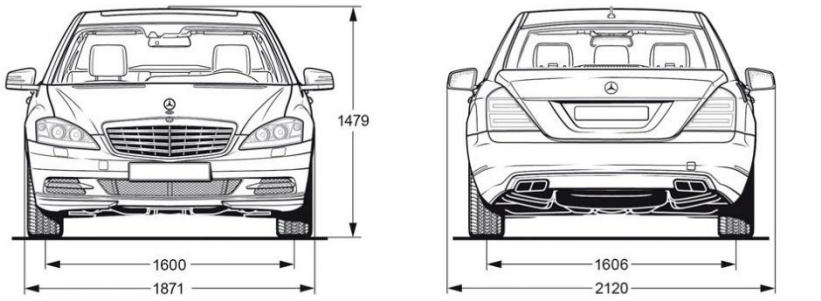
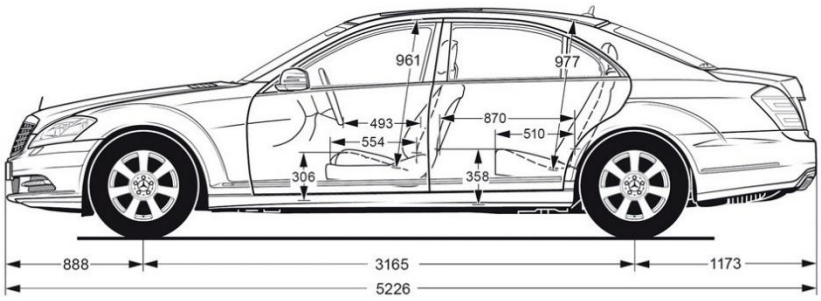
Grove Academy

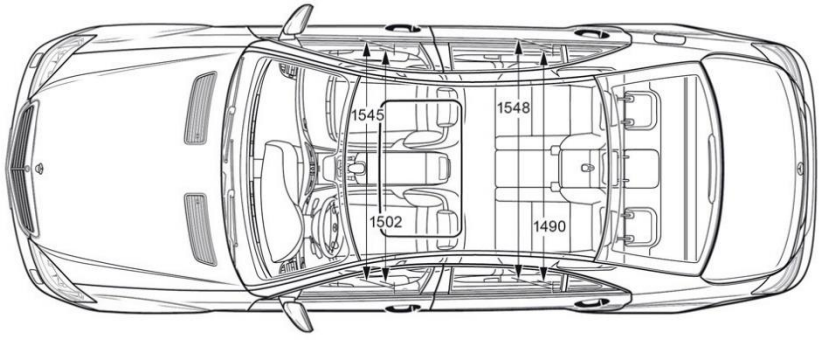
National 5 Physics

Area: Dynamics

Problems







Vectors and Scalars

Average Speed and Velocity

1. A car travels a distance of 2 km in a time of 160 seconds. Calculate the average speed of the car.

2. Jane jogs to work every day at an average speed of 4 ms^{-1}. Most days it takes her 10 minutes to reach work. Calculate the distance she jogs.

3. A model train travels round 10 m of track at an average speed of 1·5 ms^{-1}. Calculate the time taken.

4. Christopher takes 26 seconds to swim one length of a swimming pool. If the pool is 50 metres long, calculate his average speed.

5. Calculate the distance a cyclist travel in 60 seconds if he is travelling at an average speed of 13 ms^{-1}.

6. Calculate a hurdler's time if she completes the 400 m hurdle race at an average speed of 7 ms^{-1}.

7. Calculate how far a jet aircraft travel in 5 minutes if it flies at a velocity of 400 ms^{-1} south.

8. The shortest crossing of the English Channel is 34 km. Calculate how long it would take, in minutes, for a ferry to cross the Channel if it travels at an average velocity of 6·3 ms^{-1}.

9. A hill walker walks at an average speed of 0·75 ms^{-1}. Calculate how long it will take her, in hours, to cover a distance of 27 km.

10. Richard Noble captured the world land speed record in 1983 in his vehicle Thrust 2. The car travelled one kilometre in 3·5 seconds. Calculate the average speed of the car.

11. Andy Green broke the world land speed record in 1997 in his vehicle Thrust SSC. He travelled at an average speed of 340 ms^{-1} over a distance of 1000 m. Calculate the time he took to travel this distance.

12. On a motorway, travelling in a straight line, a car has a velocity of 30 ms^{-1}. If it travels for 2 minutes, calculate the distance it travels.

13. A lorry takes 4 hours to travel 160 km. Calculate the average speed of the lorry.

14. Over a period of 12 hours, a migrating bird covers a distance of 100 km. It ends its journey 72 km south of its starting point.
    a) Calculate the average speed of the bird.
    b) Calculate the average velocity of the bird.

Instantaneous Speed and Velocity

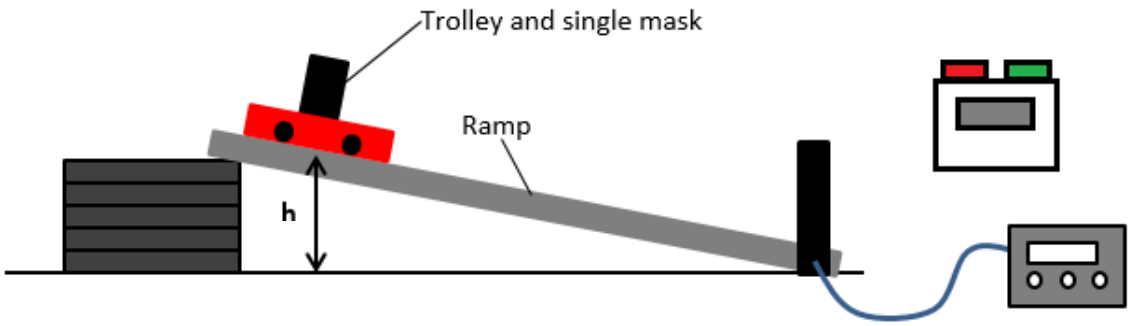
1. A car has a length of 4 m and passes a point in 0·5 s. Calculate the car's instantaneous speed.

2. Copy and complete the table by calculating the missing values.

Mask Length (cm)	Time (s)	Instantaneous Velocity (ms^{-1})
2	0·1	
1·5	0·1	
0·03		4·1
	0·05	3·5
	0·2	2·0
0·01		1·86

3. An observer wants to find the instantaneous velocity of a car as it passes a pedestrian crossing. He measures the length of the car and finds it to be 3·5 m. He then stands with a stop watch at the crossing, starts timing as the front of the car passes him and stops when the back of the car has passed. The time recorded is 2·4 s. Calculate the instantaneous speed of the car.

4. Abbie and Lucy set up the following apparatus:



Their results are as follows:

Length of ramp = 0.80 m
Length of mask = 5 cm
Time on stop clock = 1·50 s
Time on TSA (fast timer) = 62 ms

a) Calculate the average speed of the trolley on the ramp.
b) Calculate the instantaneous speed of the trolley when it passes through the light gate.
c) Explain the difference between the two results.

