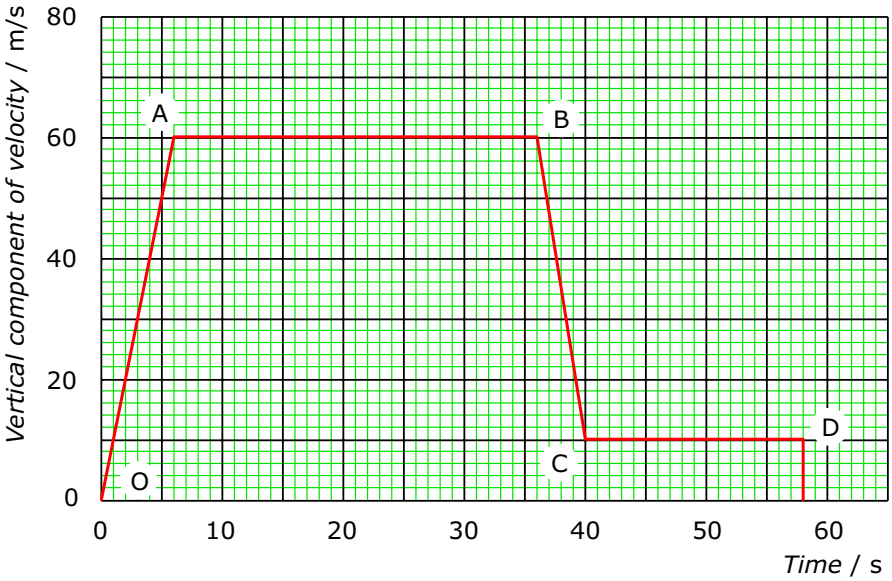
Force & Motion

Name & Set

1 A sky-diver jumps from an aeroplane. Here is a velocity-time graph to show the descent to the ground in a simplified form



(a) In section OA of the graph, what is

(i) the maximum velocity reached? _____ [1]

(ii) the time taken? _____ [1]

(iii) the acceleration of the sky-diver

_____

_____ [1]

(iv) the vertical distance that the sky-diver free falls?

_____

_____ [2]

(b) In section AB, the sky-diver has reached terminal velocity.

(i) Why does the velocity remain constant?

_____

_____ [1]

(ii) What distance does the sky-diver fall at constant velocity?

_____

_____ [2]

(c) At B, the sky-diver opens the parachute and decelerates rapidly.
(i) What is the deceleration of the sky-diver?

_____

_____ [2]

(d) why is the sky-diver again at constant velocity in the section CD of the graph?

_____

_____ [1]

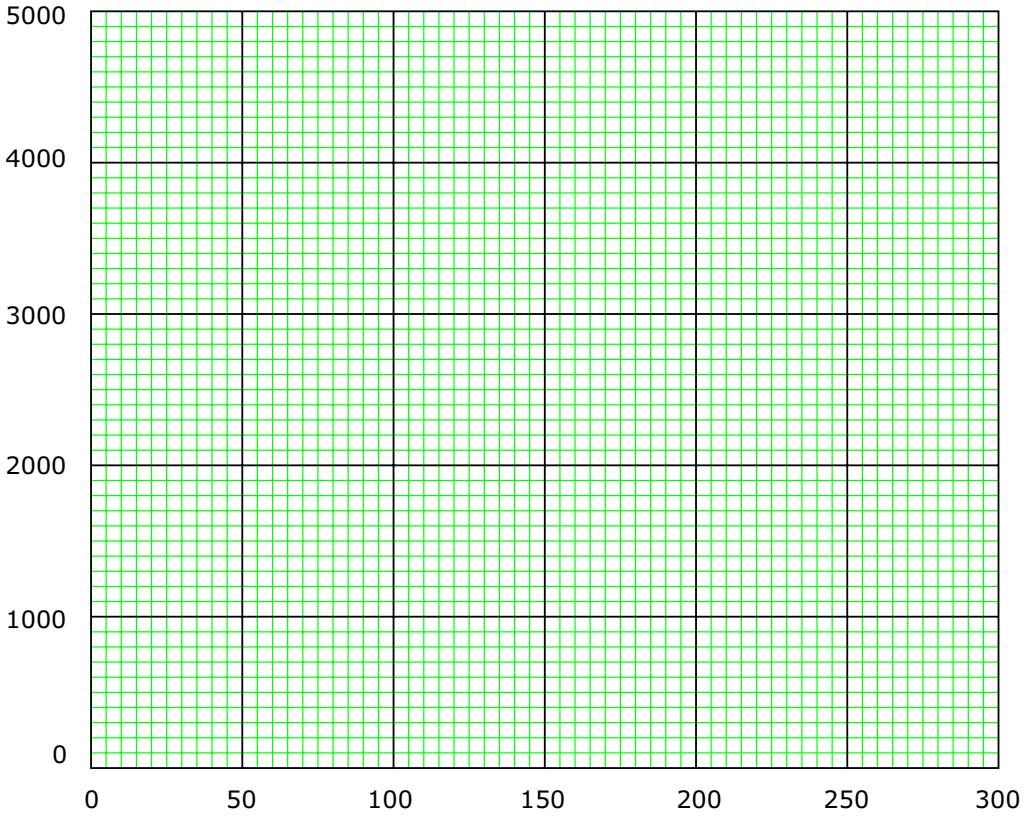
(e) What happens to the sky-diver at D?

