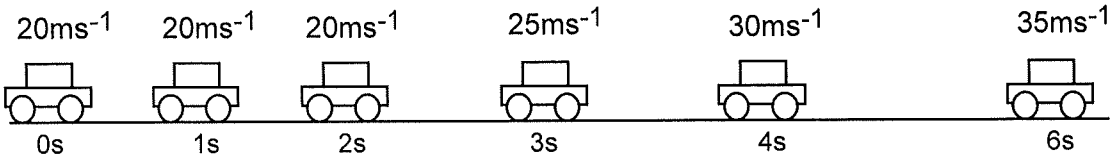
(a) What is the acceleration of the plane on the run way?
(b) What is the plane's acceleration in the 3s after it has taken off?

(5) A cyclist accelerates from rest at $2ms^{-2}$ for 3s. What is his final speed?

(6) A rocket accelerates from rest at $30ms^{-2}$ for 5s. What is its final speed?

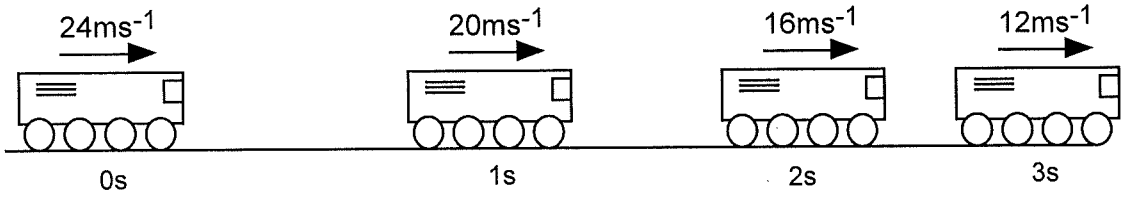
(7) A rocket travelling at a constant speed of $200ms^{-1}$ starts to accelerate at $4ms^{-2}$ What is its speed after 6s?

(8) Look at this car travelling along the road at a constant speed. It then accelerates. The diagram shows the speed of the car each second of its journey



(a) What is the acceleration of the car?
(b) If it keeps accelerating at this constant rate what is its speed after 7s.

(9) The speed of a train is shown each second as it enters a station.



(a) What is the deceleration of the train?
(b) What is the acceleration of the train?
(c) What is the speed after 4s?
(d) How long would it take to come to rest if it decelerated at a constant rate?

(10) If you know the acceleration of an object and for how long it has been accelerating, can you say how you would find the change in the speed of the object?

(11) The following describes a journey a car makes. Answer the questions related to each part of the journey. Do the working in your head.

(a) A car accelerates from rest at $5ms^{-2}$. What is its speed after 4s?
(b) The car travels at this maximum speed for 5s. How far did it travel while travelling at this **constant** maximum speed.
(c) It then decelerates from this maximum speed at $10ms^{-2}$ until it comes to rest. How long would it take to come to rest.

(12) A car travels along a road at a constant speed of $20ms^{-1}$. It then accelerates for 4s at a constant rate of $2ms^{-2}$. It travels at this new speed for 5s before decelerating at $7ms^{-2}$ for a further 2s. What is the final speed of the car?

(13) A racing car accelerates from rest at $4ms^{-2}$ for 5s then it accelerates at $6ms^{-2}$ for 3s. It then decelerates at $2ms^{-1}$ for 5s. What is the final speed of the car?

(14) A space shuttle enters the atmosphere at $4000ms^{-1}$. It decelerates at a constant rate of $300ms^{-2}$. What is its speed after 5s?

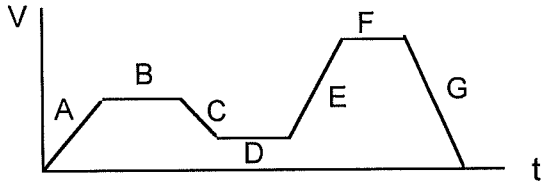
---

(8)(a) $5ms^{-2}$ (b) $45ms^{-1}$ (9)(a) $4ms^{-2}$ (b) $-4ms^{-2}$ (c) $8ms^{-1}$ (d) 6s (11)(a) $20ms^{-1}$ (b) 100m (c) 2s (12) $14ms^{-1}$ (13) $28ms^{-1}$ (14) $2500ms^{-1}$

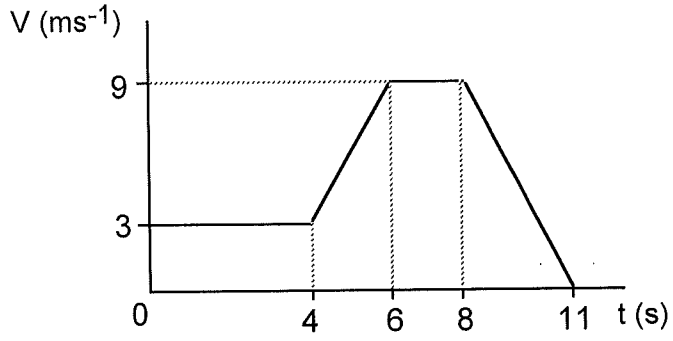
Tutorial 6	Velocity vs Time Graphs 1

(1) Look at this velocity time graph. During which part of the graph A to F was the object

(a) accelerating
(b) travelling at a constant speed
(c) decelerating

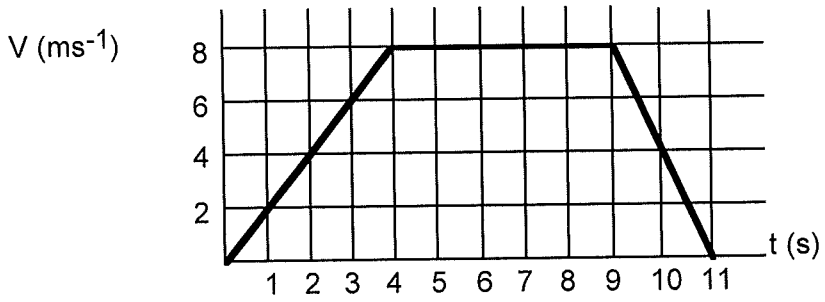


(2) This graph shows the motion of a footballer a he runs down the wing.



(a) During what time was he jogging at a constant speed
(b) When was he sprinting by the full back at a constant speed
(c) When did he try to slow down before he got to the dead ball line
(d) When did he accelerate up to his sprinting speed

(3) Look at this velocity time graph showing the speed of a sprinter during a race.



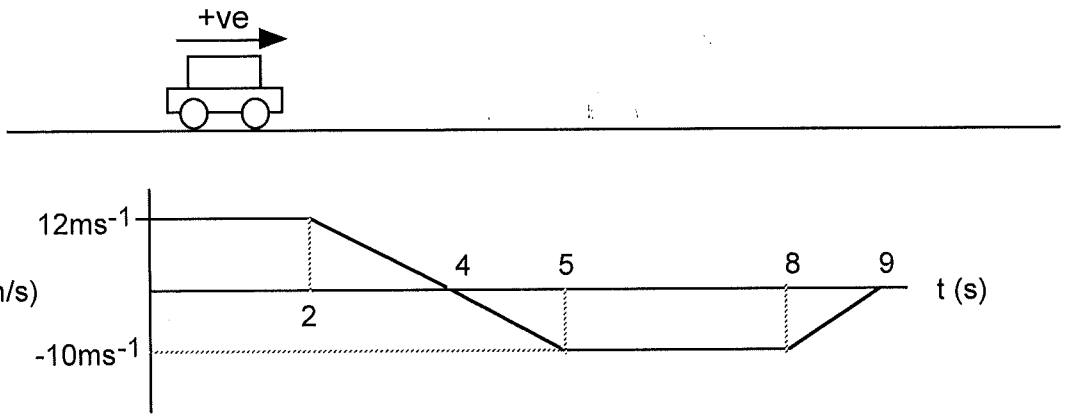
(a) What was his speed after 3s?
(b) What was his maximum speed?
(c) For how long did he travel at this maximum speed?
(d) For how long did he decelerate?
(e) What was his acceleration? (ie what is the increase in speed per 1s)
(f) What was his deceleration? (ie what is the decrease in speed per 1s)

(4) Sketch the following graphs.

(A) A racing car accelerates from rest to $18ms^{-1}$ in 3s. It then travels at this constant speed for 5s. It then decelerates to rest in a further 6s.

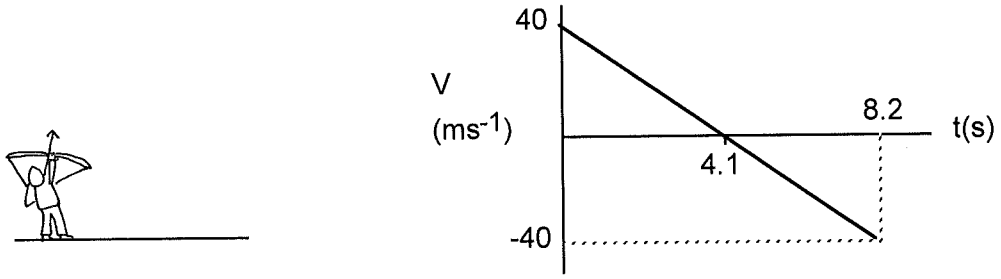
(B) A cyclist travels at a constant speed of $12ms^{-1}$ for 5s. She suddenly accelerates at $4ms^{-2}$ for 3s before holding this speed for 6s. Then he decelerates to rest in 7s.

(5) This velocity time graph shows a car travelling along the road to the right then changing direction. We set "to the right" is the positive direction



(a) At which part of the graph was the car travelling to the right at a constant velocity of $12ms^{-1}$?
(b) When was the car decelerating while travelling to the right?
(c) At what time did it change direction.
(d) When was the car accelerating but to the left?
(e) What was the velocity of the car when it was travelling at constant speed to the left?
(f) When was the car decelerating to rest while travelling to the left

(6) A girl fires an arrow up into the air. The following velocity time graph describes its motion. (assume no energy is lost). Take upwards as the positive direction.

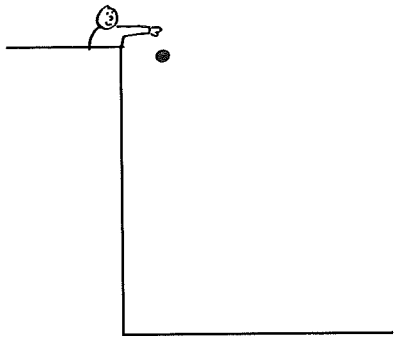


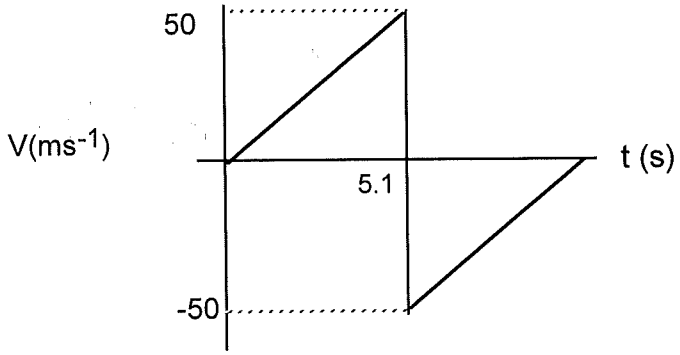
(a) At what velocity did it leave the bow?
(b) In the first 4s was the arrow accelerating or decelerating
(c) At what time did it reach its highest point?
(d) Why are the velocities after 4.1s negative values?
(e) From 4.1 - 8.2s was the arrow accelerating or decelerating

---

(3)(a) $6ms^{-1}$ (b) $8ms^{-1}$ (c) 5s (d) 2s (e) $2ms^{-2}$ (d) $-4ms^{-2}$ (5)(a) 0-2s (6)(a) $40ms^{-1}$ (b) dec (c) 4.1s (d) its travelling downwarsds (e) acc

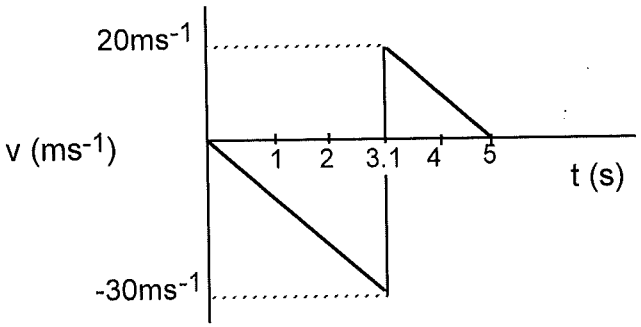
(7) The following velocity time graph shows the velocity of a ball dropped from the top of a cliff and bouncing once. (assume no energy is lost) (take downwards as the positive direction





(a) How long did it take to hit the ground?
(b) What was its velocity when it hit the ground?
(c) Why are the velocities after 5.1s negative values?

(8) The following graph shows the velocity of a ball dropped from a building and bouncing once. In this question we have taken velocities in the upward direction to be positive.



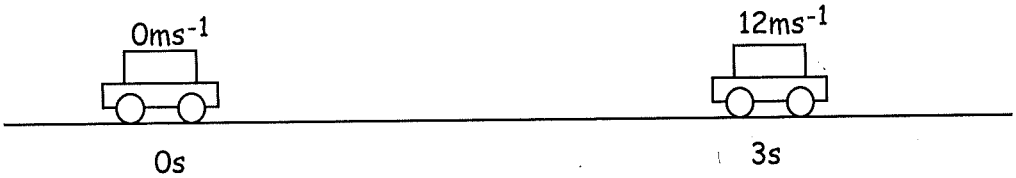
(a) What was its velocity just as it was dropped?
(b) At what velocity did it hit the ground?
(c) Why is it a minus number?
(d) At what speed did it leave the ground?
(e) Why is this less than -30m/s?
(f) How long did it take to rise to its maximum height?

(8)(a) $0ms^{-1}$ (b) $-30ms^{-1}$ (c) travelling downwards (d) $20ms^{-1}$ (e) friction (f) 1.9s

Tutorial 7	Acceleration Equation

Do the working for Q 1 - 4 in your head.

(1) This diagram shows a car accelerating from rest to 12ms in a time of 3s



(a) By how much did its speed change in the 3s?
(b) Therefore by how much did its speed change in 1s?
(c) So what is the acceleration of the car?

(2) This diagram shows a plane accelerating from $200ms^{-1}$ to $350ms^{-1}$ in 5s.

(a) By how much did its speed change in the 5s?
(b) Therefore by how much did its speed change in 1s?
(c) So what is the acceleration of the plane?

(3) A motor cyclist accelerates from rest to $28ms^{-1}$ in a time of 4s. What is its acceleration?

(4) A sports car accelerates from $12ms^{-1}$ to $30ms^{-1}$ in a time of 3s. What is its acceleration?

(5) A train accelerates from $6ms^{-1}$ to $35ms^{-1}$ in a time of 45s. What is its acceleration?

(6) A fighter plane accelerates from $230ms^{-1}$ to $640ms^{-1}$ in a time of 22s. What is the acceleration of the fighter?

(7) This table gives information about the time it takes different cars to go from 0 to $26ms^{-1}$.

Car	time (s)
Bugatti Veyron	2.5
Lamborghini Aventador	2.8
Porsche 911 GTS	3.3
Nissan Micra	15

$26ms^{-1}$ = 60mph

(a) Which car has the largest acceleration?
(b) Calculate the acceleration of the Bugatti and the Nissan Micra. ($10.4 / 1.73ms^{-2}$)

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(1)(a) $12ms^{-1}$ (b) $4ms^{-1}$ (c) $4ms^{-2}$ (2)(c) $30ms^{-2}$ (3) $7ms^{-2}$ (4) $6ms^{-2}$ (5) $0.64ms^{-2}$ (6) $18.6ms^{-2}$

(8) A car accelerates from 12kmh^{-1} to 58kmh^{-1} in a time of 5s. Calculate the acceleration of the car in kmh^{-1}s^{-1}

(9) A motorboat accelerates from 30mph to 70mph in 7s. Calculate the acceleration of the motorboat in mphs^{-1}.

---

(10) A rocket accelerates at 25ms^{-2} from rest to 100ms^{-1}. How long did it take to reach 100ms^{-1}?

(11) How long would it take a submarine to accelerate from 15ms^{-1} to 32ms^{-1} if the acceleration of the submarine was 1.8ms^{-2}?