5. The Smith family are driving from Dundee to London.
   a) On the motorway, they travel at 70 mph for 2 hours 20 minutes because there is no traffic. Calculate how far they travel in this time.

      The entire journey is 460 miles long.
   b) Calculate how long the journey would take if they were able to maintain a speed of 70 mph for the whole journey.

Vectors Addition

1. State the difference between a scalar quantity and a vector quantity.
2. Sort the following variables into either **scalars** or **vectors**:

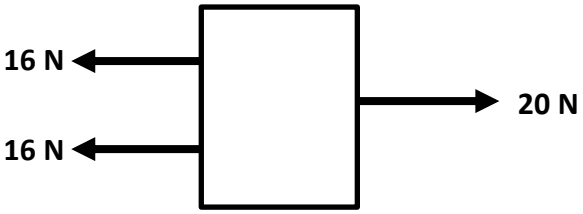
acceleration **time** **temperature** **speed** **velocity** **energy**
mass **force** **area** **volume** **displacement**

3. What is the resultant force in the below situations?

a)

b)

c)



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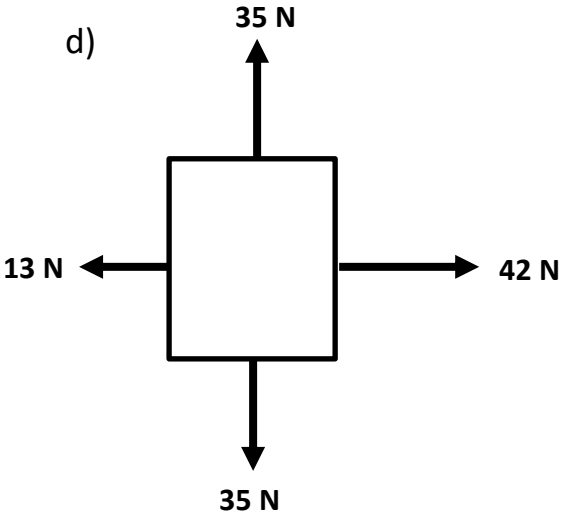

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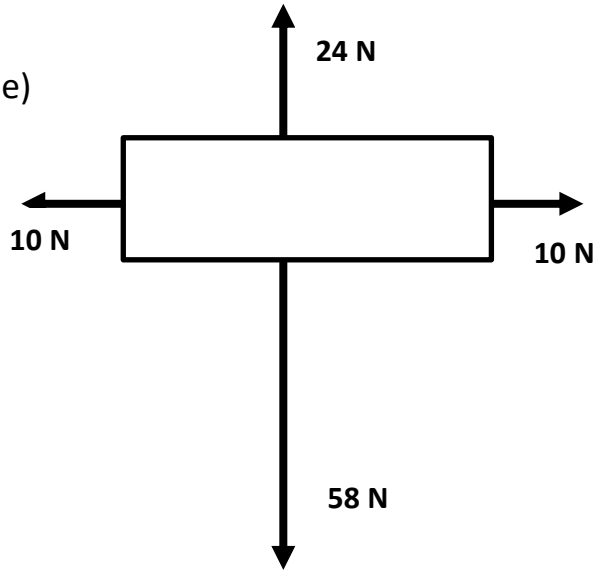
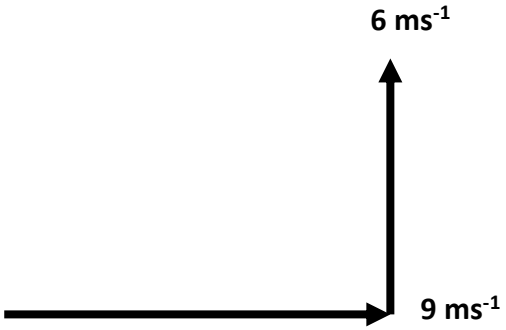


4. By means of a scale diagram, calculate the resultant vector in the below situations. Include magnitude **and** direction.

a)

b)



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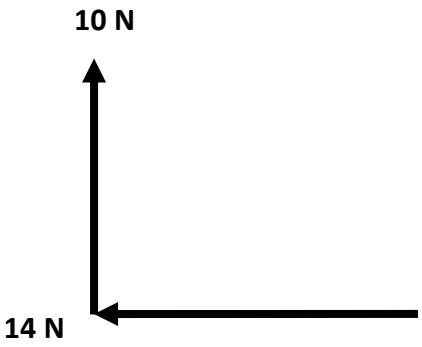

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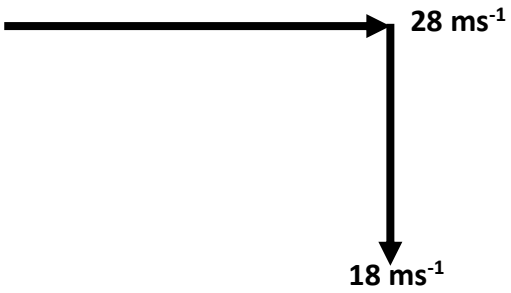

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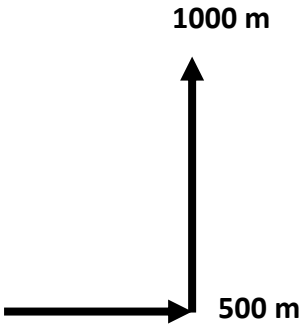

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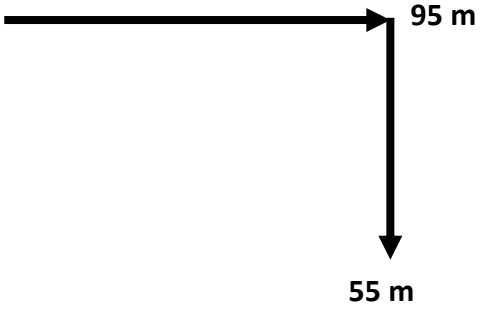
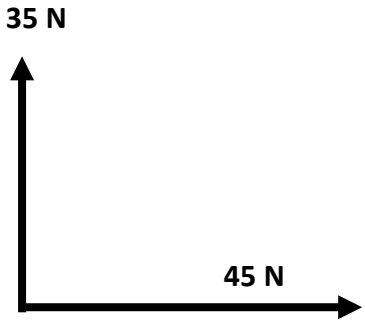


g)



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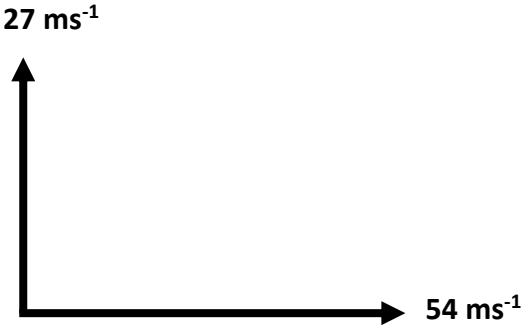
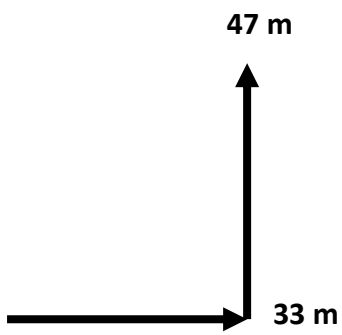