_____ [1]

2 (a) A car made a short journey. Some information about the journey is given in the table.

Time taken in seconds (s)	Distance travelled in metres (m)
50	300
100	800
150	1400
200	2200
250	3400
300	5000

(i) Complete the graph by labelling each axis, plotting the points, drawing a smooth curve through the points



(ii) How can you tell, from your graph, that the speed of the car was greater in the second half of the journey than in the first half of the journey?

_____

_____ [2]

(iii) Calculate the average speed of the car during the journey. Include in your answer the equation you are going to use. Show clearly how you get to your final answer and give the unit.

_____

_____ [4]

(b) Name three forces that act on the car when it is moving along the road.

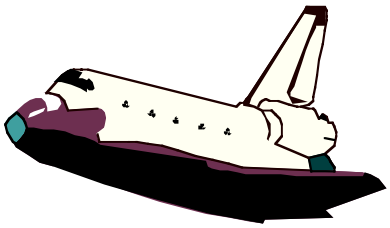
Force 1 _____ [1]

Force 2 _____ [1]

Force 3 _____ [1]

3 The diagram shows an orbiter, the reusable part of a Space Shuttle. The data refers to a typical flight.

Orbiter data	
Mass	78 000 kg
Orbital speed	7.5 km/s
Orbital altitude	200 km
Landing speed	100 m/s
Flight time	7 days



(a) (i) What name is given to the force which keeps the orbiter in orbit around the Earth?

_____ [1]

(ii) Use the following equation to calculate the kinetic energy, in joules, of the orbiter while it is in orbit.

$$\text{kinetic energy} = \frac{1}{2}mv^2$$

_____

_____ [2]

(iii) What happens to most of this kinetic energy as the orbiter re-enters the Earth's atmosphere?

_____

_____ [1]

(b) After touchdown the orbiter decelerates uniformly coming to a halt in 50 s.

(i) Give the equation that links acceleration, time and velocity.

_____ [1]

(ii) Calculate the deceleration of the orbiter. Show clearly how you work out your answer and give the unit.

_____

_____ [2]

(c) (i) Give the equation that links acceleration, force and mass.

_____ [1]

(ii) Calculate, in newtons, the force needed to bring the orbiter to a halt. Show clearly how you work out your answer.