(12) A cyclist travelling at 5ms^{-1} accelerates at a constant rate of 2.5ms^{-2}. What is the final velocity of the cyclist after 4s?

(13) A plane accelerates from rest along a runway at a rate of 18ms^{-2} for 7s . What was the final velocity of the plane?

(14) A car used in a car chase on a film accelerates to a velocity of 42ms^{-1}. If the car accelerated at 4.5ms^{-2} for 5s what was the initial velocity of the car?

(15) A boy drops a stone from rest at the top of a cliff. If it accelerates downwards at 9.8ms^{-2} what is its velocity after 6s?

(16) A plane touches down with a velocity of 78ms^{-1} if it takes the plane 25s to slow down to rest what is the acceleration of the plane?

(17) A car travelling at a constant velocity of 27ms^{-1} slows down as it approaches a 30mph (13ms^{-1}) speed zone. If it takes the car 5s to slow down from 27 to 13ms^{-1} what is the acceleration of the car?

(18) A car travelling at a constant velocity of 24ms^{-1} slows down at a rate of 4ms^{-2}. What is the velocity of the car after 5s?

(19) A train enters a station at a constant velocity of 9ms^{-1}. If it slows down at a constant rate of 0.8ms^{-2} how long did it take the train to come to rest?

(20) A cyclist travelling at a constant velocity of 18ms^{-1} slows down at a constant rate of 3ms^{-2} . How long would it take the cyclist to come to rest?

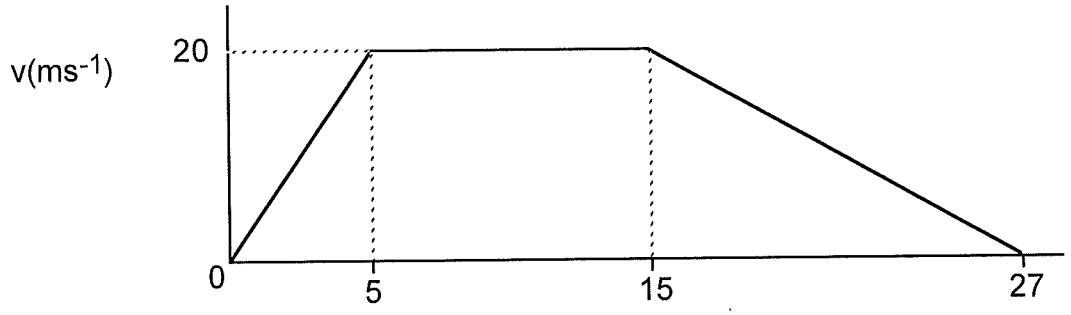
(21) A meteorite enters the Earth's atmosphere were it slows down at a rate of 100ms^{-2} . If the velocity of the meteorite after 17s is 1200ms^{-1} what was the initial velocity of the meteorite as it entered the atmosphere?

---

(8) 9.2kmh^{-1}s^{-1} (9) 5.7mphs^{-1} (10) 4s (11) 9.4s (12) 15ms^{-1} (13) 126ms^{-1} (14) 19.5ms^{-1}
(15) 58.8ms^{-1} (16) -3.12ms^{-2} (17) -2.8ms^{-2} (18) 4ms^{-1} (19) 11.3s (20) 6s (21) 2900ms^{-1}

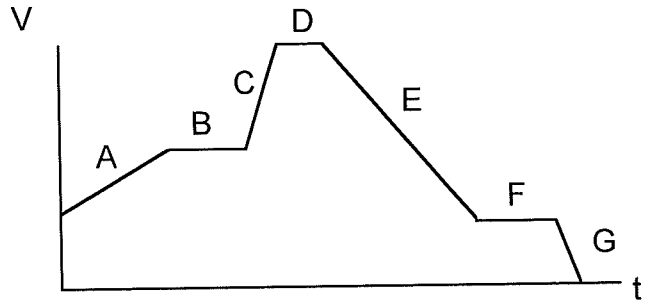
Tutorial 8	Velocity - Time Graphs 2

(1) This velocity time graph shows the velocity of a boy on a sledge racing down a hill.



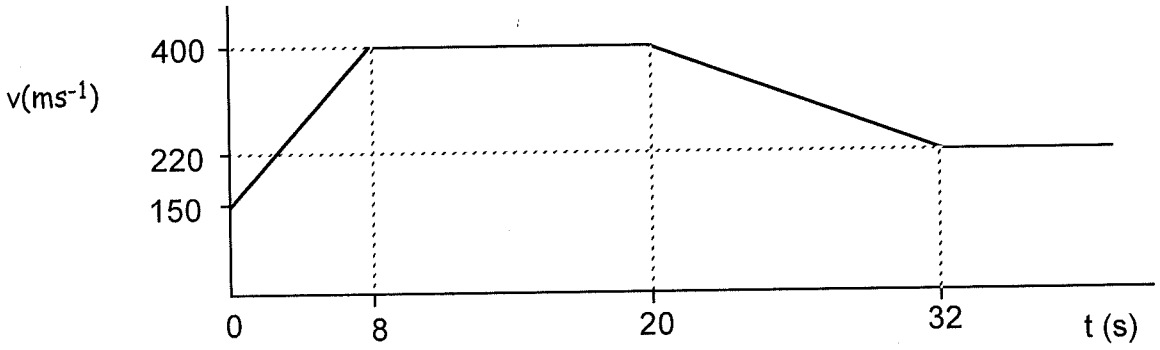
(a) What was the highest velocity of the boy?
(b) For how long did he travel at this constant velocity?
(c) Calculate the acceleration of the boy during the first 5s.
(d) Calculate the acceleration between 15 and 28s

(2) Look at this graph showing the motion of a motorboat.



(a) During which part of the motion was the acceleration the greatest?
(b) During which part of the motion was the deceleration the least?
(c) When was it travelling at the highest speed?

(3) This graph shows how the velocity of a plane changes as it flies through a storm.

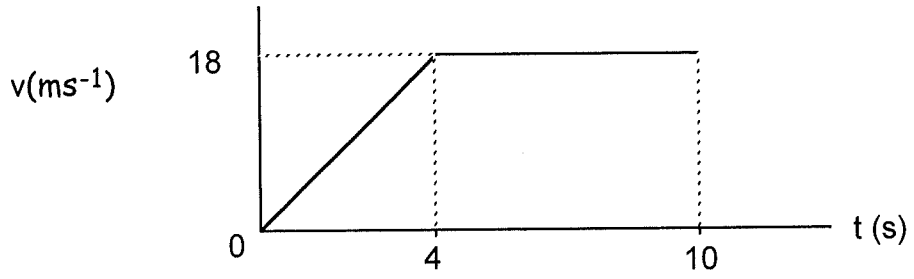


(a) What was the highest velocity of the plane?
(b) What was the initial velocity of the plane at time 0s?
(c) Calculate the acceleration of the plane during the first 8s.
(d) Calculate the acceleration between 20 and 32s

---

(1)(a) $20ms^{-1}$ (b) 10s (c) $4ms^{-2}$ (d) $-1.7ms^{-2}$ (3)(a) $400ms^{-1}$ (b) $150ms^{-1}$ (c) $31.3ms^{-2}$ (d) $-15ms^{-2}$

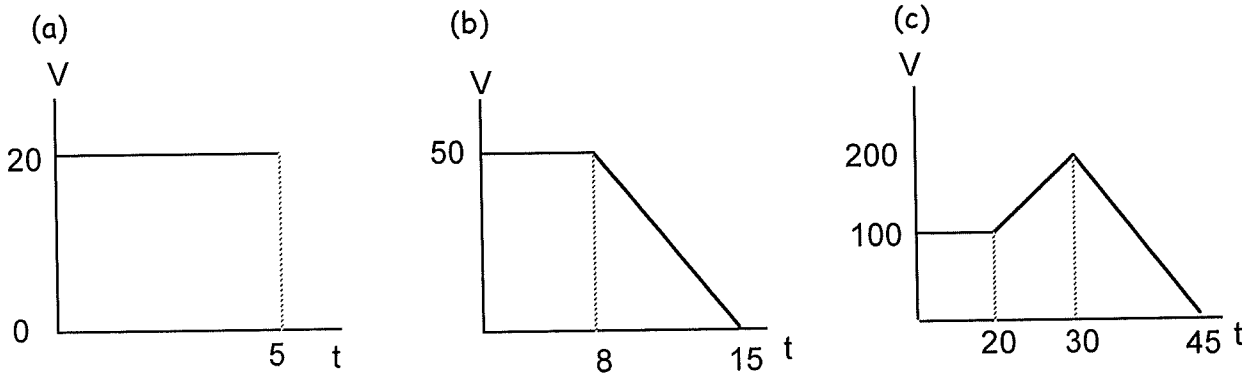
(4) This graph show the motion of a car over 10s.



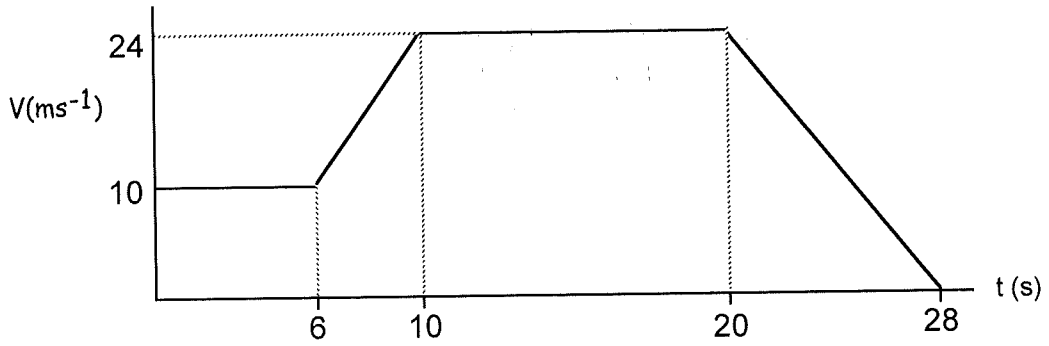
road bike tyres

(a) Calculate the distance the car covers in the 10s.
(b) What was his maximum speed of the car during the journey?
(c) What was its average speed?

(5) For each of these velocity time graphs work out the distance the object travelled Speeds are measured in ms^{-1} and time in seconds.



(6) This velocity time graph shows a car travelling at a constant speed, then accelerating, travelling at a constant speed then decelerating to rest.



(a) How far did the car travel while it accelerated?
(b) How far did it travel while decelerating

---

(4)(a) 144m (b) $18ms^{-1}$ (c) $14.4ms^{-1}$ (5)(a) 100m (b) 575m (c) 5000m (6)(a) 68m (b) 96m

Tutorial 9	Force

(1) What can cause the speed, direction or shape of an object to change?

(2) What do we call the force which pulls you down onto your chair?

(3) What do we call the force which acts between touching surfaces and tries to stop them moving?

Mass and Weight

This table shows the gravitational field strength in different situations

Place	g(Nkg^{-1})
Mercury	4
Venus	9
moon	1.6
Mars	4
Space Station	8.6
Jupiter	26
Saturn	11
Uranus	11
Neptune	12

(4) A boy has a mass of 58kg on Earth. What is his mass
- (a) on the moon
- (b) on Jupiter
- (c) in deep space?

(5) The weight of a rock on Earth is 500N. What does this mean?

(6) The gravitational field strength at sea level of the Earth is $9.8Nkg^{-1}$. What does this mean?

(7) The gravitational field strength on the top of mount Everest is $9.78Nkg^{-1}$. Why is the g force here less than at sea level.

(8) The mass of a girl is 48kg.
- (a) What is her weight on Earth?
- (b) What is the weight on Mars
- (c) What is her weight on Jupiter

(9)
- (a) On which planet would she feel the heaviest?
- (b) A woman has a mass of 64kg. What is her weight on the moon?
- (c) A rock on mars has a mass of 460kg. What is its weight on Mars?
- (d) The rock is taken back to Earth. What is its weight on Earth?
- (e) An astronaut in the space station has a weight of 720N. What is his mass?

(10) An astronaut of mass 83kg touches down on a distant planet. His weight on the planet is 350N.

(a) What is the gravitational field strength g on the planet?
(b) Would she feel lighter or heavier than on Earth.
(c) He finds a rock of mass 45kg. What is its weight on this planet?

(11) On Jupiter a space probe has a weight of 6800N. What is its mass?

(12) An astronaut has a pen of mass 24g. What is its weight in the space station?

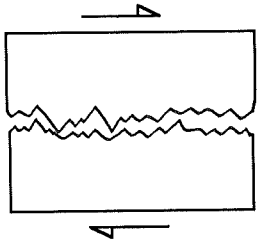
(13) If a man has a weight of 700N on Earth what is his weight on Neptune?

Friction

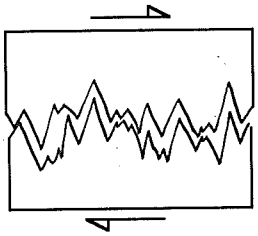
(14) When surfaces touch a force called friction acts between then to stop them moving. If we could look at the surfaces under a microscope what would they look like?

(15) Here are pictures of touching surfaces.

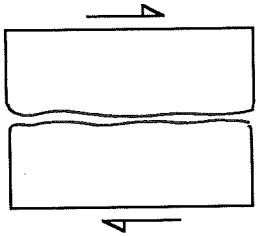
(A)



(B)



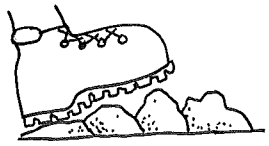
(C)



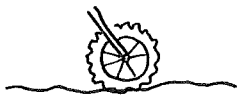
(a) Which surfaces would create the most friction if moved over each other?
(b) Which surfaces would create the least friction if moved over each other?

(16) For each of the following examples state whether you want the friction to be BIG or SMALL between the following sufaces

(a) walking boots and ground

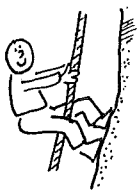


(b) mountain bike tyres and ground

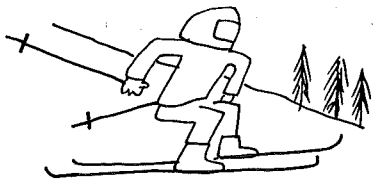


(c) bottom of boat and water surface

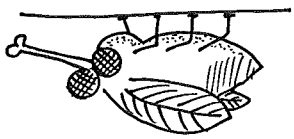
(d) climbing rope and hands



(e) bottom of skis and snow



(f) Fly's feet and the ceiling

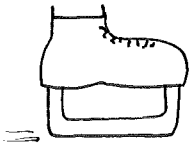


(17) In some situations we have to get a good balance

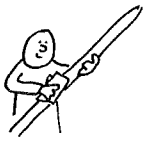
(a) Why is too much friction between car tyres and the road a bad thing?
(b) But why is too little friction also a bad thing?

(18) For each situation state if friction is being reduced by <u>separating</u> or <u>smoothing</u> the surfaces.

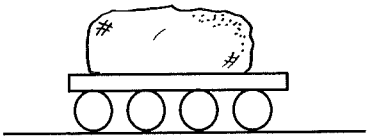
(a) ice skating boot



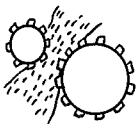
(b) sanding down skis



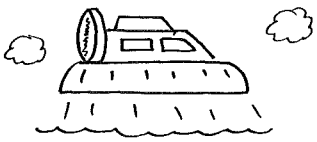
(c) Rollers under a block



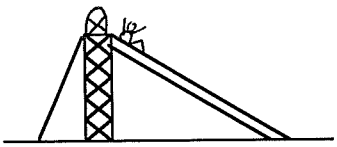
(d) Oil in engine



(e) Hovercraft



(f) Child's slide



(19) A car slides off the road on a very wet day.
(a) Why is the friction between the tyres and the road reduced?
(b) On the approach to traffic lights the road surface is made slightly rougher. Why?

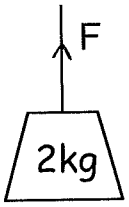
(20) How is the friction between a hockey puck and the table top reduced in a game of air hockey?

(21) A gymnast who is to perform on the bars has very sweaty hands
(a) Why would this decrease the friction between her hands and the bars?
(b) What does she do to increase the friction or grip?