5. Using scale drawing or Pythagoras' Theorem, calculate the resultant vector in the following situations.
Include magnitude **and** direction.

a)



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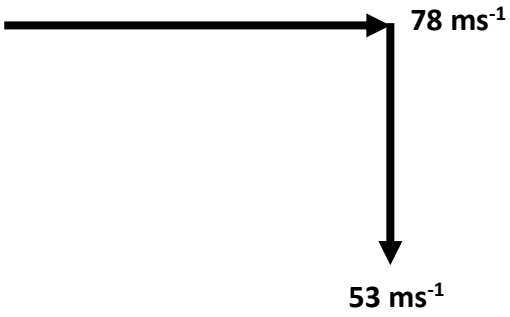

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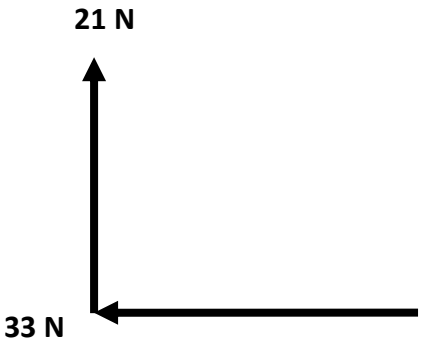

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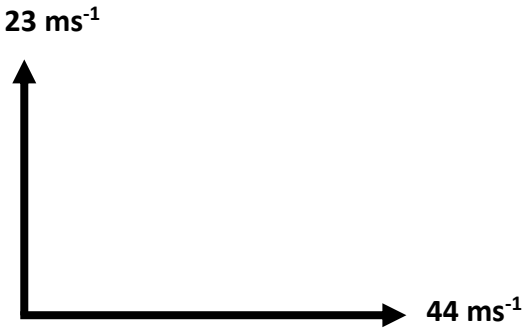

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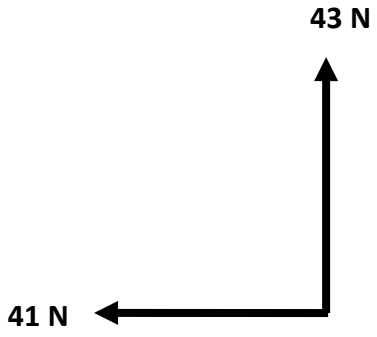

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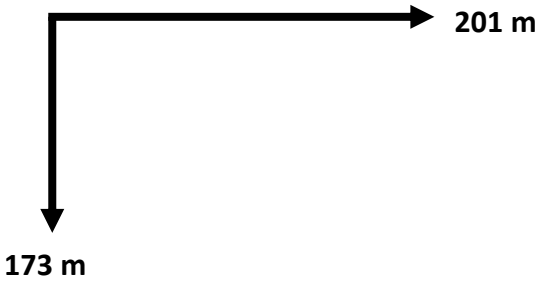

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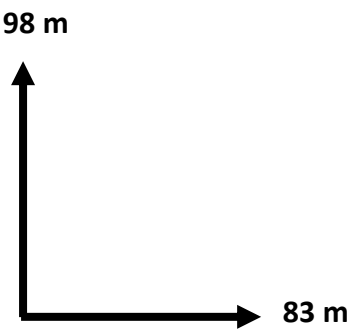

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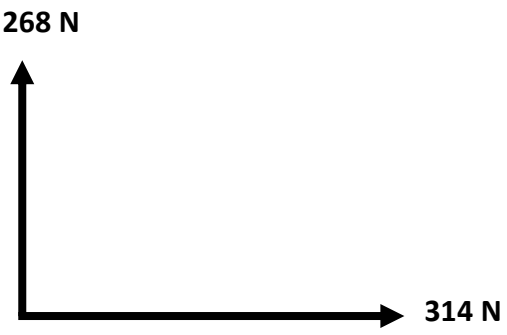


6. A man walks 23 m east then 40 m north from his house. Calculate his displacement.

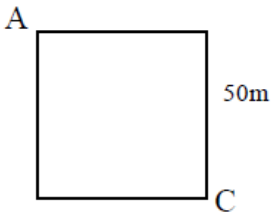
7. A car travels 14 km west then 19 km south. Calculate its displacement.

8. A woman walks 2 km north then 800 m west. Calculate her displacement.

9. During a training session Jessica sprints along a track for a distance of 80 m in a time of 10 s. She then turns round and jogs 40 m back towards the start in a time of 15 s.
    a) Calculate the total distance travelled by Jessica.
    b) Calculate her average speed.
    c) Calculate the magnitude of her total displacement.
    d) Calculate the magnitude of her average velocity.

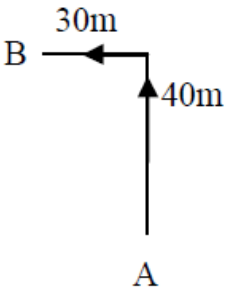
    Jessica now walks back to the starting line.
    e) Calculate the magnitude of her total displacement now.
    f) Calculate the magnitude of her average velocity for the whole exercise.

10. A runner runs on the perimeter of a square field as shown on the right. He starts at A and runs to C.
    a) Calculate the distance has the runner travelled when he reaches C.
    b) Calculate the runner's displacement on reaching C (magnitude and direction).



11. A plane is flying south with a velocity of 110 ms^{-1}, but there is a strong wind blowing from the west with a velocity of 55 ms^{-1}. Calculate the resultant velocity of the plane.

12. A runner follows the path shown on the right starting at A and arriving at B ten seconds later.
    a) Calculate the total distance travelled by the runner.
    b) Calculate the average speed of the runner.
    c) Calculate the runner's displacement.
    d) Calculate the average velocity of the runner.



13. During a race, the wind is blowing Pete's sailboat at 12 ms^{-1} due south. The tidal current in the water is 5 ms^{-1} to the east.
    Calculate the resultant velocity of the sailboat.

14. During an orienteering race, a runner runs 200 m north, 150 m east and 300 m south in a time of 3 minutes.
    a) Create a diagram showing the route that the runner ran.
    b) Calculate the total distance the runner travelled.
    c) Calculate the runner's average speed.
    d) Calculate the runner's displacement from their starting position.
    e) Calculate the runner's average velocity.