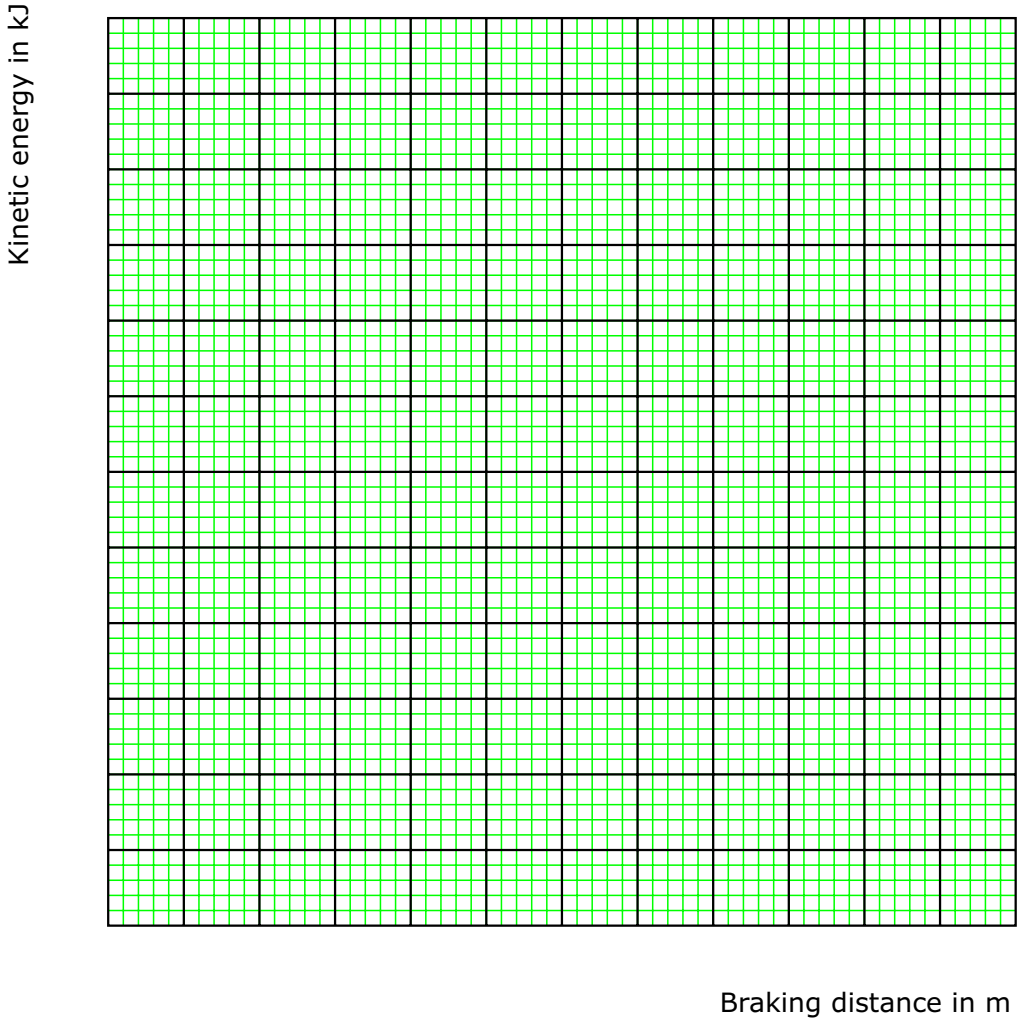
_____

_____ [1]

4 The table shows the braking distances for a car at different speeds and kinetic energy. The braking distance is how far the car travels once the brakes have been applied.

Braking distance of car in m.	*Speed of car in m/s.*	*Kinetic energy of car in kJ*
5	10	40
12	15	90
20	20	160
33	25	250
45	30	360

(a) A student suggests, "the braking distance is directly proportional to the kinetic energy."
(i) Draw a line graph to test this suggestion.



(ii) Does the graph show that the student's suggestion was correct or incorrect? Give a reason for your answer.

_____

_____ [1]

(iii) Use your graph and the following equation to predict a braking distance for a speed of 35 metres per second (m/s). The mass of the car is 800 kilograms (kg). Show clearly how you obtain your answer.

$$\text{kinetic energy} = \frac{1}{2}mv^2$$

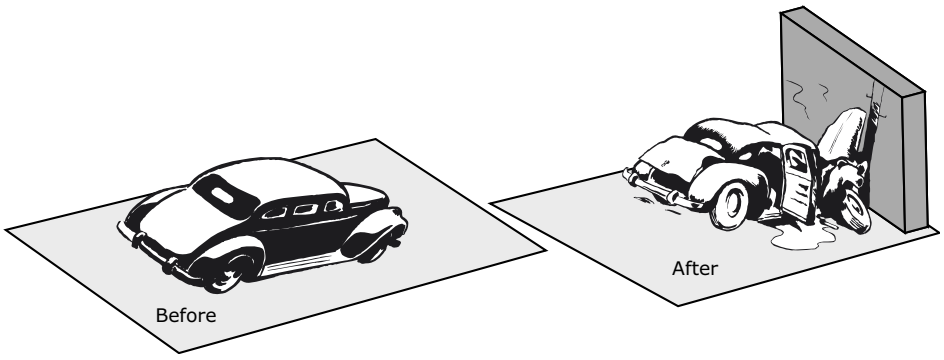
_____

_____ [2]

(iv) State one factor, apart from speed, which would increase the car's braking distance.