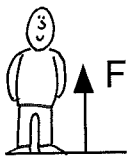
(22) (a) What type of stopping force is created when an object moves through air?
(b) Describe what a streamlined object looks like
(c) State 3 ways a cyclist can make herself streamlined?
(d) State how fast car can push itself down closer to the road so less air hits it?
(e) What do lorries add to their cabs to reduce air friction?

(23) In each diagram state whether the force F is **<u>Tension</u>** or the **<u>Reaction</u>** force.

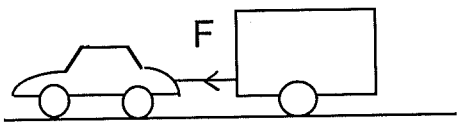
(a)



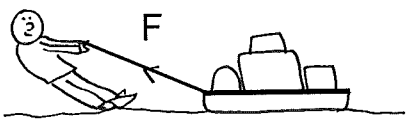
(b)



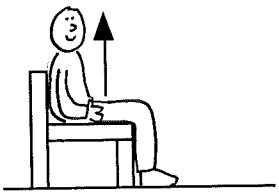
(c)



(d)



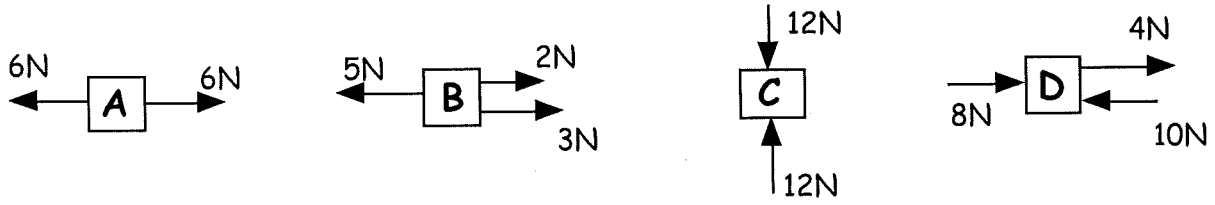
(e)



(4)(a) 58kg (b) 58kg (c) 58kg (8)(a)470.4N(b)192N (c)1248N (9)(a) Jupiter (b)102.4N (c) 1840N (d) 4508N (e) 83.7kg (10)(a) 4.2Nkg^{-1}(b) lighter (c) 189N (11) 261.5kg (12) 0.21N (13) 857N

Tutorial 10	Newton's 1st Law of Motion

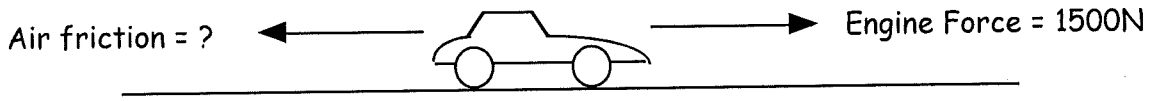
(1) (a) Here are 4 blocks. State which block(s) show balanced forces acting on the them.



(a) Object A is stationary. If the same forces are applied describe its motion 4 weeks later.

(b) Object B is moving at a constant speed. If the same forces continue to be applied describe its motion 10s later.

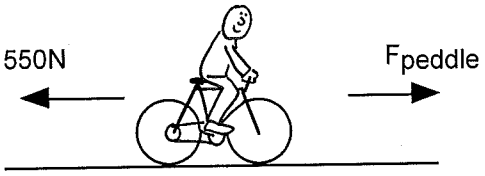
(2) This car is travelling along the road at a **constant speed**.



(a) Describe the forces on it.

(b) So what is the size of the air friction?

(3) A cyclist is travelling along the road at a **constant speed** of 8ms^{-1}. The total friction acting on him is 550N.



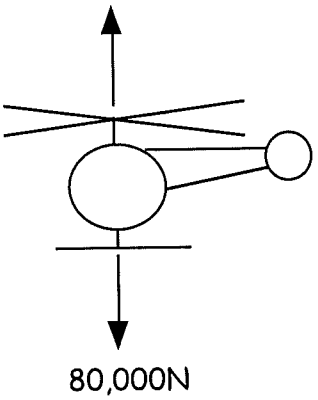
(a) What is the forward force caused by his pedalling?

(b) What is his speed 10s later if the forces do not change?

(4) The weight of a helicopter is 80,000N

(a) What is the upward lift force created by the helicopter when it is hovering

(b) What is the upward lift force created by the helicopter when is moving upwards with a **constant speed**.



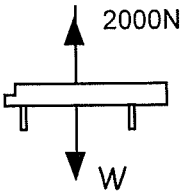
(2)(a) balanced (b) 1500N (3)(a) 550N (b) 8ms^{-1} (4)(a) 80,000N (b) 80,000N

(5) This motor boat is travelling along a river a at **constant speed.**

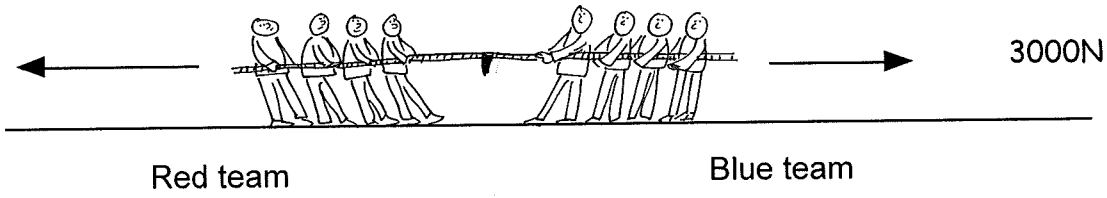
(a) If it is travelling at a constant speed what it the total frictional force acting on the boat?

(b) What is the size of the water friction on the boat?

(6) A piano is lowered onto a ship by a crane at a **constant speed.** If the tension in the wire is 2000N. What is the weight of the piano?



(7) In a tug of war competition the blue team are taking on the red team. The blue team pull to the right with a force of 3000N. The hanky remains **stationary**.



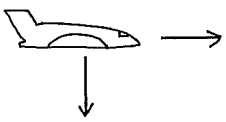
(a) What is the size and direction of the force applied by the red team?

(b) Each member of the red team can apply an average force of 250N. How many are in the red team?

(c) One member of the red team sprains her ankle and leaves the competition. State and explain what happens.

(8) In deep space a space ship accelerates to a speed of $4000ms^{-1}$. The engines are then switched off. What is the speed of the space ship 20s later? Explain.

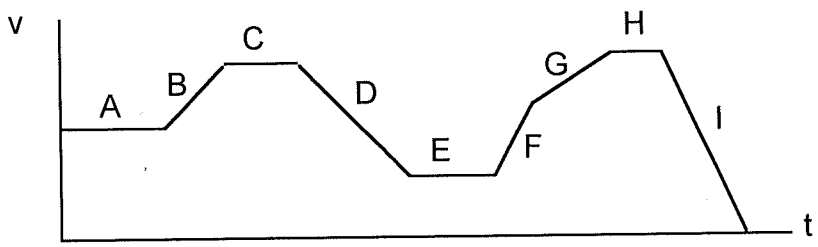
(9) An aeroplane of weight 50,000N flys at a constant speed and constant height. The forward engine force was 10,000N.



(a) What is the frictional force on the plane?

(b) What is the lift force produced by the wings?

(10) This graph shows the speed of a car on a journey.



(a) During which part of the journey are the forces on the car balanced?

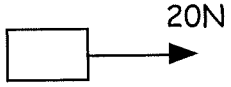
---

(5)(a) 700N (b) 500N (6) 2000N (7)(a) 3000N to left (b) 12 (8) $4000ms^{-1}$

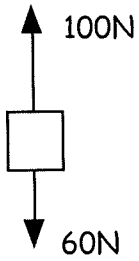
Tutorial 11	Newton's 2nd Law of Motion

(1) Look at these three diagrams. Calculate the unbalanced force and its direction on each object.

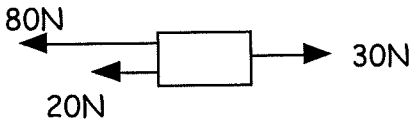
(a)



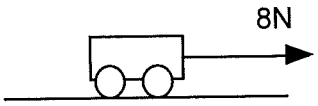
(b)



(c)

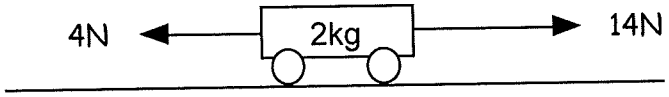


(2) A girl pulls this 4kg trolley along a frictionless floor with a force of 8N



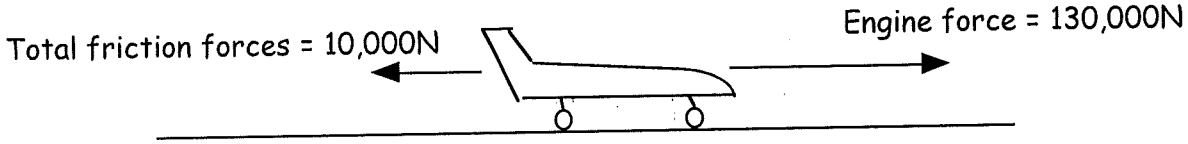
(a) What is the unbalanced force on the trolley?
(b) Calculate the acceleration of the trolley.

(3) Look at this 2kg trolley.



(a) Calculate the unbalanced force on the trolley.
(b) Calculate the acceleration of the trolley.
(c) If it started from rest and the forces remain the same what's the speed after 4s?

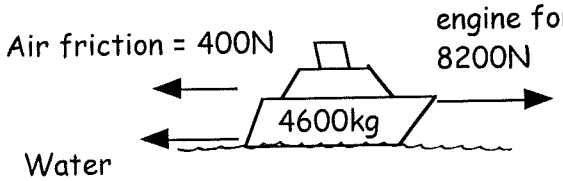
(4) This diagram shows a plane taking off.



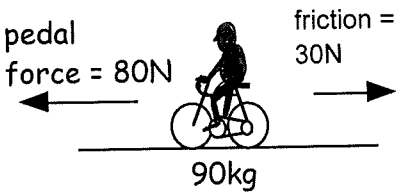
(a) What is the unbalanced force acting on the plane.
(b) If its mass is 20,000kg calculate is acceleration.

(5) Look at these two diagrams. For each work out the unbalanced force and acceleration.

(a)



(b)

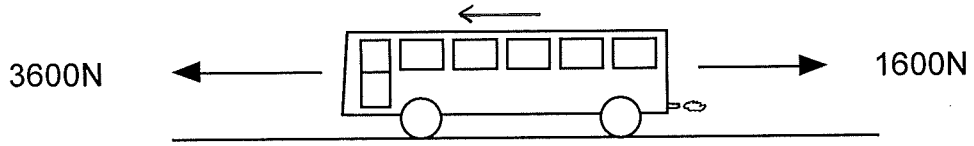


(1)(a) 20N (b) 40N (c) 70N (2)(a) 8N (b) $2ms^{-2}$ (3)(a) 10N (b) $5ms^{-2}$ (c) $20ms^{-1}$
(4)(a) 120,000N (b) $6ms^{-2}$ (5)(a)7200N, $1.6ms^{-2}$ (b) 50N, $0.56ms^{-2}$

(6) A 70kg skidoo is pulled along with an engine force of 250N as shown.

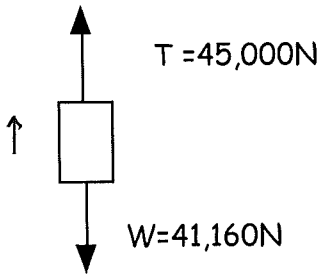
(a) What is the unbalanced force on the skidoo?
(b) What is the acceleration of the skidoo

(7) The forces on a bus of mass 4,500kg are shown



(a) Calculate the unbalanced force
(b) Calculate the acceleration.

(8) The tension in a wire pulling a lift upwards is 45,000N
The weight of the lift is 41,160N.



(a) What is the unbalanced force on the lift.
(b) If the mass of the lift is 4200kg calculate the acceleration of the lift.

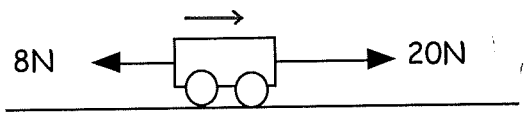
(9) A 100g pin ball is fired with a force of 1.5N. What is its acceleration?

(10) An oil tanker of mass 1.7×10^8kg is pulled by an engine force of 3.2×10^6N. If the frictional force is equal to 5.7×10^4N calculate the acceleration of the tanker.

(11) A 700kg car accelerates along a road. The engine force is 2400N and the frictional forces are 430N. By drawing a force diagram calculate the acceleration of the car.

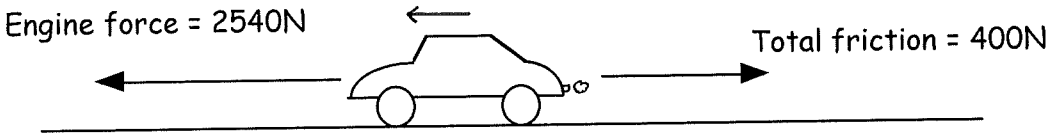
(12) A car of mass 640kg accelerates from rest to 24ms^{-1} in a time of 6s. Calculate the unbalanced force on the car. (Hint - find acceleration)

(13) A trolley accelerates to the right as shown at a constant rate of 2ms^{-2}.



(a) What is the unbalanced force on the trolley?
(b) What is the mass of the trolley?

(14) This diagram shows a car accelerating to the left at 3ms^{-2}.

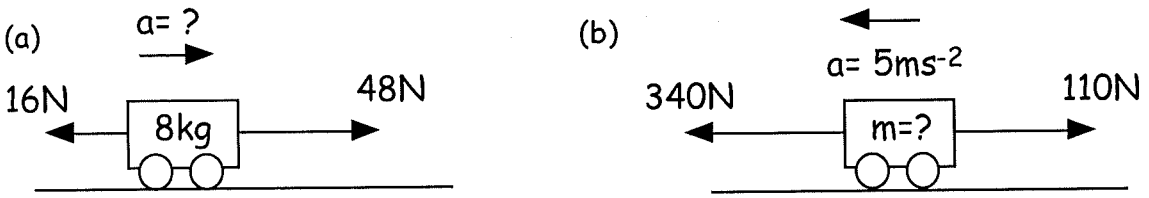


(a) Calculate the unbalanced force on the car.
(b) Calculate the mass of the car.

---

(6)(a) 200N (b) 2.9ms^{-1} (7)(a) 2000N (b) 0.4ms^{-2} (8)(a) 3840N (b) 0.9ms^{-2} (9) 15ms^{-2} (10) 0.018ms^{-2}
(11) 2.8ms^{-2} (12) 2560N (13)(a) 12N (b) 6kg (14)(a) 2140N (b) 713kg

(15) Look at these two diagrams. For each diagram calculate the unknown quantity. The arrows above the objects indicate the direction the object is travelling.



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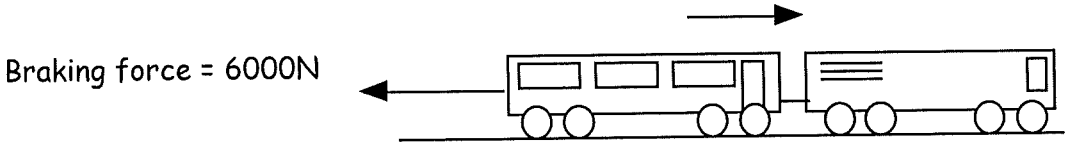
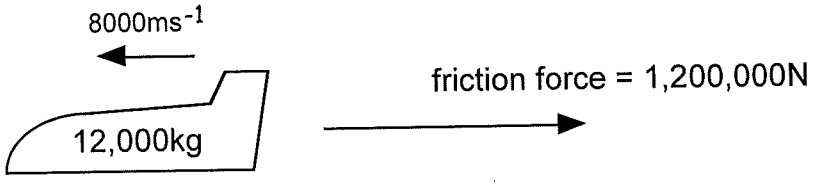
(16) A 4000kg train travels into a train station. It is travelling to the right as shown.



(a) What is the unbalanced force acting on the train?
(b) Calculate the acceleration of the train.
(c) If the train enters the station at a speed of $12ms^{-1}$ and slows down at this rate how long would it take the train to come to rest?