Acceleration

Acceleration

1. Copy and complete the following table by calculating the missing values.

Initial Velocity (ms^{-1})	Final Velocity (ms^{-1})	Time (s)	Acceleration (ms^{-2})
20	40	10	
110	30	8	
0	13		5
45	16		-3
		4	7
9·2		18	6
	76	23	4·5
10·8		12·5	7·2

2. A trolley takes 6·4 s to reach 7 ms^{-1} from rest. Calculate its acceleration.

3. A car travelling at 35 ms^{-1} decelerates at 3·4 ms^{-2}. Calculate how long it takes to come to a halt.

4. Calculate the final velocity of a rocket which accelerates at 250 ms^{-2} from rest for 5 s.

5. A man is running at 4 ms^{-1} and accelerates downhill at 1·5 ms^{-2} for 2 s, calculate his final velocity.

6. An oil tanker travelling at 15 ms^{-1} decelerates at 0·03 ms^{-2}. Calculate how long it takes to stop.

7. Calculate how long it will take a girl running at 5 ms^{-1} to reach to 1 ms^{-1} with a deceleration of 0·3 ms^{-2}?

8. A dog takes 3 s to reach 10 ms^{-1} from 1 ms^{-1}. Calculate its acceleration.

9. A plane is travelling at 123 ms^{-1} after it has accelerated at 5 ms^{-2} for 7s, what was calculate its initial velocity.

10. A car decelerates at 2·5 ms^{-2} for 13 s from an initial velocity of 30 ms^{-1}. calculate its final velocity.

11. If it takes a cruise liner 3 minutes to decelerate from 32 ms^{-1} to 5 ms^{-1}, calculate its deceleration.

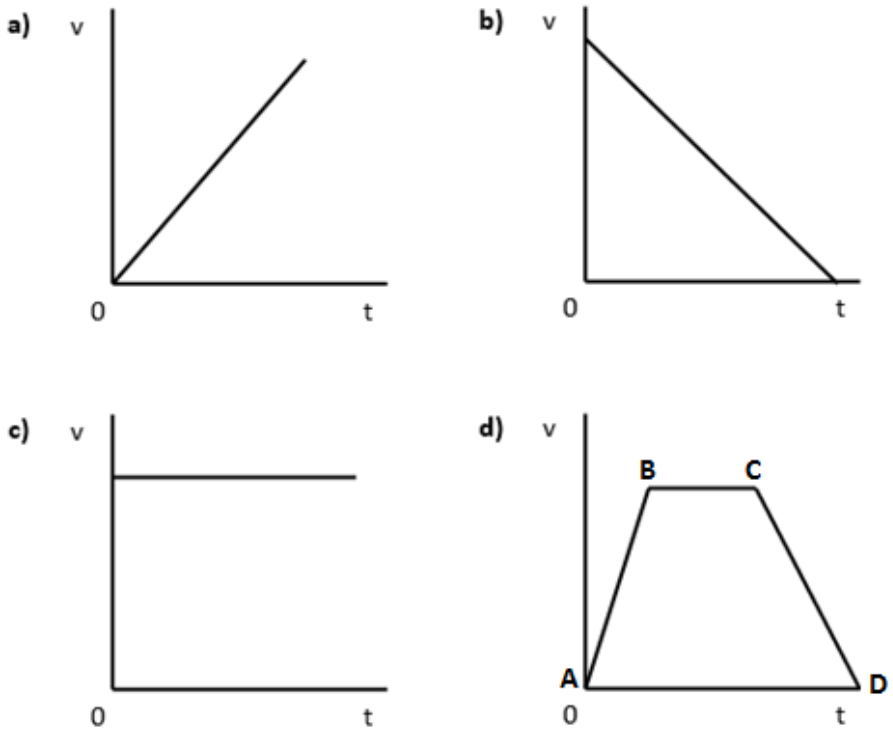
12. A van travelling at 12 ms^{-1} decelerates at 2.3 ms^{-2} to a velocity of 5.5 ms^{-1}. Calculate how long this takes.

13. When turning a corner an F1 car's speed decreases by 20 ms^{-1}. It takes 2·8 s to turn the corner. Calculate the acceleration of the car.

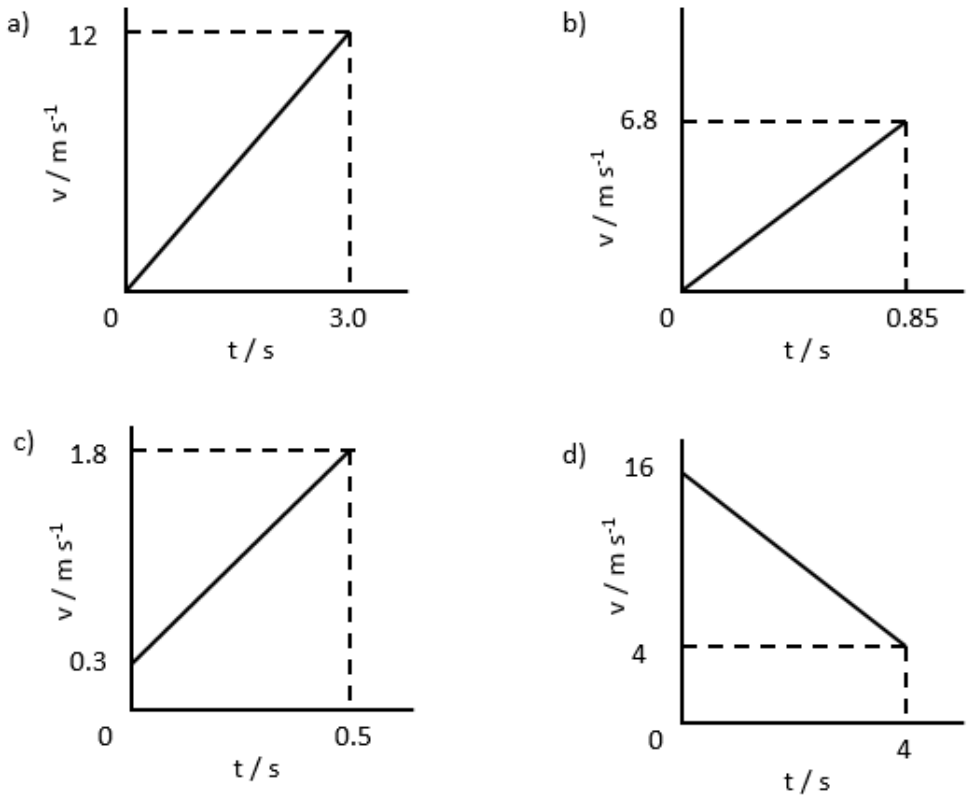
14. When the F1 car from Q14 is back on a straight it takes 3·2 s for the speed to increase by 20 ms^{-1}. Calculate the acceleration of the car.