_____ [1]

(b) The diagram shows a car before and during a crash test. The car hits the wall at 14 metres per second (m/s) and takes 0.25 seconds (s) to stop.



(i) Write down the equation that links acceleration, change in velocity and time taken.

_____ [1]

(ii) Calculate the deceleration of the car.

_____ [1]

(iii) In an accident the crumple zone at the front of a car collapses progressively. This increases the time it takes the car to stop. In a front end collision the injury to the car passengers should be reduced. Explain why. The answer has been started for you.

By increasing the time it takes for the car to stop, the _____

_____

_____ [2]

6 (a) The following table gives the total kinetic energy of a car, and the passengers inside it, at different speeds.

Speed in metres/second (m/s)	0	5	10	15	20	25	30	35
kinetic energy in kilojoules (kJ)	0	10	40	90	160	250	360	490

(i) Use part of this information to calculate the total mass of the car and its passengers.
Write down the equation you are going to use.
Then clearly show how you get to your answer.

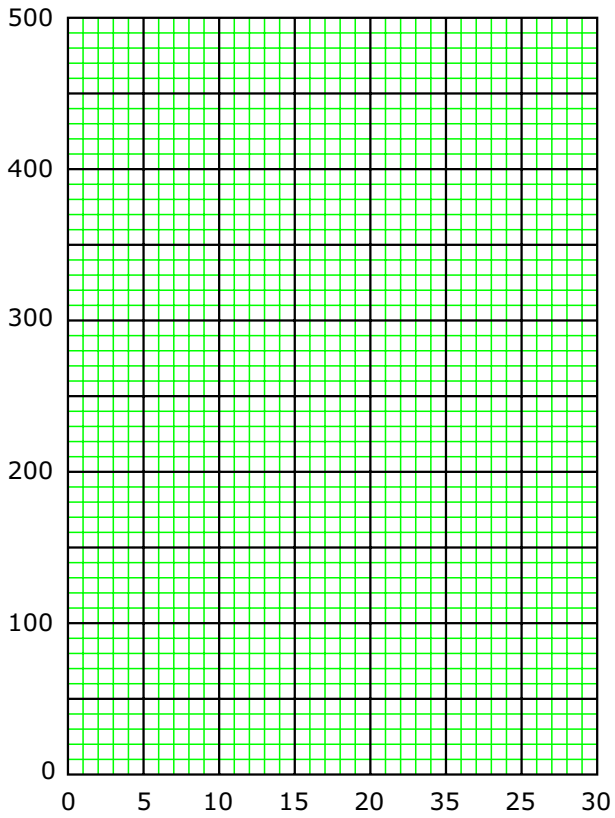
_____

_____

_____

_____ [4]

(ii) Plot a graph of speed (on the x-axis) against kinetic energy (on the y-axis).
(a) Label each of the axes. [2]
(b) Draw a smooth curve for the correct points. [1]



(iii) The speed limit in built up areas is 13 m/s. Use the graph to estimate the kinetic energy of the car and passengers at this speed.

_____ [2]

(iv) Use the graph to find out what increase in speed would be needed for the car and passengers to have double the kinetic energy which they had at 13 m/s.

_____ [2]

(v) What happens to most of the kinetic energy of a car when the brakes are applied?

_____ [1]

(b) (i) What is the braking distance of a car?

_____ [1]

(ii) Explain what the connection is between the braking distance of car and its speed

_____

_____

_____

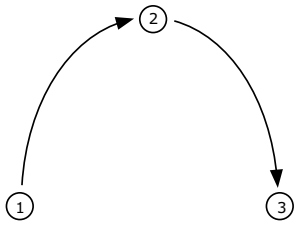
_____

_____

_____ [4]

7 The diagram shows the path of a ball when thrown through the air.

(i) Add to the diagram the name and direction of the force or forces acting on the ball in the three positions shown. Assume that position 1 corresponds to the point immediately after release and that during the whole flight air resistance is negligible [2]



(ii) Explain, in terms of the energy changes of the ball, why the ball reaches a maximum height.