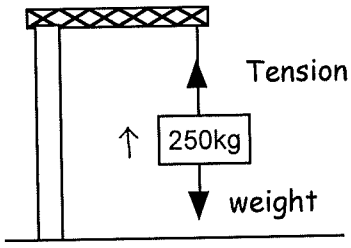
(17) A 12,000kg space shuttle enters the atmosphere with a speed of $8000ms^{-1}$ The frictional forces on it are shown



(a) What is the unbalanced force on the shuttle?
(b) What is the acceleration of the shuttle?
(c) What is the speed of the shuttle after 10s?

(18) A plane of mass 5000kg lands on the deck of an aircraft carrier. A rope catches the plane and applies a braking force of 208,000N. Calculate the plane's acceleration

(19) This 250kg mass is accelerates upwards at $0.4ms^{-1}$ using a crane.

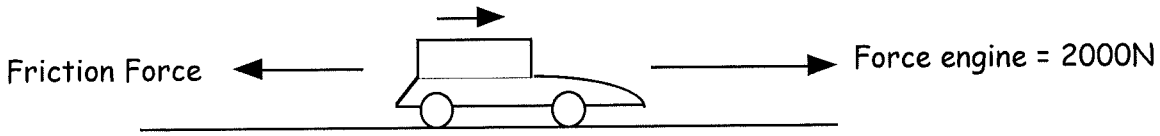


(a) If the box is accelerating upwards which force is bigger - The Tension or Weight
(b) What do we call the difference between the size of these forces?
(c) Calculate the weight of the box.
(d) Calculate the unbalanced force on the box.
(e) Calculate the upward Tension in the wire

---

(15)(a) $4ms^{-2}$ (b) 46kg (16)(a) -6000N (b) $-1.5ms^{-2}$ (c) 8s (17)(a) -1,200,000N (b) $-100ms^{-2}$ (c) $7000ms^{-1}$ (18) -41.6ms-2 (19)(c) 2450N (d) 100N (e) 2550N

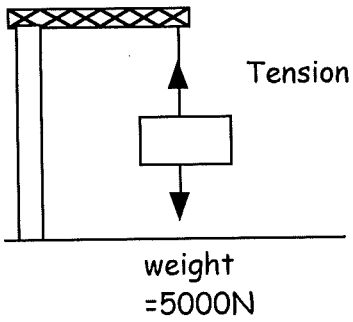
(20) Here is a picture of a car accelerating to the **right**. The engine force is 2000N



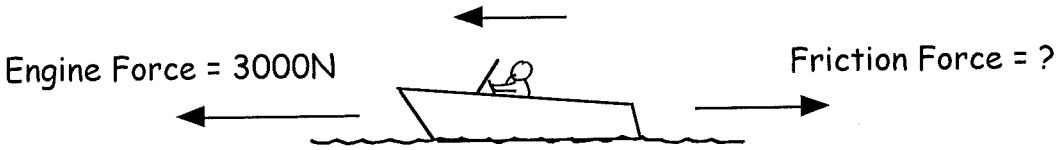
(a) Which force is bigger - the engine force of the friction force?
(b) What do we call the difference between the engine and frictional force?
(c) The unbalanced force is 500N. So what is the frictional force

(21) A crane accelerates a box off a building site.
The weight of the box is 5000N.

(a) If it is accelerating upwards which force is bigger - the Tension upwards or the weight?
(b) If the unbalanced force is 2000N what is the upward force?



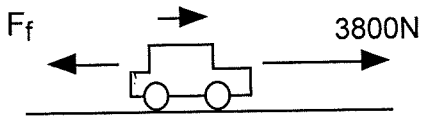
(22) Look at this 780kg motor boat accelerating to the left at a constant 2.2ms^{-2}.



(a) If the boat is accelerating to the left, which force is bigger - the Engine force or the frictional force?
(b) What do we call the difference between the size of these forces ?
(c) Calculate the unbalanced force on the boat.
(d) Calculate the friction force.

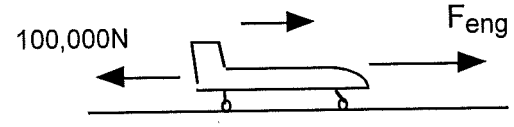
(23) A car of mass 1000kg is accelerating along a motorway at a constant rate of 3ms^{-2}.

(a) Calculate the unbalanced force
(b) If the engine force is 3800N calculate the frictional force.



(24) A 20,000kg jet plane accelerates at constant 15ms^{-2} along a runway at take off.
The frictional force is 100,000N.

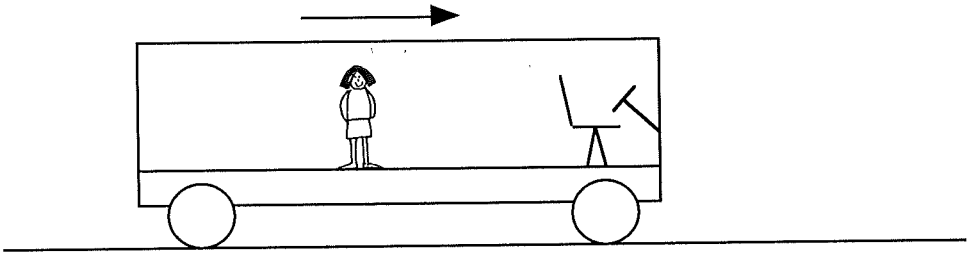
(a) Calculate the unbalanced force.
(b) Calculate the engine force.



(22)(c) 1716N (d) 1284N (23)(a) 3000N (b) 800N (24)(a) 300,000N (b) 400,000N

Tutorial 12	Newton's Laws and Car Safety

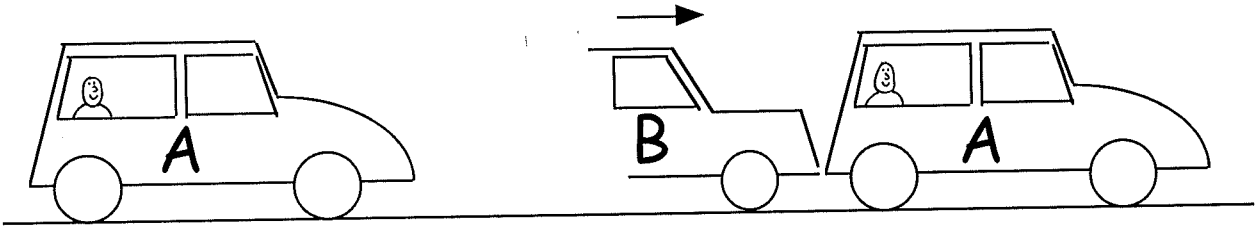
(1) A girl is standing up in a bus which is travelling at a constant speed of $12ms^{-1}$. The driver brakes suddenly.



(a) If the girl is not holding onto anything describe her motion?
(b) Which of Newton's laws describes this motion?
(c) What will apply the unbalanced force required to decelerate and stop her?
(d) Which of Newton's laws describes this motion?

(2) In a car, the driver applies brakes to slow the car down. What provides the unbalanced force to slow YOU down?

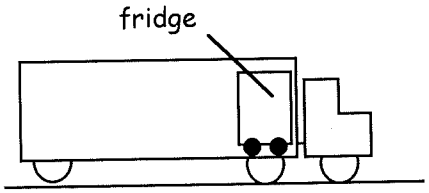
(3) A car is parked. A child is sitting in the rear of car A as shown in diag 1 without a seat belt on. Another car B hits the stationary car from the rear. Diag 2



diag 1 diag 2

(a) What happens to the car A when it is rear ended like this?
(b) If the child is not wearing a seat belt, use Newton's first law to describe what happens to her.
(c) Why would wearing a set belt have made a difference?

(4) A large fridge is packed, put on wheels and put in the back of a lorry as shown. The floor of the lorry is very smooth. The driver puts his foot down and accelerates. Use Newton's laws to say what will happen to the fridge

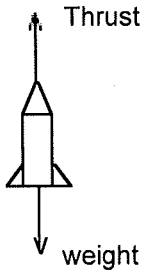


(5) In most cars air bags are fitted. How do they prevent you from damaging your head when the car is stopped suddenly?

(6) The front of a car is made to crumple when in a head on collision. How does this crumpling prevent the passenger from being severely injured?

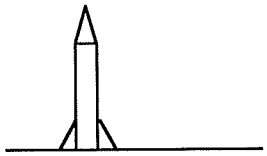
Tutorial 13 — Rocket Motion and Freefall

(1) This 60kg rocket is travelling upwards at a **constant speed.** (ignore air friction)



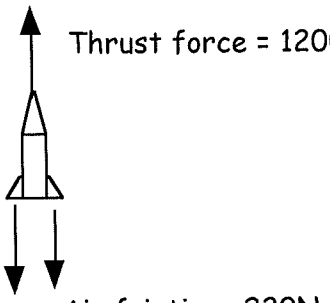
(a) What is the weight of the rocket?
(b) Therefore what is the upward force or thrust on the rocket?

(2) A toy rocket with mass 0.8kg is released in the school yard The initial upward thrust on the rocket was 12N



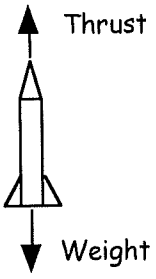
(a) Calculate the weight of the rocket
(b) Draw a diagram showing the forces on the rocket
(c) Calculate the unbalanced force on the rocket.
(d) Calculate the acceleration of the rocket.

(3) Look at the forces on this 50kg rocket.



(a) Calculate the unbalanced force on the rocket.
(b) Calculate the acceleration of the rocket.

(4) A probe of mass 860kg is to take off from the surface of Mars. The engines provide an upward thrust of 5000N.



(a) What is the weight of the probe on Mars
(b) Draw a diagram showing the forces on the probe.
(c) Calculate the unbalanced force on the probe at lift off
(d) Calculate the initial acceleration of the probe.

(5) A 480kg space probe is to accelerate from the moon surface at $4ms^{-2}$. Calculate the upward thrust required.

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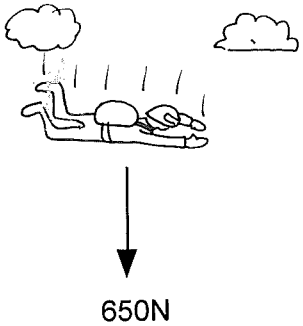
(6) A skydiver, who has a weight of 650N, jumps from a plane.



(a) **Just** as she jumps what is the only force on her?
(b) So what is the unbalanced force on her at this point?
(c) Why is air friction negligible at this point?
(d) What happens to her speed as she falls?
(e) How does this effect the air friction force acting on her?
(f) Does this increase or decrease the unbalanced force?
(g) So does the downwards acceleration increase or decrease?

---

(1)(a) 588N (b) 588N (2)(a) 7.84N (c) 4.16N (d) $5.2ms^{-2}$ (3)(a) 482N (b) $9.64ms^{-2}$ (4)(a) 3440N (c)2560N (d) $1.8ms^{-2}$ (5) 2688N (6)(a) weight (b) 650N

(7) Eventually the parachutist in Q6 reaches terminal velocity

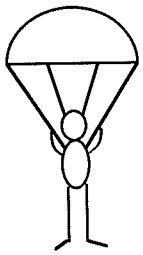
(a) What can you say about the forces on her at this point?
(b) Describe her speed at terminal velocity?

She puts up her parachute

(c) Is the frictional force bigger or smaller than her weight now?
(d) Will she accelerate or decelerate?
(e) As she decelerates frictional forces decrease and she reaches a new lower terminal velocity. What is the size of air friction at this point?

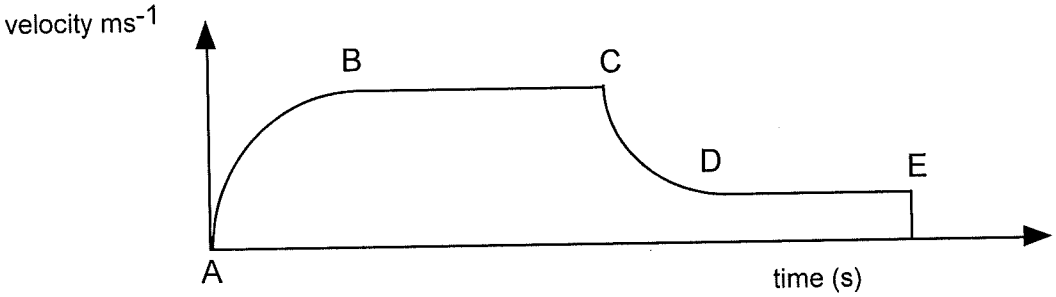
(8) A base jumper of mass 78kg jumps off a High Cliff in California. After a few second the frictional forces on him are 240N. calculate his acceleration at this point. (hint - draw a force diagram)

(9) Here is a picture of a parachutist falling at a **constant speed**. The mass of the parachutist and equipment is 96kg.



(a) What is the weight of the parachutist?
(b) Draw a free body diagram showing the forces on him.
(c) Therefore what is the air friction acting on him?

(10) This graph shows the velocity of a skydiver from the moment he jumps to the moment she lands



(a) Which parts of the graph show points where the forces on the parachutist were balanced?
(b) Why does the acceleration between A and B decrease?
(c) Which part of the graph shows the parachute just being opened?

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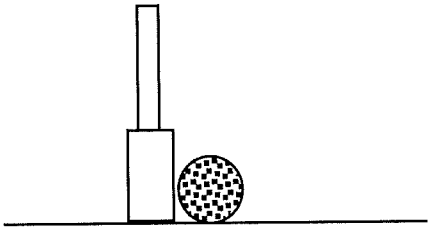
(8) $6.7ms^{-2}$ (9)(a) 940.8N (c) 940.8N

Tutorial 14	Newton's 3rd Law

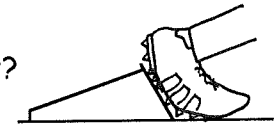
(1) A golf club hits a golf ball as shown.



What are the missing words in this sentence

The club exerts a ___A___ on the ball.
The ball exerts an ___B___ and opposite
___C___ on the club.

(2) Sprinters in the Olympic games use blocks to get a fast start



(a) How does Newtons 3rd law allow them a fast start?
(b) Are these two forces balanced?

(3) Use Newton's 3rd Law to explain why when you accidentally kick your toe against the leg of s bed it hurts.

(4) When a rifle is fired, the person holding the rifle recoils backwards.

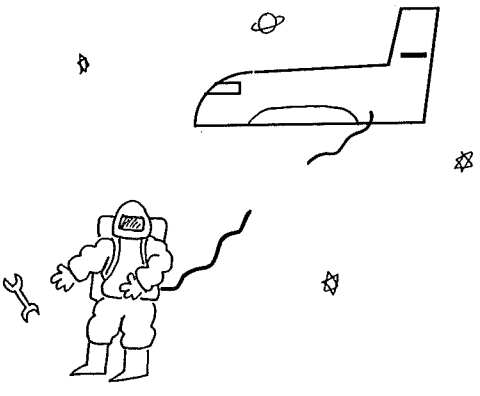
(a) Explain why this happens.
(b) Explain why you accelerate back a wee bit but the bullet accelerates to a very high speed.

(5) A jet engine works by applying Newton's 3rd law. The engine applies a huge force against the burning fuel and pushes it out the back of the back of the jet engine. Why does the plane move forward?

(6) In space a 2000kg rocket applies a force of 3000N to the the burning fuel.

(a) What force does the burning fuel apply to the rocket?
(b) Why are these two forces NOT balanced forces?
(c) Calculate the acceleration of the rocket.

(7) In space an astronaut is on a space walk. Suddenly the rope attaching him to the shuttle snaps. To get back to the shuttle he throws a spanner he is holding in a direction away from the shuttle.



Why does this strange move get him back to the shuttle?

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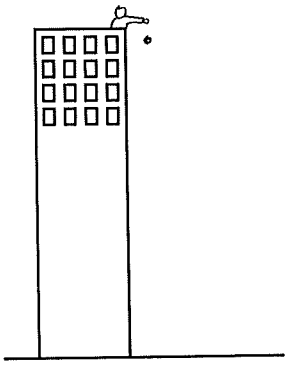
(6)(a) 3000N (c)1.5ms^{-2}

Tutorial 15	Projectile Motion

In the following questions ignore air friction.

(1) An ball is dropped vertically from the top of a building as shown. (take a = $9.8ms^{-2}$)



(a) What is the vertical speed just as the ball is released?