Velocity-Time Graphs

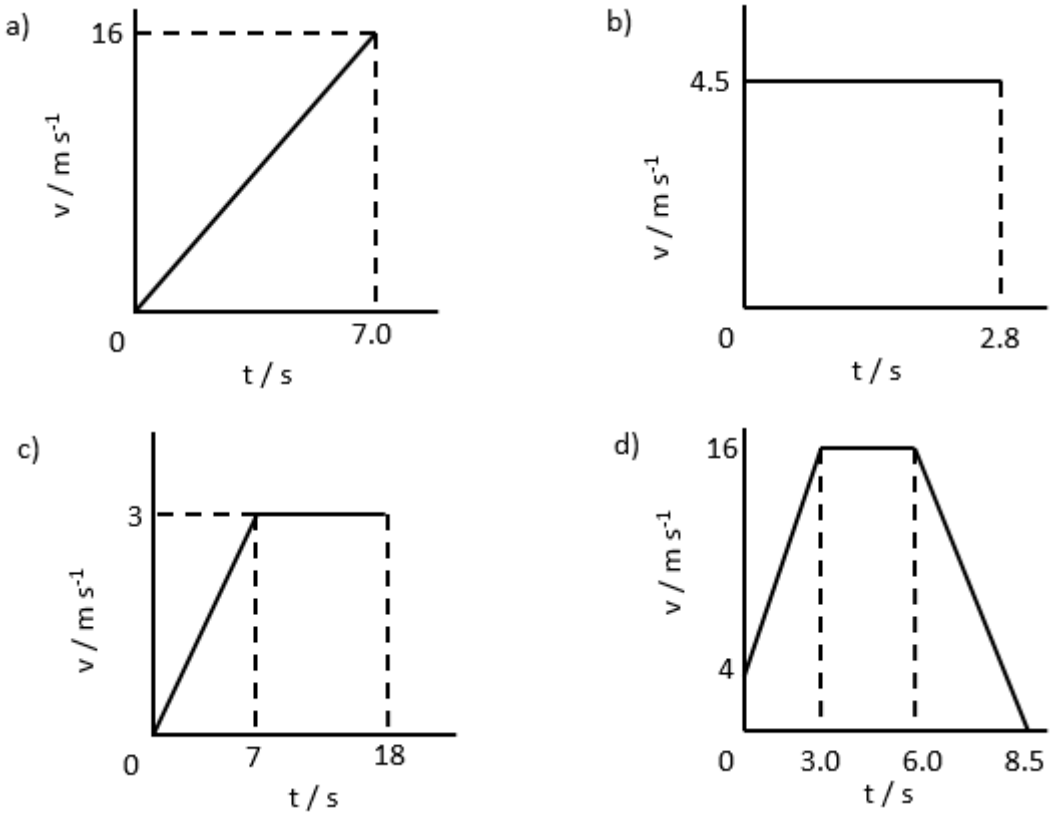
1. For each of the following velocity-time graphs, describe each stage in the motion.
   Key terms: **Constant acceleration** **Constant velocity** **Constant deceleration**



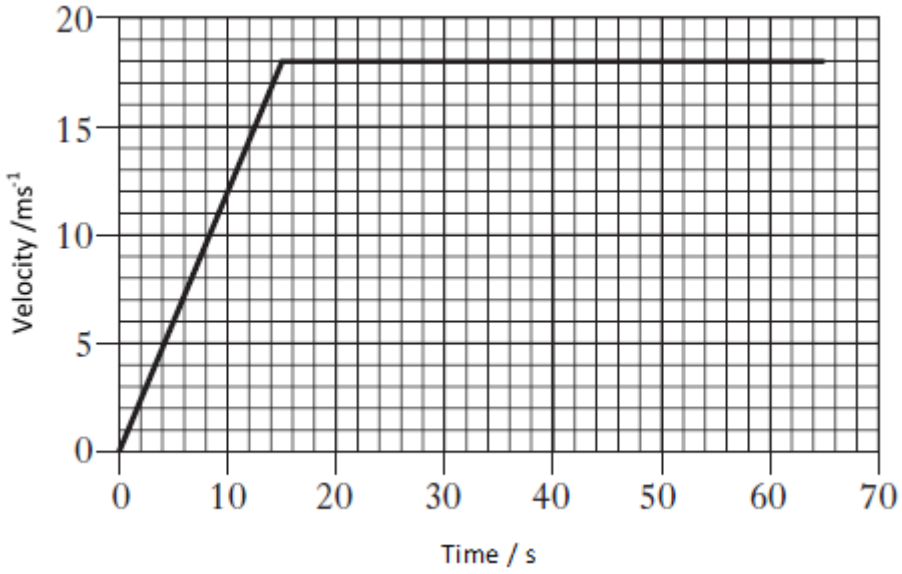
2. Calculate the magnitude of the acceleration for the following velocity-time graphs.



3. Calculate the displacement for each of the following velocity-time graphs.

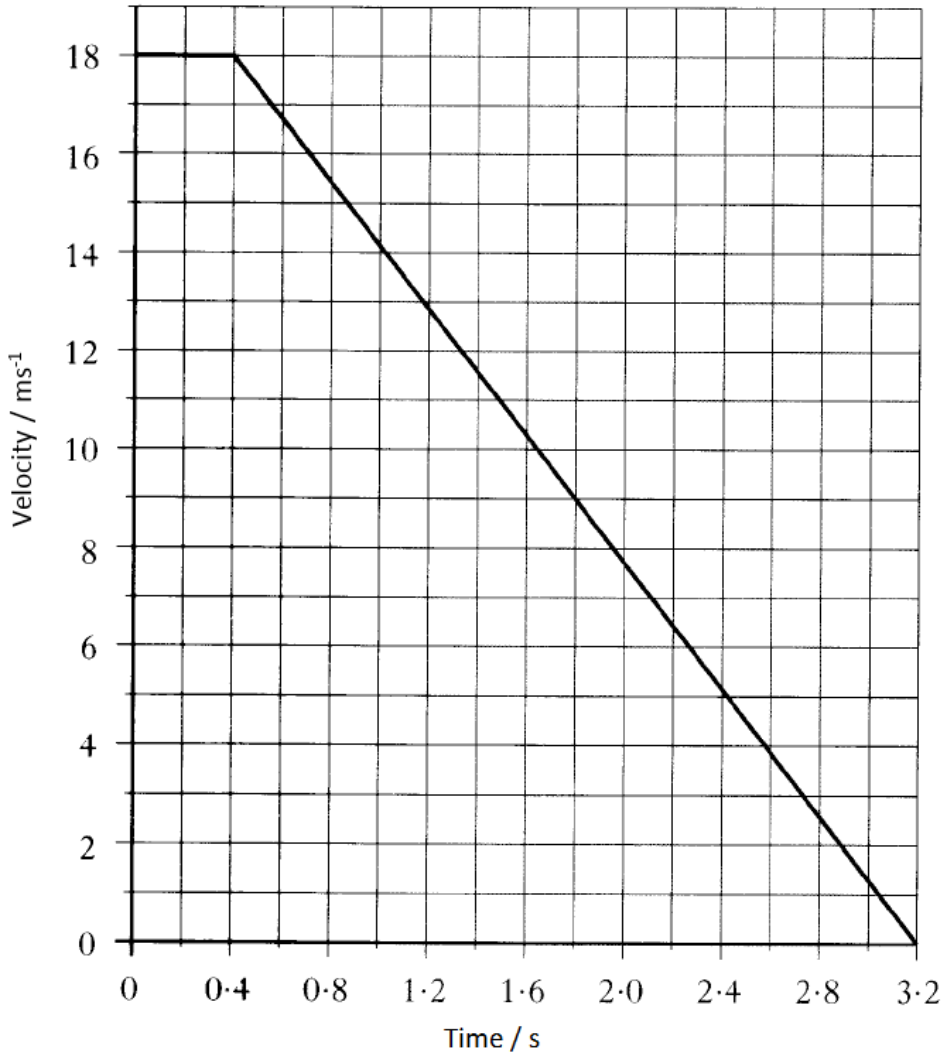


4. The following velocity time graph is obtained for a car on a short journey.



a) Calculate the acceleration of the car.
b) Calculate the distance the car travelled in the first 60 s.
c) Calculate the average velocity of the car over the first 60 s.