_____

_____

_____ [3]

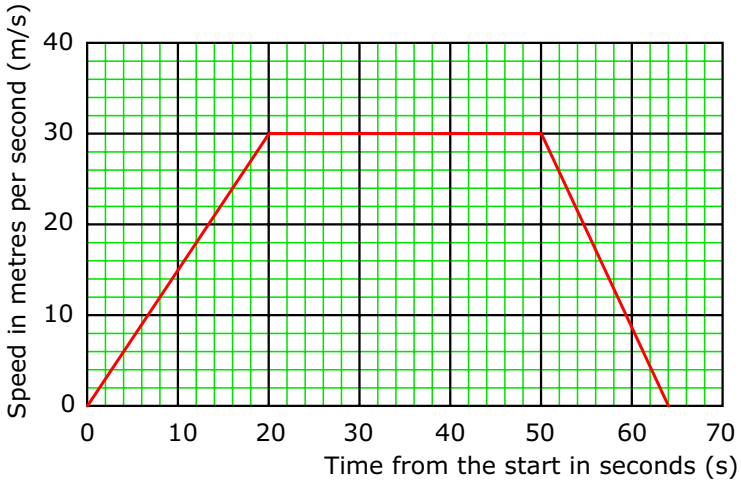
(iii) If the ball had been thrown with the same velocity on the moon, describe and explain how the path of the ball would be changed.

_____

_____

_____ [3]

8 (a) The following graph shows the speed of a car at different times during a short journey.



Use the information from the graph to help you to answer the questions.

(i) What additional information would you need in order to know the velocity of the car?

_____ [1]

(ii) During part of its journey the car was travelling at a steady speed.

Calculate the distance that the car travelled during that part of its journey. Include in your answer the equation you are going to use. Show clearly how you get to your final answer and give the unit.

_____

_____

_____ [4]

(iii) During part of its journey the car was slowing down.

Calculate the deceleration of the car during that part of its journey. Include in your answer the equation you are going to use. Show clearly how you get to your final answer and give the unit.

_____

_____ [4]

(b) Later the car accelerates at 2.5 metres per second per second (m/s^2).

The mass of the car is 800 kilograms (kg).

Calculate the force needed to accelerate the car. Include in your answer the equation you are going to use. Show clearly how you get to your final answer and give the unit.

_____

_____ [3]

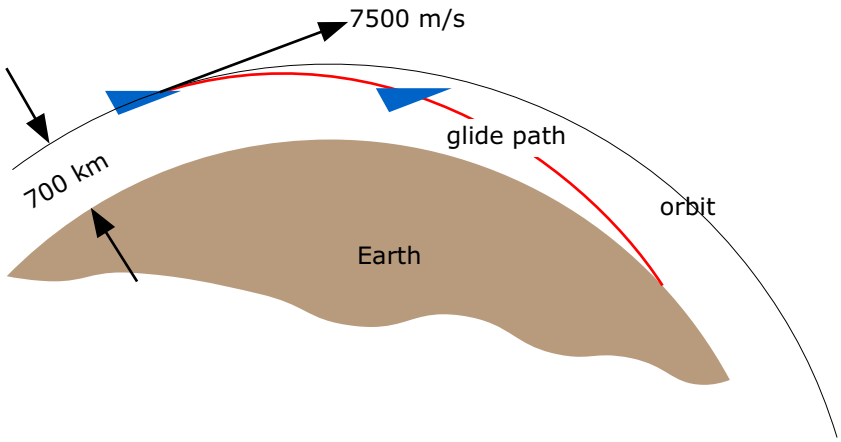
(c) The car driver and passengers wear seatbelts. Explain how a seatbelt reduces the risk of injury if a car stops suddenly. You should include ideas about acceleration and force in your explanation.

_____

_____

_____ [4]

9 A space shuttle orbits the earth 700 km above the surface at a speed of 7500m/s. To return to Earth 'falls' out of orbit. It has no engine for most of its descent – it glides. A few minutes later it lands on the ground at a speed of 100 m/s.



(a) What energy changes take place during the descent?

_____

_____ [2]

(b) What percentage of its energy in orbit is left at touch-down?
(You don't have to know the actual mass of the shuttle to work this out.)