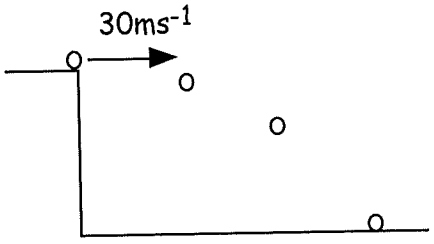
(b) What is its speed after (i) 1s
(ii) 2s
(iii) 5s.

(c) It hits the ground when its speed was $78.4ms^{-1}$. How long did it take to hit the ground?

(2) A ball is dropped from a high building what was its speed after

(a) 1s (b) 2.2s (c) 6.5s

(3) This ball is kicked off the top of a cliff with a horizontal speed of $30ms^{1}$ as shown

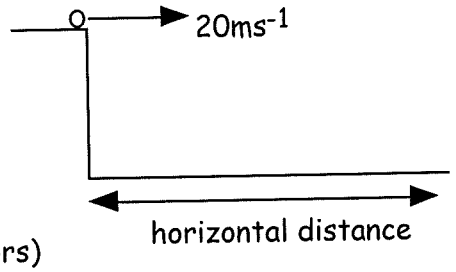


(a) What was the horizontal speed after
(i) 1s (ii) 2s (iii) 3s

(b) Why is the horizontal speed constant?

(c) What is the vertical speed after
(i) 1s (ii) 2s (iii) 3s

(4) A ball is kicked off the top of this cliff with a horizontal speed of $20ms^{-1}$. It takes 5s to hit the ground.

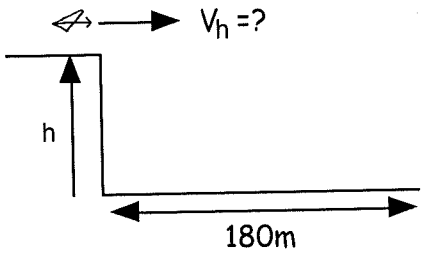


(a) What was the horizontal distance travelled by the ball?

(b) What was the final vertical speed as it hits the ground?

(c) Find the resultant velocity of the ball when it hits the ground. (hint - adding vectors)

(5) A crossbow bolt is fired as shown. It travels a horizontal distance of 180m in a time of 4.2s

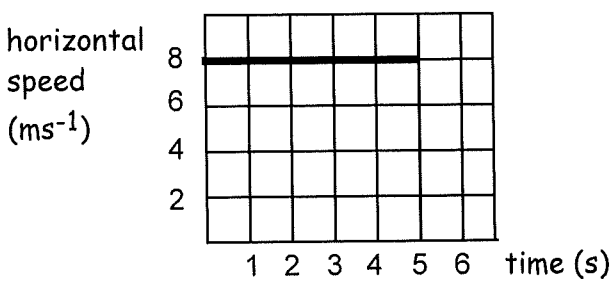


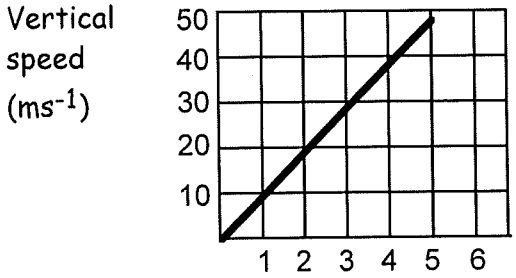
(a) What was the horizontal speed of the bolt?

(b) What was the vertical speed of the bolt just as it hits the ground?

(c) What was the vertical height h of cliff?

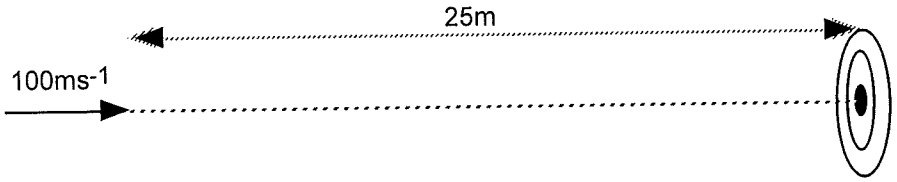
(6) These speed diagrams show the horizontal and vertical speeds of a horizontally projected object as it falls.





(a) How long was the ball in the air?
(b) What is its horizontal speed?
(c) Calculate the horizontal distance it travelled?
(d) What was its vertical speed when it hit the ground after 5s
(e) Calculate the vertical distance it fell. (hint - area under graph)

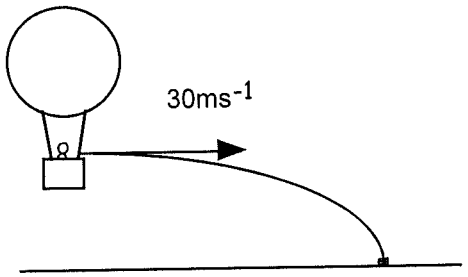
(7) An archer fires an arrow with a horizontal velocity of $100ms^{-1}$ at a target 25m away.



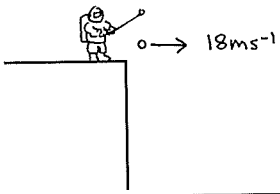
(a) How long did it take the arrow to reach the target?
(b) What was arrows vertical speed as it hit target?
(c) How far below the bulls eye did the arrow hit the target?

(8) A sand bag is projected horizontally at $30ms^{-1}$ from a stationary hot air balloon. The sandbag lands 10s later. Calculate

(a) the horizontal distance it travels
(b) the final vertical speed of the ball.
(c) the resultant velocity of the ball when the sand bag hits the ground.



(9) An astronaut plays a game of golf on the moon. He hits a ball horizontally with a horizontal velocity of $18ms^{-1}$. The ball takes 8s to hit the ground. (g on moon = $1.6Nkg^{-1}$)

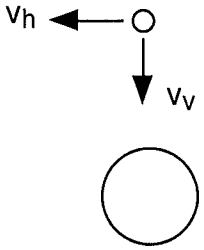


(a) How far did it travel horizontally?
(c) How did it manage to travel this very long distance?
(c) What was its final vertical speed?

(1)(a) $0ms^{-1}$ (b)(i) $9.8ms^{-1}$ (ii) $19.6ms^{-1}$ (iii) $49ms^{-1}$ (c) 8.2s (2)(a) $9.8ms^{-1}$ (b) $21.6ms^{-1}$ (c) $59.8ms^{-1}$ (3) (a)(i) $30ms^{-1}$ (b)(ii) $30ms^{-1}$ (c)(iii) $30ms^{-1}$ (c) $9.8ms^{-1}$ (ii) $19.6ms^{-1}$ (iii) $29.4ms^{-1}$ (4)(a) 100m (b) $49ms^{-1}$ (5)(a) $42.9ms^{-1}$ (b) $41.2ms^{-1}$ (c) 86.5m (6)(a) 5s (b) $8ms^{-1}$ (c) 40m (d) $49ms^{-1}$ (e) 122.5m (7)(a) 0.25s (b) $2.45ms^{-1}$ (c) 0.31m (8)(a) 300m (b) $98ms^{-1}$ (c) $102.5ms^{-1}$ (73 below horz) (9)(a)144m (c) $12.8ms^{-1}$

Tutorial 16	Satellites

(1) (a) What do we call an object which orbits another object.
(b) Name a natural satellite of Earth.
(c) Name a satellite of the Sun.
(d) The Earth has got a horizontal and vertical velocity. What would happen to the Earth if it stopped moving horizontally?



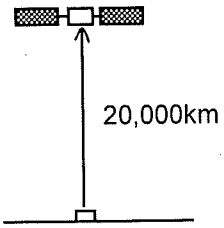
(2) Communication satellites orbit the Earth. As they get further from the Earth the time it takes the satellite to orbit the Earth increases. The following table tells you the period of some satellites

Satellite	Period (hrs)
Spudnik	8
Geodak	12
Satmo 3	24
Expo 6	36

(a) Which satellite is furthest from Earth?
(b) How many times would Spudnik orbit the Earth in a day?
(c) What is interesting about Satmo3?
(d) What do we call this type of satellite?
(e) If this satellite was placed directly over Glasgow. Where would it be relative to Glasgow a day later

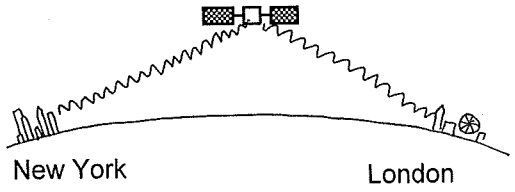
(3) A satellite company can choose to use 5 different microwave frequencies 4GHz, 7GHz, 12GHz or 18GHz.
The company chose the wave with the shortest wavelength. Without doing any calculations which one did they choose?

(4) A telecommunication satellite is placed 20,000km above the Earth
A microwave signal of frequency 6GHz is sent up to the satellite.

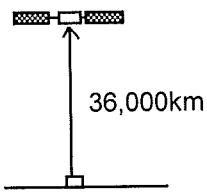


(a) Calculate the wavelength of the source.
(b) How long would it take the microwave signal to travel the 20,000km up to the satellite?

(5) A signal was sent from New York to London via a satellite. The signal took 0.38s to travel between the two cities. What was the total distance it travelled?



(6) A microwave with a wavelength of 3cm is used to communicate with a satellite which is in geostationary orbit 36,000km above the Earth.



(a) Calculate the frequency of the microwaves.
(b) How long would it take a signal to travel vertically up to the satellite **and** return to Earth if it was sent vertically upwards.

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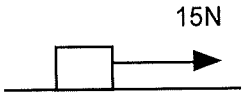
(3) 18GHz (4)(a) 0.05m (b) 0.067s (5) 1.14×10^8 m (6)(a) 1×10^{10}Hz (b) 0.24s

Tutorial 17	Work Done

(1) (a) What is "done" when you apply a force F to a mass over a distance d?
(b) When work is done what is transferred?

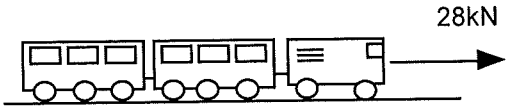
(2) A boy pulls a box across the floor using a force of 15N.
How much work is done if he pulls the box a distance of 6m?



(3) A car's engine applies a force of 2000N over a distance of 150m. How much work is done by the engine?

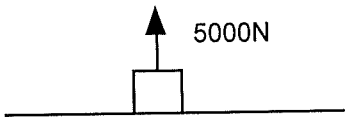
(4) A boy applies a force of 45N to pull a sledge 60m up a hill. How much work did he do?

(5) A locomotive applies a force of 28kN on the train carriages and moves the carriages 2.6km. How much work was done by the locomotive?



(6) A weight lifter holds a 200kg set of weights above his head for 5s. How much work is done by the weight lifter in holding the weights in this stationary position?

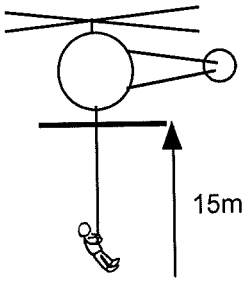
(7) A crane applies a force of 5000N to lift a box a vertical height of 12m off a harbour at a constant speed.
Calculate the work done by the crane.



(8) A boy of weight 800N climbs 8m up a rope in PE.
Calculate the work done by the boy

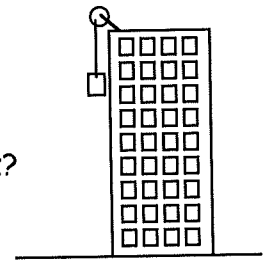
(9) A helicopter lifts a man of mass 60kg from a cliff a height of 15m

(a) Calculate the weight of the man.
(b) So what force did the helicopter have to apply to lift him at a constant speed?
(c) Calculate the work done by the helicopter.



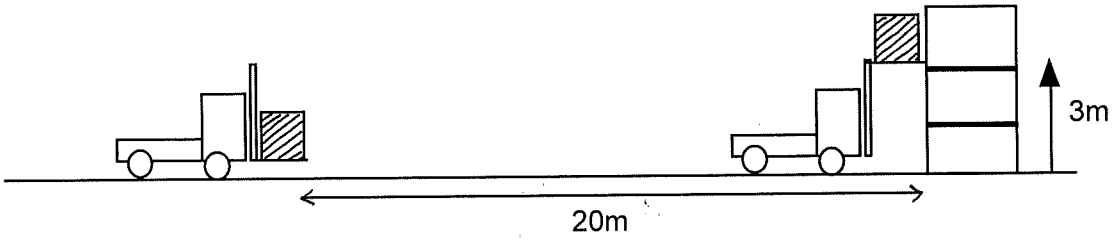
(10) A 12kg box is to be lifted onto the roof of a building.
The roof is 30m above the ground.

(a) Calculate the weight of the box?
(b) What is the minimum upward force required to lift the box?
(c) Calculate the work done in lifting the box the 30m.



(2) 90J (3) 300,000J (4) 2700J (5) 7.28×10^7J (6) 0J (7) 60,000J (8) 6400J (9)(a) 588N (b) 588N (c) 8820J (10)(a) 117.6N (b) 117.6N (c) 3528J

(11) A forklift truck applies a horizontal force of 400N to move a 80kg box 20m across a wharehouse floor. It then lifts the box 3m off the floor onto a shelf.



Calculate the total work done by the truck during this motion.
(Hint - there is 2 parts - a horizontal and a vertical)

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(12) A crane does 12000J of work in lifting a box 18m off a ship's deck.
What force did the crane apply?

(13) A car's engine applies a force of 7600N to move the car along a horizontal road.
If it does 145,000J of energy how far did the car move?

(14) On an expedition to the North pole a pack of husky dogs pulled a sledge.
In one journey the dogs did 650MJ of work in pulling the sledge 1500km.

(a) What was the average force the dogs applied.
(b) If there where 8 dogs in the team what was the average force each dog applied?

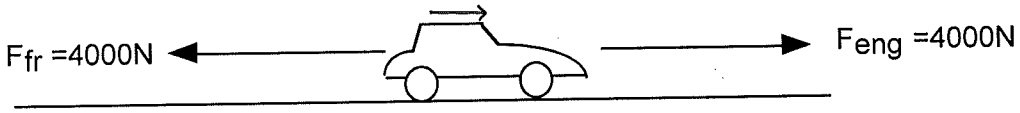
(15) A train enters a station with 500,000J of movement or kinetc energy.

(a) How much work has to be done or energy transferred to bring the train to a halt?
(b) If the brakes apply a force of 14,000N what distance will the train travel before it is brought to rest?

(16) A cyclist is travelling along the road with 6000J of kinetic energy, The cyclist applies the breaks and the bike comes to rest in 5m

(a) What was the 6000J of kinetic energy transferred into by the braking force?
(b) Calculate the size of the braking force.

(17) A car travels 50m along a road at a constant speed. The forces on it are shown



(a) Calculate the work done by the engine force.
(b) Calculate the work done by the frictional force.
(c) In terms of energy why does the car NOT speed up or gain more kinetic energy)

---

(11) 10,352J (12) 666.7N (13) 19.1m (14)(a) 433N (b) 54N (15)(a) 500,000J (b) 35.7m
(16)(a) heat (b) 1200N (17)(a) 200,000J (b) 200,000J

Tutorial 18	Kinetic Energy

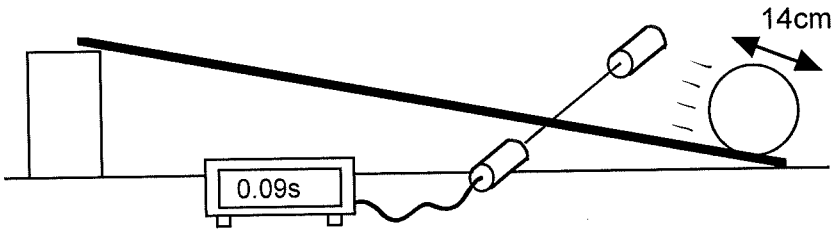
(1) A trolley of mass 4kg rolls down a slope with a speed of $5ms^{-1}$. calculate the kinetic energy of the trolley.

(2) A car has a mass of 1200kg and is travelling at $15ms^{-1}$. Calculate the kinetic energy of the car.

(3) Usain bolt has a mass of 75kg. If he crosses the 100m finish line with a speed of $10.5ms^{-1}$ calculate his kinetic energy when he crosses the line.