5. A bus is travelling along a road when the driver notices a traffic light ahead turning red. The following velocity-time graph shows the bus' motion from the moment the driver spots the red light until it comes to a halt.



a) State how long it takes the driver to apply the brakes after seeing the red light.
b) Calculate the acceleration of the bus.
c) Calculate how far the bus travels in total, from the moment the driver spotted the red light until it actually stopped.
d) Calculate the average velocity of the bus over the 3·2 s.

Newton's Laws

Weight

Use your data sheet to help you with the following questions.

1. Calculate the weight on Earth of the following masses:
    a) 8500 kg
    b) 3×10^{-5} kg
    c) 54 g
    d) 2×10^{-3} kg

2. Calculate the mass of objects which have the following weight on Earth:
    a) 589 N
    b) 0·643 N
    c) 6×10^{-3} N
    d) 234 kN

3. State how the value of gravitational field strength varies as an object rise further from the Earth's surface.

4. A car has a mass of 3000 kg on Earth.
    a) Calculate the car's weight on Earth.
    b) State the mass of the car on Saturn.
    c) Calculate the weight of the car on Saturn.

5. A rock has a weight of 30 N on Earth.
    a) Calculate the rock's mass.
    b) State the mass of the rock on Venus.
    c) Calculate the weight on the rock on Mars.

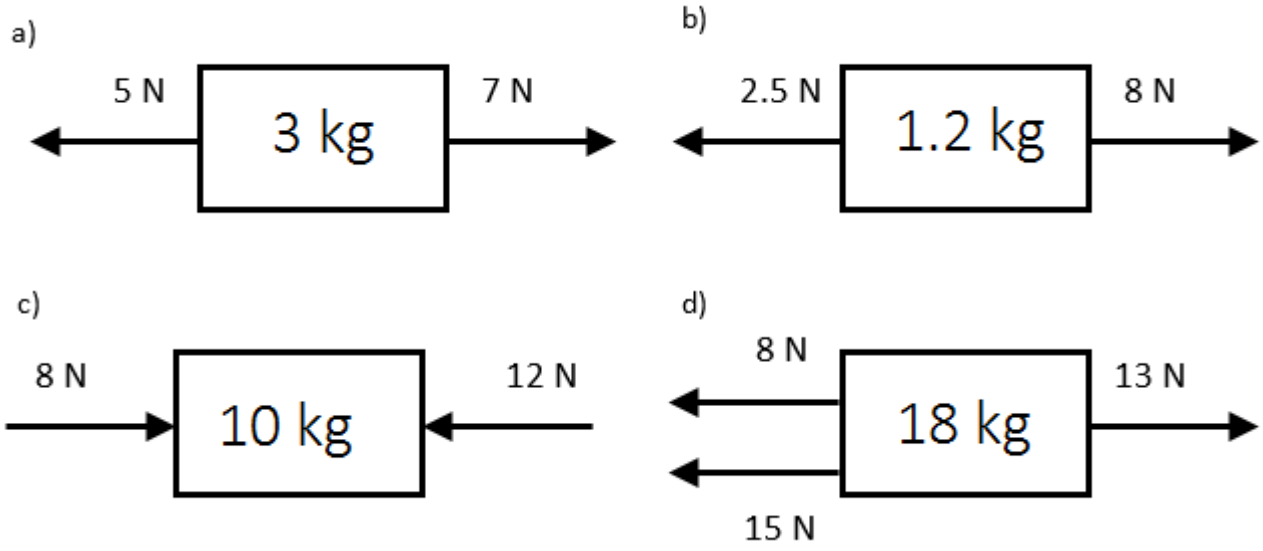
6. A ball has a weight of 0·45 N on Earth.
    a) Calculate the ball's mass
    b) State the mass of the ball on Jupiter.

7. A lift has a warning sign that states: **DO NOT EXCEEED MAXIMUM WEIGHT OF 800 KG**
   State what is wrong with this sign.

8. If an object has a mass of 23 kg and a weight of 658 N on a distant planet, calculate the gravitational field strength on the planet.

Newton's Second Law

1. For each of the following masses calculate:
   - The unbalanced force.
   - The acceleration.



2. In a tug of war competition, two teams of eight people are competing against each other. The teams start at rest, then each team exerts a total of 5·6 kN of force on the rope.
   a) Describe and explain the motion of the teams.
   b) Calculate the average force exerted by each person taking part.
   c) One person leaves the competition.
   Assuming that the opposing team still pulls with a force of 5·6 kN, determine the average force per person required to stop the other team from winning.

3. State the meaning of friction.

4. State two examples of situations where it is a good idea to increase friction.

5. State two examples of situations where it is a good idea to decrease friction.

6. A 65 kg man accelerates at 1·2 ms^{-2}. Calculate the unbalanced force.

7. A man uses a rope to pull an object of mass 0·7 kg with an average force of 2·5 N. The object accelerates at 3·2 ms^{-2}.
   a) Calculate the unbalanced force which accelerates the object.
   b) Calculate the force of friction acting on the object.

   A second man attaches an identical rope and pulls with the same force in the same direction as the initial rope. Friction remains constant.
   c) Calculate the new unbalanced force.
   d) Calculate the new acceleration.

8. A force of 54 N is applied to a mass of 6 kg and produces an acceleration of 7 ms^{-2}.
   a) Calculate the frictional force.
   b) If the force is tripled, and the friction remains constant, calculate the resultant force.
   c) Calculate the new acceleration.

9. A trolley has a mass of 6 kg and a resultant force of 23 N is applied to it.
   a) Calculate the acceleration produced.
   b) Calculate the speed after 6 s, starting from rest.

10. A weight-lifter lifts 260 kg at a constant speed of 1·7 ms^{-1}.
    a) Calculate the minimum force that the weight-lifter must exert.
    b) State why he must be able to exert a greater force than this, in reality.

11. A rocket has an initial mass of 5·2 x 10^3 kg and accelerates at 6 ms^{-2}. Later on, the engine is still producing the same force but the mass has dropped to 2·6x10^3 kg. Calculate the new acceleration.

12. A trolley of mass 4·3 kg is pulled by a force of 18·3 N but there are frictional forces of 3·4 N acting. Calculate the acceleration of the trolley.