_____

_____ [2]

10 (a) A rocket is travelling through space at a constant velocity of 2000 ms^{-1}.
State what forces act on it.

_____ [1]

(b) The rocket's motor is fired in a direction opposite to that of its motion for 10 s.
Explain what happens to its velocity and explain why.

_____

_____ [2]

(c) The force on the rocket is 20 kN.
If the mass of the rocket is 1000 kg, calculate its acceleration during the 10 s period.

_____

_____ [3]

(d)Calculate the final velocity of the rocket after the motors have been turned off.

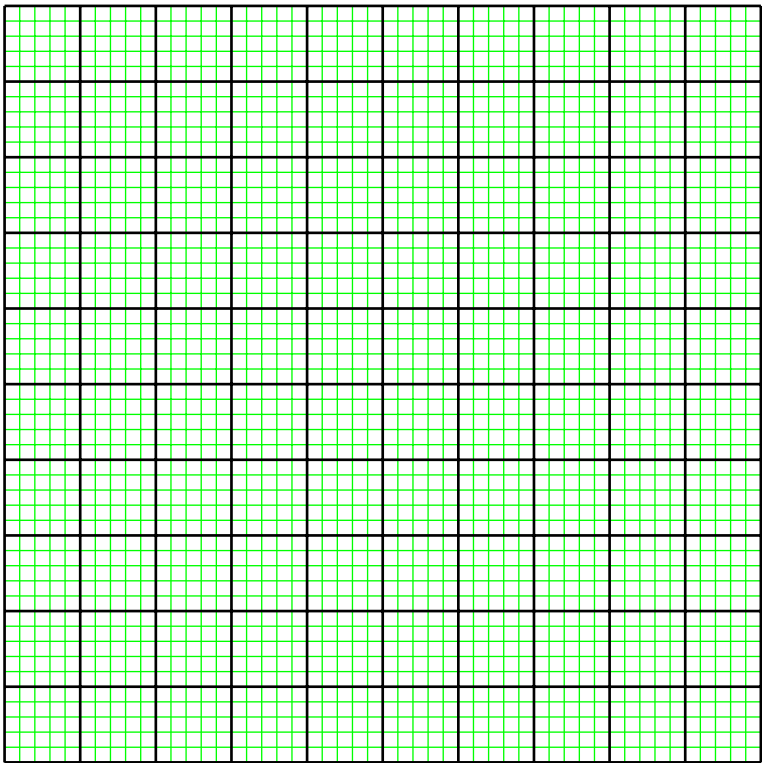
_____

_____

_____ [4]

11 An aeroplane must reach a velocity of 100 m/s before it can take off. Starting from rest it accelerates down the runway at a uniform rate. It takes 25 seconds to become airborne.

(a) Use this information to plot a velocity time graph for the aeroplane during take-off.



(b) What is the acceleration of the plane?

_____

_____ [2]

(c) How far has the plane travelled along the runway before it gets airborne?

_____

_____ [2]

11 A jet aircraft is taking off from an airport.
Its mass, including passengers and fuel is 150,000 kg. Its take-off speed is 100 ms^{-1}.
The maximum thrust of its engines is 500,000 N.

(a) Calculate the kinetic energy of the aircraft at the moment of take-off.

_____

_____

_____ [2]

(b) Name the *two* main forces acting on the plane at take-off.

_____

_____ [2]

(c) We can assume there are no forces of resistance and the engines maintain maximum thrust.
Using the equation

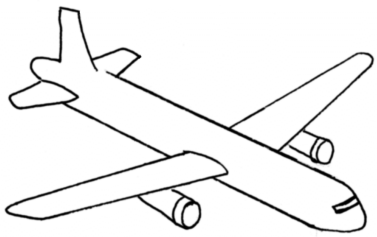
Work done (joules) = force x distance

Calculate the minimum length of runway needed for take-off.

_____

_____ [3]

(d) The following forces act on an aircraft when it is in flight: **weight**, **drag**, **lift** and **thrust**. On the diagram below draw labelled arrows to show the size and direction of these forces when a plane is travelling at constant speed and constant height above the ground. [4]



Describe what will happen to the speed and height of the plane if the trust of the engines is reduced?

_____

_____ [1]

Describe what will happen to the speed and height of the plane if the lift of the wings is reduced?

_____

_____ [1]