(4) An electron has a mass of $9.11x10^{-31}kg$. What is the kinetic energy of the electron if it is travelling at $2 \times 10^{7}ms^{-1}$?

(5) A student wants to measure the kinetic energy of a 0.2kg ball at the bottom of a slope. The ball has a diameter of 14cm. The timer measures the time it takes the ball to cut the light beam.



(a) What is the instantaneous speed of the ball as it cuts the light beam.
(b) Calculate the kinetic energy of the ball as it cuts the light beam.

---

(6) A car has 14,400J of kinetic energy. If its speed is $6ms^{-1}$ calculate the mass of the car.

(7) A 1.2kg ball is dropped from the roof of a building. When it hits the ground it has 735J of kinetic energy. What is the speed of the ball when it hits the ground?

(8) A space shuttle has a mass of $2x10^{6}kg$. At one point it has $6x10^{11}J$ of kinetic energy. What is the speed of the shuttle.

(9) A 50g bullet leaves a rifle with 490J of kinetic energy. Calculate the speed of bullet when it leaves the rifle.

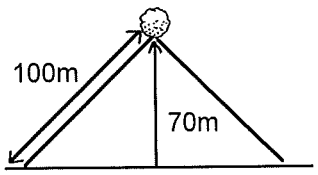
(10) A hospital lift has a mass of 800kg. At one point is is travelling upwards with a speed of $1.5ms^{-1}$ and has 1215J of kinetic energy. How many people are in the lift?
(Assume the average mass of a person is 70kg) (Hint - find total mass of lift + people)

---

(1) 50J (2) 135,000J (3) 4134.4J (4) $1.82x10^{-16}$ J (5)(a) $1.56ms^{-1}$ (b) 0.24J (6) 800kg (7) $35ms^{-1}$ (8) $774.6ms^{-1}$ (9) $140ms^{-1}$ (10) 4

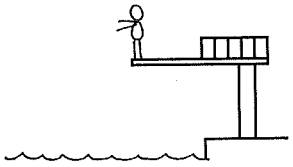
Tutorial 19	Gravitational Potential Energy

(1) When measuring the gravitational potential energy of this rock would you use the 100m or the 70m as the height h in your equation $E_p=mgh$?



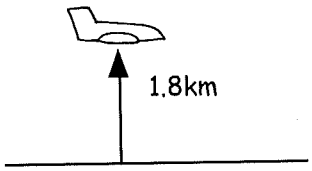
(2) A crate of mass 20kg is lifted 12m off the ground. Calculate the gravitational potential energy of the crate relative to the ground

(3) A 62kg diver stands on a 5m high platform. Calculate the gravitational potential energy of the diver relative to the water.



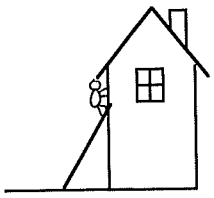
(4) A 75kg climber stands at the top of a 500m high hill. Calculate the gravitational potential energy of the climber relative to the bottom of the hill.

(5) A small plane has a mass of 1500kg. Calculate the gravitational potential energy of the plane relative to the ground.



(6) How much gravitational potential energy does a 30g ping pong ball have relative to the table when it is 40cm above the table?

(7) A window cleaner has 1800J of gravitational potential energy relative to the ground. If his mass is 72kg what is his height above the ground.



(8) A helicopter hovering 60m above the ocean has 2.8MJ of gravitational potential energy. What is the mass of the helicopter?

(9) A 75kg skier standing at the top of a slope has 94,000J.of gravitational potential energy relative to the finish line . What is the vertical height of the skier above the finish?

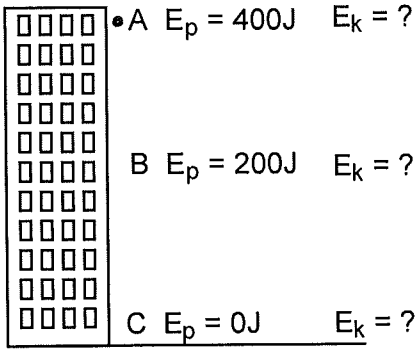
(10) The space station is 200km above the surface of the Earth and its mass is 14,000kg. If it has 2.4×10^{10}J of gravitational potential energy relative to the ground calculate the gravitational potential energy at this height.

(1) 70m () 2352J (3) 3038J (4) 367,500J (5) 2.65×10^{7}J (6) 0.12J (7) 2.55m (8) 4761.9kg (9) 127.9m (10) 8.6Nkg

Tutorial 20	Energy Conservation

In all these questions - ignore friction.

(1) A ball is dropped from the roof of a building. The gravitational potential energy, E_p of the ball is shown at 3 points as it falls.

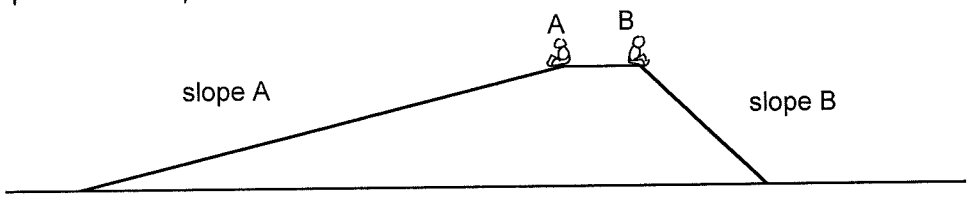


(a) What happens to the gravitational potential energy of the ball as it drops?
(b) If this energy decreases what does it turn into?
(c) State the kinetic energy at the 3 points A,B and C?

(2) A boy drops a 1kg ball from a height of 3m.

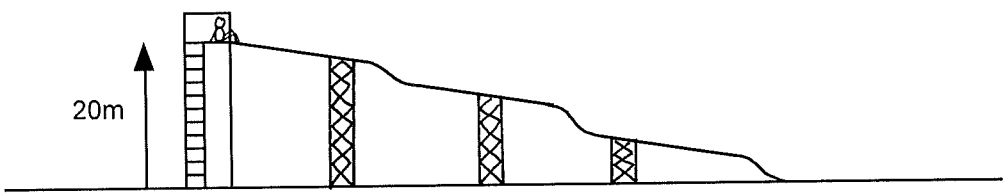
(a) Calculate the gravitational potential energy of the ball at a height of 3m.
(b) As is is dropped it loses gravitational potential energy. What does it change into?
(c) How much gravitational potential energy does it have just as it hits the floor?
(d) Therefore how much kinetic energy does it have at this point.
(e) Therefore what is its speed just as it hits the ground.

(3) Two boys A and B sit at the top of a hill as shown. One boy slides down slope A the other slope B. The boys have the same mass. (ignore friction)



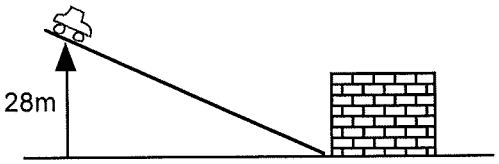
(a) Which boy has the most gravitational potential energy at the top? (careful)
(b) Compare the kinetic energy of each boy when they get to the bottom of the slope?

(4) A 50kg girl sits at the top of a water slide as shown



(a) Calculate her gravitational potential energy at the top of the slide.
(b) How much kinetic energy does she have at the bottom of he slope?
(c) Calculate her speed at the bottom of the slide.

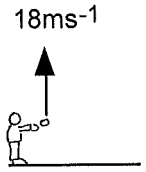
(5) A 800kg car's brakes fail and it rolls down the slope as shown.



(a) Calculate the cars gravitational potential energy at the top of the slope.

(b) At what speed does it crash into the wall at the bottom?

(6) A boy throws a 0.4kg ball vertically up in the air. It leaves the girls hand with a speed of $18ms^{-1}$.



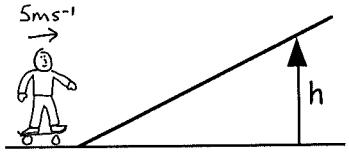
(a) Calculate the kinetic energy of the ball when it leaves her hand.

(b) As it travels up in the air the ball slows down and therefore loses kinetic energy. What does this kinetic energy turn into?

(c) Therefore how much gravitational potential energy does it have at its highest point?

(d) Calculate the height h the ball reaches.

(7) A skate boarder of mass 48kg travels towards a hill with a speed of $5ms^{-1}$.

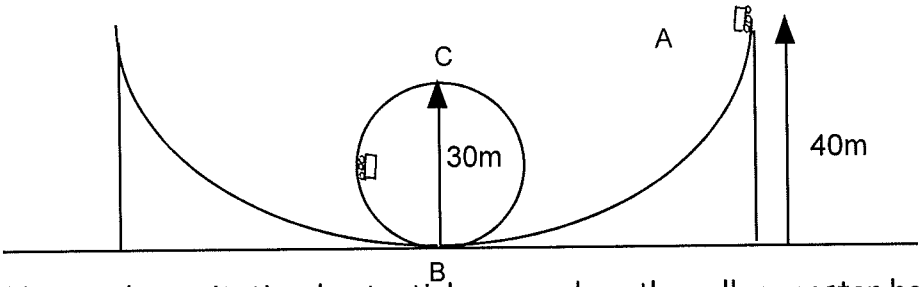


(a) What is the kinetic energy of the skate boarder at the bottom of the hill?

(b) What is the maximum height the skate boarder h reaches.

(8) A bullet is fired vertically upwards with a speed of $150ms^{-1}$. What height does it reach? (hint can something cancel out)

(9) A roller coaster of mass 3000kg is released from point A and performs a loop the loop. (If we ignore friction $E_k + E_p$ at all points should be a constant value.)



(a) How much gravitational potential energy does the roller coaster have at point A?

(b) How much kinetic energy does it have at point B?

(c) Calculate its gravitational potential energy at point C?

(d) Therefore how much kinetic energy does it have at point C.

(e) Calculate its speed at point C

---

(1)(c) 0, 200, 400J (2)(a) 29.4J (c) 0J (d) 29.4J (e) $7.7ms^{-1}$. (3)(a) same (b) same (4)(a) 9800J (b) 9800J (c) $19.8ms^{-1}$. (5) 219,520J (b) $23.4ms^{-1}$. (6)(a) 64.8J (c) 64.8J (d) 16.5m (7)(a) 600J (b) 1.28m (8) 1148m (9)(a) 1,176,000J (b) 1,176,000J (c) 882,000J (d) 294,000J (e) $14ms^{-1}$.

Tutorial 21	Space Exploration

(1) (a) What do we call the telescopes which can pick up visible light?
(b) How can long wavelength radio waves give us so much information about stars which are hidden behind gas clouds in our Galaxy?
(c) Why are terrestrial telescopes unable to pick up some types of radiation from space, for instance UV or X-rays?

(2) Name one very powerful telescope which has been positioned on a satellite, to pick up signals from all parts of the electromagnetic spectrum coming from deep space?

(3) What are the names of the two space probes, launched in 1977 which first explored and sent back images from the outer planets?

(4) Read the following article about the USA's space probes:

The USA launched many Mariner probes to study the inner planets. In 1962 Mariner 2 discovered the lead melting temperatures on the surface of Venus and that it did not have a magnetic field. Mariner 4 launched in 1964 gave us the first close up pictures from Mars. But it wasn't until 1971 when Mariner 9 sent back over 7000 video images of the surface of Mars and its 2 moons Phoebos and Deimos that we got a detailed picture of the red planet. In 1973 Mariner 10 captured more detailed images of Venus and Mercury. In 1973 the Pioneer probes were sent to study Jupiter, sending back the first detailed images of Jupiter's huge storm, the so called Red spot.

(a) What phrase tells you that it is very hot on the surface of Venus?
(b) Which probe sent back images from the two moons of Mars?
(c) What are the names of the space probes sent to Jupiter?

(5) (a) What do we call a satellite which stays above the same point on the Earth's surface?
(b) What is the period of a geostationary satellite.
(c) A weather satellite has a period of 4hrs. How many times does it orbit the Earth in 1 day?

(6) Apart from communication state 3 uses for satellites.

(7) State 3 commonly used items which were originally developed for use in space.

(8) Do you think that space satellites make war between countries more or less likely?

Tutorial 22	Reentry 1 - Force and Energy

(1) A meteorite enters the earth's atmosphere with 40,000J of kinetic energy. After travelling for a few km the kinetic energy of the meteorite is now 10,000J.

(a) How much kinetic energy has been lost?
(b) What has this lost kinetic energy been transferred into?
(c) What do we call the force which is transferring this energy from kinetic to heat?
(d) What is another phrase for "energy transferred"?
(e) If the meteorite travels 500m through the atmosphere as this work is done then calculate the frictional force acting on the meteorite.

(2) A small piece of metal of mass 2kg falls off a satellite and enters the atmosphere at a speed of $4000ms^{-1}$

(a) How much kinetic energy does it have as it enters the atmosphere?

After a distance of 6000m its speed has decreased to $2000ms^{-1}$.

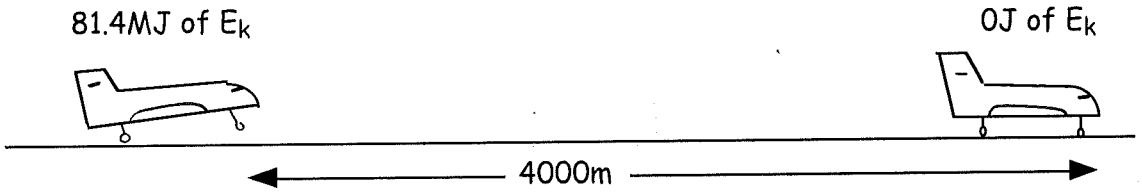
(b) Calculate the amount of kinetic energy it has now?
(c) Calculate the work done by air friction to transfer the kinetic energy to heat.
(d) Calculate the average frictional force on the piece of metal.

(3) The space shuttle Columbia has a mass of $2x10^6kg$. The atmosphere slows its speed from $8000ms^{-1}$ to $2000ms^{-1}$.

(a) How much kinetic energy does the shuttle loose?
(b) So how much heat energy is produced?
(c) If the shuttle travel through 14000km of atmosphere calculate the average frictional force caused by the air.

(4) A space probe enters the dense Venus atmosphere and its kinetic energy falls from 780MJ to 220MJ. If the average frictional force acting on the probe was 578kN calculate the length of atmosphere it has travelled through.

(5) At touchdown the kinetic energy of the shuttle is shown. 4000m later it comes to rest



(a) How much work has to be done by friction to bring the shuttle to rest?
(b) Calculate the frictional force required to do this amount of work over 4km.

---

(1)(a) 30,000J (e) 60N (2)(a) $1.6x10^7J$ (b) $4x10^6J$ (c)$1.2x10^7J$ (d) 2000N (3)(a) $6x10^{13}J$ (b) $6x10^{13}J$ (c) $4.29x10^6$ N (4) 969m (5)(a) 81.4MJ (b) 20,350N

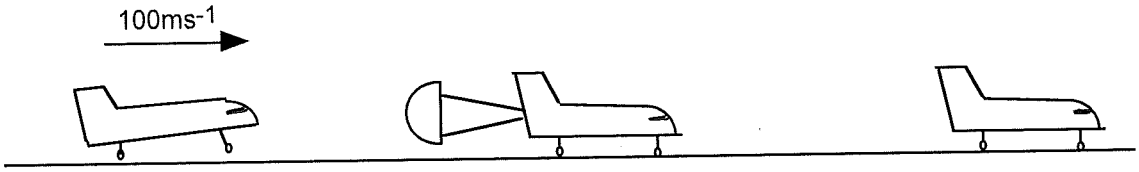
(6) A space shuttle of mass $2x10^6$kg touches down on the runway with a speed of $150ms^{-1}$.

(a) How much kinetic energy does it have when it touches down?
(b) How much kinetic has to be lost or transferred to heat by the time it comes to a halt?
(c) If travels 4.8km along the runway before it comes to rest calculate the average frictional force on the shuttle.
(d) State 3 sources of this frictional force during the deceleration on the runway.
(e) Calculate the deceleration of the space shuttle. (hint F_u=ma)

(7) Another shuttle of mass $4x10^6$kg touches down with a speed of $90ms^{-1}$. The average braking force on the shuttle is $5.2x10^6$N.