13. A toy car with a mass of 435 g is accelerating at 2·1 ms^{-2}. The frictional force acting is 2·3 N. Calculate the applied force.

14. If the frictional force acting on an object is 3·9 kN and the applied force is 8·7 kN, an acceleration of 0·82 ms^{-2} is produced. Calculate the mass of the object.

15. A rocket with a mass of 120 000 kg produces a thrust from the engines of 3 x 10^6 N.
    a) Create a diagram of the rocket showing the forces which are acting on it vertically.
    b) Calculate the weight of the rocket.
    c) Calculate the unbalanced force acting on the rocket during take-off.
    d) Calculate the initial acceleration of the rocket at take-off.

16. A second rocket has a mass of 100 000 kg. Its engines provide a thrust of 2 x 10^6 N. Calculate the initial acceleration of the rocket on Earth.

Energy of Motion

Kinetic and Potential Energy

1. Calculate the kinetic energy of a 9000 kg aeroplane flying at 200 ms^{-1}.

2. Calculate the mass of a ball, which has 22·5 J of kinetic energy, when travelling at 8 ms^{-1}.

3. Calculate the speed a 4 kg trolley is moving at if it has 180·5 J of kinetic energy.

4. A football of mass 2·5 kg is lifted to the top of a cliff. If the cliff is 180 m high, calculate how much potential energy the football gains.

5. If a 30 kg boy gains 735 J of potential energy from climbing a flight of stairs, calculate how high he climbed.

6. Calculate the mass of a model plane flying at a height of 60 m, with 2058 J of potential energy.

7. A pupil with a mass of 52 kg climbs a 9 metre rope in a PE lesson.
    a) Calculate the weight of the pupil.
    b) Calculate the work done by the pupil in order to climb the rope.
    c) Calculate the gravitational potential energy gained by the pupil.

8. A 450 g ball rolls off a 1·5 metre high table onto the ground. Calculate the gravitational potential energy lost by the ball.

9. A high jumper gains 1107 J of gravitational potential energy as she jumps 2·05 metres in to the air. Calculate the mass of the high jumper.

10. A helicopter has a mass of 4800 kg and a gravitational potential energy of 7·2 MJ. Calculate how far from the ground the helicopter is.

11. A space probe lands on the surface of a planet in our Solar System to collect rock samples. A rock of mass 50 g is picked up and lifted vertically to a height of 40 cm. The work done by the probe in lifting the rock is 0·178 J.
    a) Calculate the gravitational field strength on the surface of the planet.
    b) State the name of the planet that the probe has landed on.

12. Calculate the kinetic energy of a sprinter with a mass of 75 kg and a speed of 9·5 ms^{-1}.

13. A toy car has a kinetic energy of 24·5 mJ and a speed of 0.7 ms^{-1}. Calculate the mass of the toy car.

14. An aeroplane has a mass of $3·5 \times 10^5$ kg and a kinetic energy of 3·9375 GJ. Calculate the speed of the aeroplane.

Work Done

1. A man exerts a force of 1 kN on a trolley and pushes it for 150 m. Calculate how much work he does.

2. A man exerts a force of 300 N on a rock but fails to move it. Calculate how much work he does.

3. A woman does 25 000 J of work in moving a block 125 m. Calculate the average force she exerts.

4. A man has to exert an average force of 255 N to push a trolley round a shop. If he does 280 kJ of work, calculate how far he walks.

5. Calculate how much energy is used by a car engine which exerts an average force of 3540 N for a distance of 5·3 km.

6. A trolley is brought to rest by a 7·5 N frictional force in a distance of 27 m. Calculate how much work is done by the frictional force.

7. A ship of mass 3400 tonnes is slowed by its engines (1 tonne = 1000 kg). It takes 6·3 km for the ship to stop and the engines exert a force of 70 kN. Calculate how much work the engines do.

8. An ant has to do 2×10^{-3} J of work in dragging a leaf 165 cm. Calculate the force the ant exerts.

9. A man has to overcome a frictional force of 95 N and provide a resultant force of 229 N to move an object. If he moves the object a distance of 76 m, calculate the work done.

10. There is a frictional force of 850 N acting on a car and the resultant force is 3500 N. If the car travels 2 km, calculate the work done by the car's engine.

11. Calculate the distance that a boy pushes his bike if he does 240 000 J of work and applies a constant force of 6000 N.

12. Calculate the work done by a truck if it drives 20 km with an average engine force of 1·5 kN.

13. Six snow dogs pull a sledge with an average force of 600 N each. Calculate the distance that the sledge has been pulled when the total work done by all of the dogs is 90 MJ.

14. The Formula 1 Australian Grand Prix is a race where the winning car drives 308 km. The work done by a car that completes the full race is $2{\cdot}43 \times 10^{9}$ J. Calculate the average engine force of the car.

15. In a P.E. lesson, a pupil of mass 58 kg climbs 12 metres up a rope. Calculate the work done by the pupil during this climb.

Conservation of Energy

1. A 1·3 kg rock is dropped from the top of a cliff which is 80 m high.
    a) Calculate the potential energy of the rock at the top of the cliff.
    b) State the kinetic energy of the rock at the bottom of the cliff, assuming that friction is negligible.
    c) Calculate the speed of the rock at the bottom of the cliff.

2. A 0·5 kg ball rolls off a table and hits the floor at 5 ms^{-1}. Calculate the height of the table.

3. A car of mass 900 kg is travelling at 30 ms^{-1}. At the bottom of a hill the driver switches off the engine and coasts up the hill until the car comes to a stop just at the top.
    a) Calculate the kinetic energy of the car at the bottom of the hill.
    b) State the kinetic energy of the car at the top of the hill.
    c) State the gain in potential energy of the car from the bottom to the top of the hill.
    d) Calculate the maximum height that the car can travel up the hill.
    e) Explain why the actual height reached by the car will be less that the value calculated in part (d).

4. A crane drops a mass from a height of 120 m.
    a) Calculate the speed of the mass as it hits the ground if air resistance is negligible.
    b) Suggest a speed for the mass if air resistance was not negligible.

5. A 57 g tennis ball is dropped from a height of 90 cm.
    a) Calculate the gravitational potential energy of the tennis ball before it is dropped.
    b) State the kinetic energy of the ball as it lands.
    c) Calculate the vertical speed of the ball as it lands on the ground.

6. A diver of mass 70 kg jumps off a 10 metre diving platform into a swimming pool. Calculate the vertical speed of the diver as he enters the water.

7. After retrieving his 46 g golf ball from a bush, a golfer takes a penalty drop by holding the ball at arm's length and allowing it to drop a height of 1·5 m to the ground.
    a) Calculate the gravitational potential energy of the ball just before it is dropped.
    b) Calculate the speed of the ball when it hits the ground.
    c) Calculate the speed of the ball when it is 0·75 metres above the ground.

8. An 85 kg skydiver jumps out of an aeroplane which is at a height of 3800 metres. The parachute is opened at a height of 1300 metres above the ground.
    a) Calculate the speed of the skydiver just before the parachute is opened.
    b) In reality, the speed of the skydiver is 55 ms^{-1} at this point.
    Explain the difference in the speed calculated in part (a) and the actual speed of the sky diver.