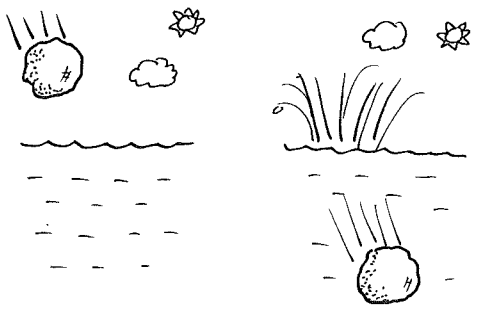
(a) How much kinetic energy does the shuttle have on touch down?
(b) How much work must be done by the frictional force to bring the shuttle to a halt?
(c) Calculate the minimum length of runway required to stop the shuttle

(8) A shuttle of mass $4x10^6$kg touches down with a velocity of $100ms^{-1}$. After 50s the shuttle came to rest



(a) Calculate the acceleration of the shuttle.
(b) Therefore use Newton's 2nd law to calculate the frictional force on the shuttle.
(c) Friction is created from 3 sources - tyres against runway, parachute and air friction on body of shuttle.
If friction between runway and tyres was 2,000,000J. Friction created by the parachute was 5,000,000J calculate the air resistance acting on the shuttle.

(9) A giant 4000kg meterorite lands in the middle of the Atlantic oceon. It travels 3.8km through the depths before it is brought to rest. The average frictional force applied by the water is 75,000N. calculate



(a) the work done by the water is bringing the meteorite to rest.
(b) the kinetic energy of the meteroite when it hit the water
(c) the speed of the meteroite when it hit the water.

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(6)(a) $2.25x10^{10}$J (b) $2.25x10^{10}$.J (c) 4,687,500N (e) $2.3ms^{-2}$. (7)(a) $1.62x10^{10}$.J (b) $1.62x10^{10}$J (c) 3115.4m. (8)(a) $-2ms^{-2}$. (b) $-8x10^6$N (c) $1x10^6$N (9)(a) $2.85x10^8$J (b) $2.85x10^8$J (c) $377.5ms^{-1}$.

Tutorial 23	Specific Heat Capacity

(1) The specific heat capacity of a metal is $500 Jkg^{-1}{}^{o}C^{-1}$. How much energy is required to heat 1kg of this metal by (a) $1^{o}C$. (b) $4^{o}C$.

(2) A metal has a specific heat capacity of $400 Jkg^{-1}{}^{o}C^{-1}$. How much heat energy is required to heat 5kg of this metal by $30^{o}C$?

(3) A liquid has specific heat capacity of $2500 Jkg^{-1}{}^{o}C^{-1}$. How much heat energy is required to heat 3kg of the liquid by $15^{o}C$.

(4) If you wanted to measure the specific heat capacity of a metal rearrange the formula to allow you to calculate the specific heat capacity.

Use the following specific heat capacities to answer the following questions

Substance	Specific Heat Capacity $Jkg^{-1}{}^{o}C^{-1}$
methylated spirits	2300
aluminium	900
crown glass	670
iron	480
copper	385
brass	370
silver	235
mercury	140
lead	130

(5) If you had 1kg of each of the above substances which would require the most heat energy to raise its temperature by $1^{o}C$

(6) How much heat is required to raise the temperature of 4kg of aluminium by $12^{o}C$?

(7) A 20kg lump of iron is heated up by $50^{o}C$. How much heat energy is required?

(8) The temperature of a metal rose from $20^{o}C$ to $30^{o}C$. What is the change in temperature ΔT?

(9) How much heat energy is required to heat 6kg of mercury from $20^{o}C$ to $100^{o}C$?

---

(2) 60,000J (3) 112,500J (5) methylated spirits (6) 43,200J (7) 480,000J (8) $10^{o}C$ (9) 67,200J

(10) How much heat energy is required to raise the temperature of 200kg of methylated spirits from 20°C to 55°C.

---

(11) 2600J of heat energy is added to a 4kg block of lead.

(a) Calculate the rise in the temperature of the lead.
(b) If the starting temperature of the lead was 20°C. what was its final temperature?

(12) 70kJ of heat energy is supplied to 18kg of copper.

(a) What is the rise in the temperature of the lead?
(b) If its starting temperature of the copper was 22°C. then what is was its final temperature?

(13) In an experiment 154,000J of heat energy is added to a block of iron. If the temperature of the iron rose by 48°C what was the mass of the iron block?

(14) 254,000J of heat energy are required to raise the temperature of 2kg of glycerol from 30°C. to 82°C. What is the specific heat capacity of glycerol?

(15) A 450g block of silver at 20°C is heated by adding 12kJ of heat energy. What is the final temperature of the silver? (Hint - find change in temperature)

(16) 2000J of heat energy is used to heat a block of metal from 10°C to 40°C. If the block cooled down from 40°C to 10°C, how much heat energy would the block give out?

(17) A 5kg block of iron is allowed to cool down from 100°C to 20°C. How much heat energy does the iron block give out?

(18) An iron girder is taken out of a furnace. It was dipped into a pool of water to cool it down. As it cooled down from 300°C to 20°C it emitted 46MJ of heat energy. What was the mass of the girder?

(19) A brass bar of mass 14kg is cooled down it emits 820kJ of heat.

(a) What was the fall in its temperature?
(b) If its starting temperature was 400°C what was its final temperature?

(20) (a) What is interesting about the specific heat capacity of water?
(b) Why is it used as the liquid in our central heating systems to transport the heat from the boiler to radiators?

---

(10) 1.61×10^7J (11)(a) 5°C (b) 25°C (12)(a) 10.1°C (b) 32.1°C (13) 6.7kg (14) 2442Jkg^{-1}
(15) 133.4°C (16) 2000J (17) 192,000J (18) 342kg (19)(a) 158.3°C (b) 241.7°C

Specific heat capacity of water = 4180Jkg^{-1}°C^{-1}

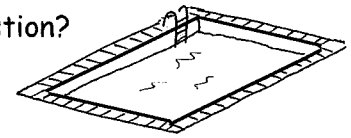
(21) A kettle heats up 2kg of water from 20°C to 25°C. How much heat energy is required?

(22) How much heat energy does a boiler supply to heat up 48kg of water from 30°C to 50°C?

(23) A cup containing 0.08kg of water cools down by 60°C when left on a table. Calculate the amount of energy the water gives out.

(24) An immersion heater supplies 15MJ of heat energy to 85kg of water.

(a) What was the rise in the temperature of the water?
(b) If the starting temperature of the water was 20°C what was the final temperature of the water?
(c) What is the big assumption you are making in this question?



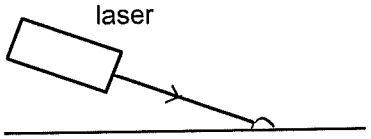
(25) A swimming pool heater supplies 7.6×10^8J of heat energy. This is enough to heat the water in the pool from 18°C to 25°C. Calculate the mass of water in the pool.

(26) The water in a car's radiator cools down from 86°C to 23°C. As it cools down 1.2MJ of eat energy are given out. What is the mass of the water in the radiator?

(27) In an experiment 7.2kg of water is heated. The heater delivers 450kJ of heat to the water.

(a) What is the rise in the temperature of the water?
(b) If the water started at a temperature of 18°C then what is its final temperature?

(28) A laser delivers 2.4kJ of energy to 1.4g of a metal. The temperature rise was 1905°C



(a) Calculate the specific heat capacity of the metal.
(b) Use the data table to identify the metal
(c) Each pulse of the laser delivers 4.8J of energy. How many pulses would have been required to deliver this energy

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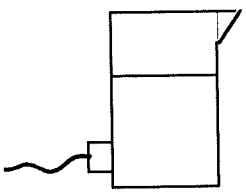
(29) A kettle has a power of 2000W and it is switched on for 3minutes to heat up 1.5kg of water.

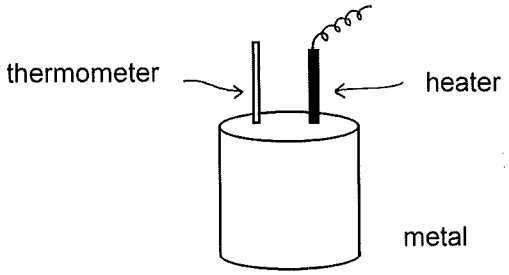


(a) How much electrical energy does the kettle use?
(b) If all this energy is converted to heat and all of it is absorbed by the water what is the rise in the temperature of the water?

---

(21) 41,800J (22) 4.0×10^6J (23) 20,064°C (24)(a) 42.2°C (b) 62.2°C (25) 25,974kg (26) 4.6kg
(27)(a) 15°C (b) 33°C (28)(a) 900Jkg^{-1}°C^{-1} (b) Aluminium (c) 500 (29)(a) 360,000J (b) 57.4°C

(30) In an experiment to measure the specific heat capacity of a metal block the following measurements were taken:



mass of block = 2kg
Temperature of block at start = 20°C
Temperature of block at end = 72°C
Power of heater 36W
Time heater was on for = 15mins

(a) Show that 32,400J of heat energy was delivered to the block in the 15mins?
(b) Calculate the specific heat capacity of the metal block.
(c) What assumption are you making in this experiment?
(d) How could you have improved the experiment?

(31) A 18kW heater is used to heat a block of copper from 20 to 140°C.
The heater is switched on for 2hours.
(Assume all electrical energy is transferred to heat and absorbed by the block.)

(a) How much heat energy is delivered to the block?
(b) What is the mass of the block

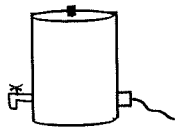
(32) A 24W heater is switched on for 900s and heats a beaker containing 0.7kg of water

(a) How much electrical energy is used by the heater?
(b) If all this energy is turned to heat and absorbed by the water calculate the rise in the temperature of the water.

(33) A paddling pool containning 5000kg of water is heated from 12°C to 20°C.

(a) How much energy was required?
(b) If the power of the heater was rated at 14kW how long did it take to heat the water from 12 to 20°C?

(34) An urn of water contains 40litres of water. It is switched and it takes 36mins to heat the water from 20 to 100°C. (1litre = 1kg)



(a) How much heat energy is delivered to the water in this time?
(b) What is the power rating of the urn's heater?

(35) An electric power shower heats 5kg of water from 16°C to 40°C each minute.

(a) Calculate the heat energy supplied to the water every minute.
(b) Calculate the power output of the shower.

---

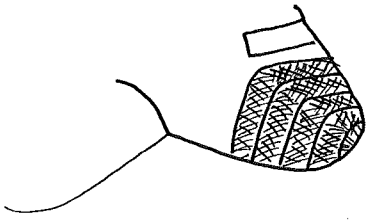
(30)(b) 311.5Jkg^{-1}°C^{-1} (31)(a) 1.30x10^{8}J (b) 2814kg (32)(a) 21,600J (b) 7.4C (33)(a) 1.67x10^{8}J (b) 11,929s (34)(a) 1.34x10^{7}J (b) 6192.6W (34)(a) 501,600J (b) 8360W

Tutorial 24	Reentry 2 - Tiles Heating

(1) A space shuttle is covered in tiles to protect the metal body of the shuttle..

(a) During reentry what do these tiles absorb?
(b) How does this protect the metal body?

(2) The nose of a space shuttle is covered in 250kg of heat resistant tiles. As it is acted on by air friction during reentry the tiles absorb 2.1×10^8J of heat energy.
(specific heat capacity of the tiles = 780Jkg^{-1}°C^{-1})



What is the rise in the temperature of the tiles?

(3) A satellite of mass 80kg is made mostly of aluminium.
It malfunctions and starts to spin in towards earth.
As it travels through the atmosphere it
absorbs 3.6×10^8J of heat and burns to a cinder.
By working out the possible rise in temperature of
the satellite say why it is unlikely to stay in tact.

(4) A new substance is used as heat shield tiles on a space shuttle. As the shuttle travels through the atmosphere the tiles absorb 4.7×10^{10}J of heat energy. If the mass of the tiles is 24,000kg and the temperature rise is 1200°C what is the specific heat capacity of this new material?

(5) (a) Why is it important to cover the shuttle in tiles with a very high melting point?
(b) Why is it important to cover the tiles in a material with a large specific heat capacity?

(6) Aluminium has a higher specific heat capacity than silica (a material used to make heat tiles). By looking at data for solids why would engineers not chose aluminium from which to make the heat tiles?

(7) The temperature of 600kg of tiles on a space shuttle is 100°C just as they enter the atmosphere. During reentry they heat up to 1400°C. If the specific heat capacity of the tiles is 850Jkg^{-1}°C calculate the amount of heat energy the tiles absorb.

---

(2) 1077°C (3) 5000°C (4) 1632Jkg^{-1}°C^{-1}. (7) 6.63×10^8J

Tutorial 25	Latent Heat

(1) The latent heat of fusion of napthalene is 350,000Jkg^{-1}.

(a) How much energy is required to change 1kg of solid napthalene to liquid napthalene at its melting point?

(b) If the 1kg of liquid napthalene changed back into 1kg of solid napthalene how much heat energy was given out?

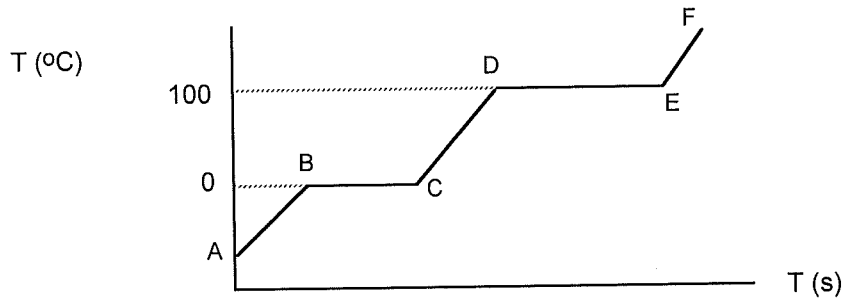
(2) In questions involving substances changing from a solid to a liquid or a liquid back to a solid do we use the specific latent heat of <u>fusion</u> or <u>vaporisation</u>?

(3) In questions involving substances changing from a liquid to a gas or a gas back to a liquid do we use the specific latent heat of <u>fusion</u> or <u>vaporisation</u>?

Substance	Latent heat of fusion (Jkg^{-1})	Latent heat of vaporisation (Jkg^{-1})
ice	3.34×10^5	
water	——	22.6×10^5
Ammonia	3.39×10^5	13.69×10^5
Carbon dioxide	1.84×10^5	5.74×10^5
turpentine	——	2.93×10^5
Nitrogen	0.26×10^5	2.00×10^5
Gold	0.66×10^5	3.34×10^5
Iron	2.76×10^5	3.34×10^5
Mercury	0.12×10^5	

(4) The latent heat of fusion of a substance is 64,000Jkg^{-1}. How much heat is required to melt 5kg of the substance at its melting point?

(5) This graph shows 4kg of ice being heated over a period of time



(a) What happens between points B-C?

(b) Why does the temperature not change even though the heater is still on?

(c) What happens between points D-E?

(d) Why does the temperature not change even though the heater is still on?

(e) From graph, does it take more energy to melt 1kg of ice or boil off 1kg of water?

(6) In a foundry 62kg of gold is to be melted. How much energy is required to melt the gold at its melting point?

(7) The specific latent heat of fusion of ice is $3.34 \times 10^5 Jkg^{-1}$. How much energy is required to change 8kg of ice to 8kg of water at 0°C?

(8) How much energy does 16kg of liquid iron give out when it freezes to solid iron at its melting point?

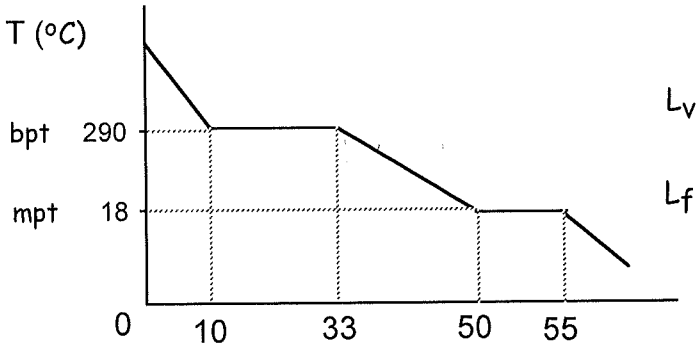
(9) At an ice rink the engineer has a pool of 140kg of water at 0°C. How much energy is given out when this water freezes into 140kg of ice at 0°C?