9. A bouncy ball of mass 50 g is thrown into the air with a kinetic energy of 1·6 J.
    a) State the gravitational potential energy of the bouncy ball at its highest point.
    b) Calculate the maximum height that the ball will reach.

10. A roller coaster car has a mass of 5000 kg and is travelling with a speed of 18 ms^{-1} as it enters a loop which has a height of 12 metres.
    a) Calculate the kinetic energy of the roller coaster car at the moment it reaches the loop.
    b) Calculate the gravitational potential energy of the roller coaster car at the top of the loop.
    c) Calculate the kinetic energy of the roller coaster car at the top of the loop.
    d) Calculate the speed of the roller coaster car at the top of the loop.

Projectile Motion

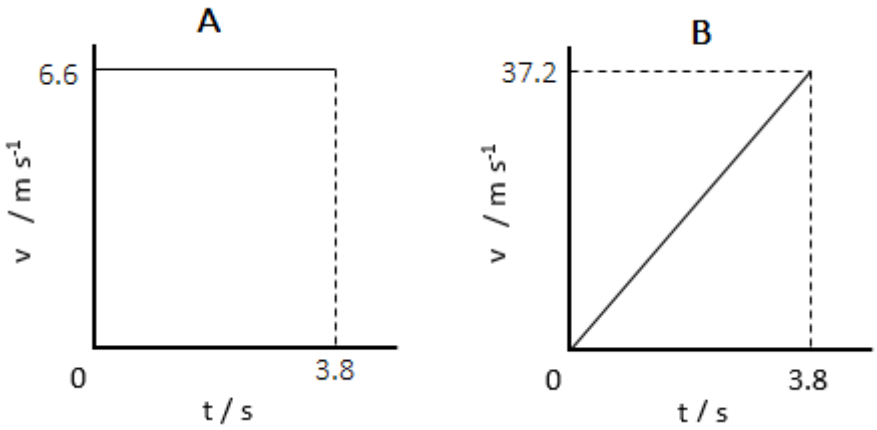
1. Describe what is meant by projectile motion.

2. State why an object which has been projected horizontally follows a curved path to the ground when it is in a gravitational field.

3. A ball is thrown vertically upwards. It leaves the hand at 23 ms^{-1}.
   a) Calculate the time taken to reach the top of the flight, where the final velocity is zero.
   b) Calculate the time taken to fall back down to the hand.
   c) State the velocity it will be travelling at when it reaches the hand.

4. A ball is dropped out of a window. Its initial velocity is zero and it takes 5 s to reach the ground.
   a) Calculate the final velocity of the ball just before it touches the ground.
   b) Create a velocity-time graph for the ball's flight.
   c) Calculate the total distance travelled by the ball.

5. The following graphs represent the motion of a ball which has been projected horizontally from an upstairs window until it hits the ground:



   a) State which of the graphs, A or B represents the vertical motion of the ball. Justify your answer.
   b) Calculate how far the ball travelled horizontally before it hit the ground.
   c) Calculate how height of the window from which the ball was thrown.

6. A package is dropped from a helicopter which is hovering at rest. The package takes 12 s to reach the ground.
   a) Describe the forces acting on the helicopter as it hovers.
   b) Calculate the final velocity of the package just before it touches the ground.

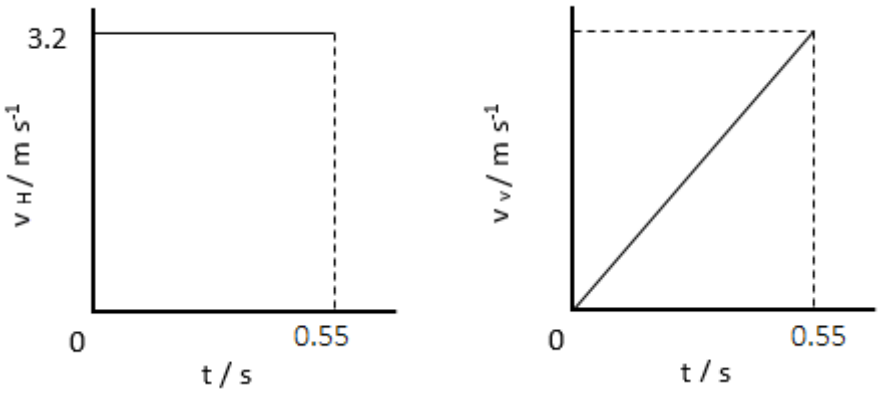
7. A cat jumps vertically out of a window with a velocity of 6 ms^{-1}. It takes 1·5 s to reach the ground.
   a) State the final horizontal velocity of the cat.
   b) Calculate the final vertical velocity of the cat.
   c) Create a velocity-time graph for the cat's horizontal motion.
   d) Calculate the total horizontal distance travelled by the cat.
   e) Create a velocity-time graph for the cat's vertical motion.
   f) Calculate the total vertical distance travelled by the cat.

8. A plane is flying horizontally at 180 ms^{-1} when it drops a bomb. The bomb hits the ground 13 s later.
    a) State the final horizontal velocity of the bomb just before it touches the ground.
    b) Calculate the final vertical velocity of the bomb just before it touches the ground.
    c) Calculate the total horizontal distance travelled by the bomb.
    d) Create a velocity-time graph for the bomb's vertical motion.
    e) Calculate the total vertical distance travelled by the bomb.
    f) State where the plane is located, compared to the bomb, at the moment that the bomb hits the ground. (Assume the plane does not alter course or speed.)

9. A ball rolls across a table at 7 ms^{-1} then reaches the edge and rolls off. The ball lands 2·5 m from the table.
    a) State the final horizontal velocity of the ball just before it touches the ground.
    b) Calculate the time it takes for the ball to land.
    c) Calculate the initial vertical velocity of the ball.
    d) Calculate the vertical acceleration of the ball.
    e) Calculate the final vertical velocity of the ball just before it touches the ground.
    f) Create a velocity-time graph for the ball's vertical motion.
    g) Calculate the total vertical distance travelled by the ball.

10. A package leaves a helicopter with a horizontal velocity of 22 ms^{-1}. The package lands 125 m in front of the point where it left the helicopter.
    a) Calculate the time it takes for the package to land.
    b) Calculate the initial vertical velocity.
    c) Calculate the vertical acceleration.
    d) Calculate the final vertical velocity of the package just before it touches the ground.
    e) Create a velocity-time graph for the package's vertical motion.
    f) Calculate the height of the helicopter.

11. The following graphs demonstrate the motion of a tennis ball which has been struck until it reaches the ground.



    a) Describe the horizontal speed of the tennis ball.
    b) Calculate how far does the tennis ball travelled horizontally.
    c) Calculate the vertical acceleration of the tennis ball.
    d) Calculate the final vertical speed of the tennis ball before it hits the ground.
    e) Calculate the height the tennis ball was struck at.