(10) A new substance is discovered. In a test a scientist finds that it takes 680,000J of heat energy to melt 5kg of the substance at its melting point. What is the latent heat of fusion of the substance?

(11) $4.2 \times 10^6 J$ of heat energy is added to a solid iron bar at its melting point. What mass of iron would be changed to liquid iron?

(12) (a) Calculate the latent heat of fusion of lead if it takes 500,000J of energy to convert 20kg of solid lead to liquid lead.
(b) If this 20kg now turns back into 15kg of solid lead how much energy is given out?

(13) This graph shows the temperature of 0.4kg of benzene as it cools down from a gas.



L_v benzene = $1.8 \times 10^5 Jkg$

L_f benzene = $0.68 \times 10^5 Jkg$

(a) What happens to the benzene between 10-30s?
(b) What happens to the benzene between 50-65s?
(c) How much energy is released as it condenses?
(d) How much energy is released as it freezes?
(c) By looking at the time it took to freeze the benzene what is the power output of the refrigerator?

---

(14) How much heat energy is required to change 6kg of liquid carbon dioxide into 6kg of carbon dioxide gas at its boiling point?

---

(1)(a) 350,000J (b) 350,000J (4) 320,000J (6) $4.1 \times 10^6 J$ (7) $2.67 \times 10^6 J$ (8) $4.4 \times 10^6 J$
(9) $4.68 \times 10^7 J$ (10) $1.36 \times 10^5 Jkg^{-1}$ (11) 15.2kg (12)(a) $2.5 \times 10^4 Jkg^{-1}$ (b) 500,000J
(13)(c) 72,000J (d) 27,200J (e) 90.7W (14) $3.4 \times 10^6 J$

(15) A kettle brings water to its boiling point.

(a) How much energy is required to change 1.5kg of water to 1.5kg of vapour at 100°C?

(b) If the 1.5kg of vapour condenses back to 1.5kg of water at 100°C how much energy is emitted?

(16) How much heat energy is required to boil off 0.6kg of water at 100°C?

(17) A scientist wants to change 18kg of liquid nitrogen into 12kg of nitrogen gas at its boiling point. How much energy is required?

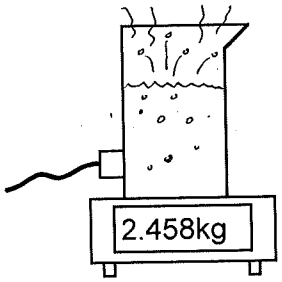
(18) How much energy needs to be removed to turn 24kg of gaseous ammonia to liquid ammonia at its boiling point?

(19) A steam wallpaper stripper delivers 160×10^5 J of heat energy to 15kg of water at 100°C. What mass of water is turned into steam?

(20) 13×10^5 J of heat energy is required to boil off 0.26kg of liquid Methane at its boiling point. What is the latent heat of vaporisation of methane?

(21) 2.7kg of gaseous turpentine condenses back into 2.7kg of liquid turpentine at a constant. How much energy was given out

(22) A pupil carried out the following experiment to determine the latent heat of vaporisation for a new liquid. The liquid was poured into a kettle and the kettle was switched on. At its boiling point the mass of the kettle and liquid was measured. The kettle was left left on for a further 12mins and a mass of liquid was boiled off.



Mass of kettle and liquid at boiling point = 2.788kg
Mass of kettle and liquid after 12mins = 2.058kg

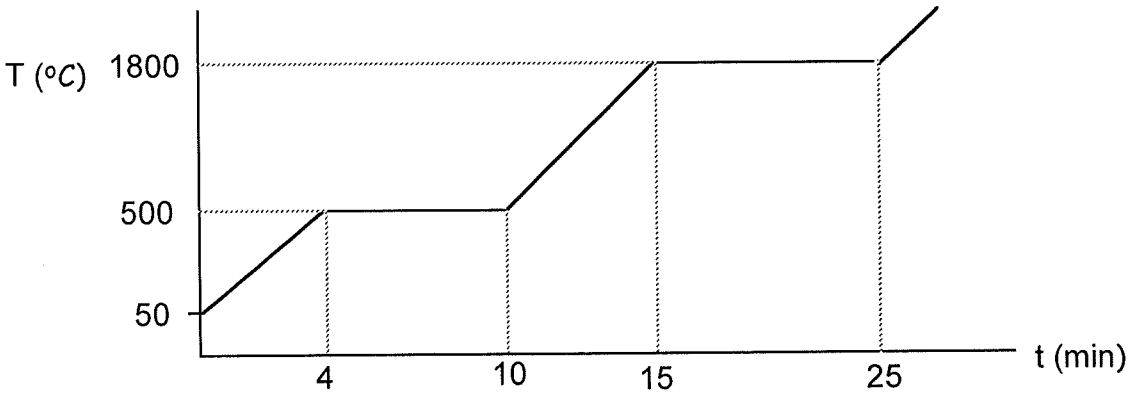
Power of the kettle = 1850W

(a) Calculate the energy supplied to the water at its boiling point.
(b) Calculate the mass of water boiled off.
(c) Therefore calculate the latent heat of vaporisation of the liquid.

---

(15)(a) 3.39×10^6 J (b) 3.39×10^6J (16) 1.36×10^6 J (17) 2.4×10^6J (18) 3.29×10^7J (19) 7.1kg
(20) 5×10^6J (21) 7.9×10^5J (22)(a) 1.33×10^6J (b) 0.73kg (c) 18.2×10^5Jkg^{-1}

(23) Look at this graph showing a 2kg solid being heated by a 3400W heater until it turns into a gas.

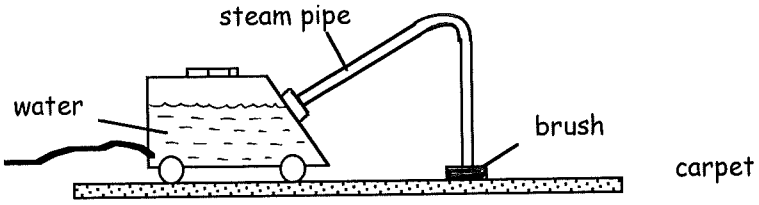


(a) How much energy was absorbed by the water in the first 4minutes?
(b) calculate the specific heat capacity of the solid.
(c) What happens to the solid between 4 and 10mins?
(d) How much heat energy did it absorb between 4 and 10mins?
(e) Calculate its latent heat of fusion.
(f) Calculate its latent heat of vaporisation.
(g) How can you tell from the graph that it takes more energy to boil off a liquid than to melt a solid?

(24) The owner of an ice rink finds that all the 8000kg of ice in the rink has melted and is at a temperature of 20°C.

(a) How much heat has to be removed to cool the water from 20°C to water at 0°C?
(b) How much extra heat must be removed to change the 8000kg of water at 0°C to 8000kg of ice at 0°C
(c) If the refrigeration unit takes 32 hours to cool the water from 20°C to ice at 0°C what is the power of the refrigeration unit?

(25) A steam carpet cleaner rated at 2kW is used to clean a carpet. The water tank is filled with 1.6kg of water at 20°C. The heater brings the water to its boiling point then is left on to turn the water to steam.



(a) Calculate the amount of heat energy is needed to bring this water to its boiling point of 100°C?
(b) How much heat energy is required to boil off 0.9kg of water
(c) How long would it take to heat the water to 100°C then boil of 0.9kg?

---

(23)(a) 816,000J (b) 906.6Jkg (d) 1.22×10^6J (e) 6.1×10^5Jkg (f) 1.02×10^6Jkg^{-1}
(24)(a) 6.69×10^8J (b) 2.67×10^9J (c) 28,984W (25)(a) 5.35×10^5J (b) 2.03×10^6J (c) 1283s

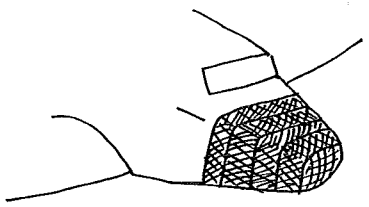
Tutorial 26	Reentry 3 - Heat Shields Melting

(1) The tiles of a space shuttle reach their melting point during reentry.

(a) Why will the tiles still protect the metal body of the shuttle even while they melt?

(b) If the latent heat of fusion of the tiles is $1.7 \times 10^5 Jkg^{-1}$ how much heat will the 24,000kg absorb if they all melt?

(2) A space shuttle's nose is covered in 160kg of heat shield tiles. At one point they reach their melting point.



After a few minutes they absorb a further $6.8 \times 10^6 J$ of heat. If this causes 40kg of tiles to melt calculate the latent heat of fusion of the tiles.

(3) Why will tiles with latent heat of fusion $5 \times 10^5 Jkg^{-1}$ be more effective in protecting the metal body of the shuttle than tiles with a latent heat of fusion $2 \times 10^5 Jkg^{-1}$

(4) A space shuttle is covered with 18,000kg of a new type of tile. In a test, when half the tiles melted, they absorbed $3.84 \times 10^9 J$ of heat energy. Calculate the latent heat of fusion of the tiles.

(6) Each m^2 of the underside of the shuttle is covered in 36 heat resistant tiles tiles. The mass of each tile is 0.06kg and its latent heat of fusion is $860 Jkg^{-1}$.

(a) How many tiles are needed to cover a total area of $300m^2$?

(b) On reentry 2000 tiles melted. How much heat energy did the tiles absorb?

(7) A shuttle covered in 20,000kg of heat tiles reenter the atmosphere. The temperature of the tiles at this point is 100°C. They heat up to their melting point of 1600°C and then a quarter of the tiles melt.

specific heat capacity of tiles = $760 Jkg^{-1}{}^{o}C^{-1}$ **L_f tiles** = $1.9 \times 10^5 Jkg^{-1}$

(a) What is the total amount of heat energy absorbed by the tiles during reentry?

---

(1)(b) $4.08 \times 10^9 J$ (2) $1.7 \times 10^5 Jkg^{-1}$. (4) $4.27 \times 10^5 Jkg^{-1}$ (6)(a) 10,800tiles (b) 103,200J
(7) $2.38 \times 10^{10} J$

Tutorial 27	Cosmology

(1) (b) The moon is 1.28 light seconds from Earth. How long would it take a beam of light to travel from the moon to Earth?

(a) The sun is 8 light minutes from Earth. How long would it take a beam of light to travel from the Sun to Earth

(c) The star Proxima Centauri is 4.2 light years from Earth. How long would it take a beam of light to travel from Proxima Centauri to Earth?

(2) The speed of light in a vacuum is $3x10^8 ms^{-1}$.

(a) How far does light travel in 1 second?

(b) How far will it travel in 1minute?

(3) Mars is 320 light seconds from Earth. What is this in m?

(4) Jupiter is 35 light minutes away from Earth. How far is this in m?

(5) The star Vega is 27 light years from Earth. How far is this in m?

(6) The massive star Betelgeuse is 520 light years from Earth. How far is this in m?

(7) Our galaxy is 100,000 light years across. How far is this in m?

(8) The distance to the super bright star Rigel is $8.5x10^{18}$ m. What is this in light years?

(9) The distance to or nearest Galaxy Andromeda is $2.37x10^{22}$m. What is this in light years?

(10) Read the following clues and choose your answers from the following list

star	**moon**	**planet**	**solar-system**	**universe**
exo planet	**super clusters**	**galaxy**	**Milky way**	

(a) What is a ball of extremely hot gas which emits light and heat.

(b) What orbits a star.

(c) Our sun and its 8 planets is called this.

(d) This is the name for a large group of billions of stars

(e) This is the name of our galaxy

(f) This is the name we give to the space which includes everything.

(g) This is a natural satellite of a planet

(h) Galaxies usually group together in these structures

(i) These orbit stars outside our solar system

---

(1) 1.28s (b) 8mins (c) 4.2years (2)(a) $3x10^8$m (b) $1.8x10^{10}$m (3) $9.6x10^{10}$m (4) $6.3x10^{11}$m

(5) $2.55x10^{17}$ m (6) $4.92x10^{18}$ m (7) $9.46x10^{20}$ m (8) 898light years (9) $2.5x10^6$ light years

(11) Why would a planet be very unlikely able to sustain live if

(a) It is too close to its star.
(b) It is too close to the centre of its galaxy.
(c) It is too small.
(d) It is too big.
(e) It does not have a magnetic field surrounding it.

(12) Most physicists agree that the universe began in an enormous explosion called the Big Bang

(a) How long ago did the big bang occur?
(b) What happened to some of this heat energy as the universe cooled?
(c) Which force started to clump bits of mass together?

(13) Microwave radiation can be detected from all parts of the universe.

(a) When was this microwave radiation created?
(b) If it is the heat left over from the big bang why is it not the shorter wavelength infra red radiation we are detecting?
(c) Give one other bit of evidence indicating the universe is still expanding.
(d) When we say the universe is expanding what is actually expanding?
(e) So why is the distance from school to your house not getting greater?

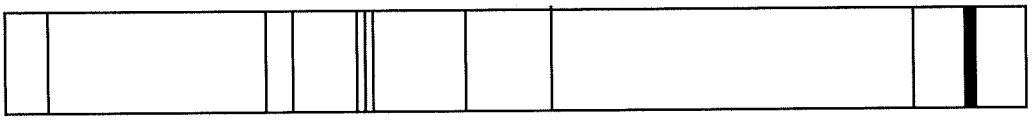
(14) Give an example of an extreme astronomical event which would produce very high frequency UV, X-rays and Gamma rays.

(15) The following table gives information about stars

Spectral Type	Example	Temperature range (K)	Brightest wavelength emitted
O	Orionus	> 30,000	> 97nm (UV)
B	Rigel	30,000 to 10,000	97 - 290nm (UV)
A	Sirius	10,000 to 7500	290 to390nm (Violet)
F	Polaris	7500 to 6000	390 - 480nm (Blue)
G	Sun	6000 to 5000	480 - 580nm (Yellow)
K	Arcturus	5000 to 3500	580 - 830nm (red)
M	Betelgeuse Proxima Centauri	< 3,500	>830m (infra red)

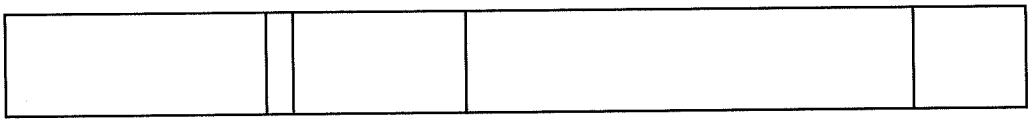
(a) Light from which end of the spectrum- blue or red indicates a hotter star?
(b) Which spectral type is our sun?
(c) Name a star which has a temperature between 6000 and 7500°C?
(d) Why would life probably not develop on planets round very hot bluish stars?
(e) Why would life probably not develop on planets round cool red stars?

(16) Spectral data from a distant star is shown below.

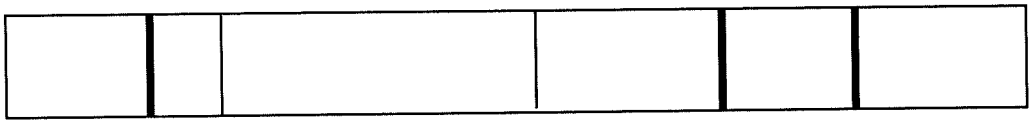


Known specta from various elements are shown below

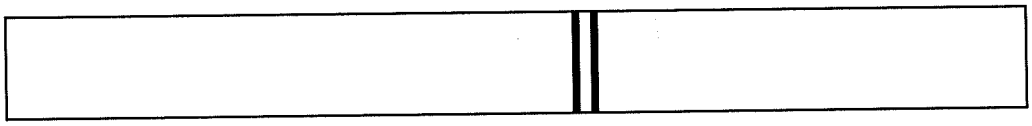
Hydrogen



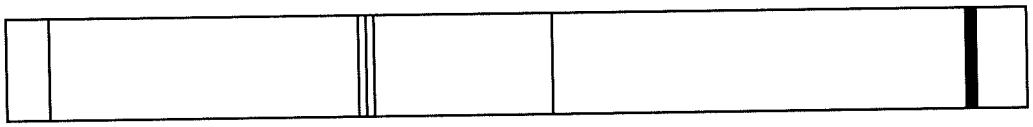
Helium



Sodium



Calcium



Identify the elements in the star