Forces and their interactions

Questions

Name: _____

Class: _____

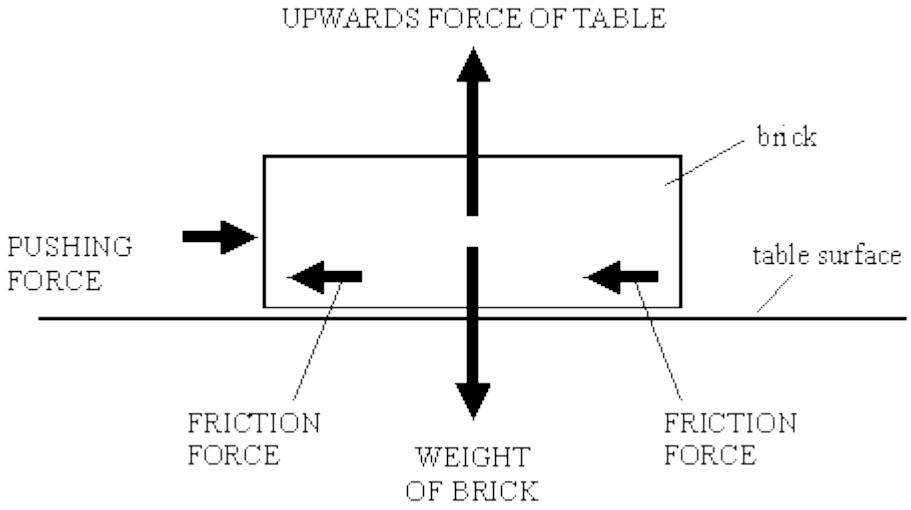
Date: _____

Time: **93 minutes**

Marks: **91 marks**

Comments:

1 The brick shown in the diagram is being pushed but it is **not** moving.



(a) The pushing force does **not** make the brick move. Explain why.

_____

(1)

(b) The weight of the brick does **not** make it move downwards. Explain why.

_____

(1)

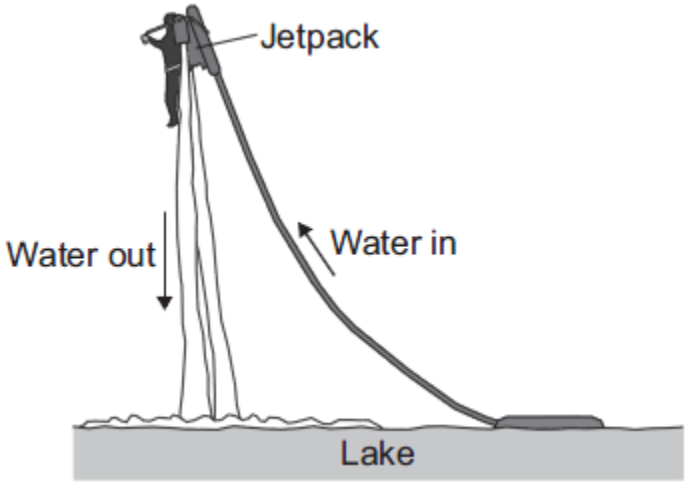
(c) A bigger pushing force **does** make the brick slide across the table.
Write down **one** thing that the sliding brick will do to the surface of the table.

_____

(1)

(Total 3 marks)

2 The diagram below shows a person using a device called a jetpack. Water is forced downwards from the jetpack and produces an upward force on the person.



(a) State the condition necessary for the person to be able to remain stationary in mid-air.

_____

_____

(1)

(b) The person weighs 700 N and the jetpack weighs 140 N.

(i) Calculate the combined mass of the person and the jetpack.

Gravitational field strength = 10 N/kg

_____

_____

_____

Combined mass = _____ kg

(2)

(ii) Increasing the upward force to 1850 N causes the person to accelerate upwards.

Calculate the acceleration of the person and the jetpack. Give the unit.

_____

_____

_____

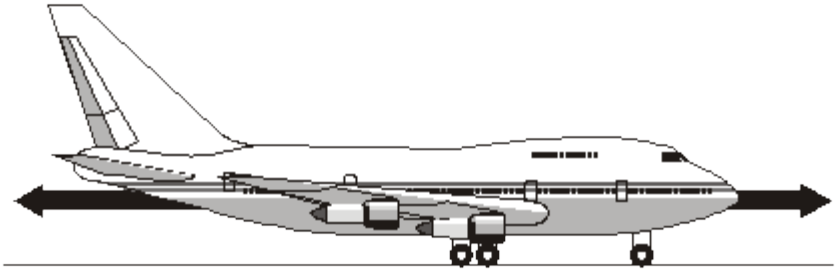
_____

Acceleration = _____ Unit _____

(3)

(Total 6 marks)

3 (a) The diagram shows an aircraft and the horizontal forces acting on it as it moves along a runway. The *resultant force* on the aircraft is zero.



(i) What is meant by the term *resultant force*?

_____

_____

(1)

(ii) Describe the movement of the aircraft when the resultant force is zero.

_____

_____

(1)

(b) The aircraft has a take-off mass of 320 000 kg. Each of the 4 engines can produce a maximum force of 240 kN.

Calculate the maximum acceleration of the aircraft.

Show clearly how you work out your answer and give the unit.

_____

_____

_____

Acceleration = _____

(3)

(c) As the aircraft moves along the runway to take off, its acceleration decreases even though the force from the engines is constant.

Explain why.

_____

_____

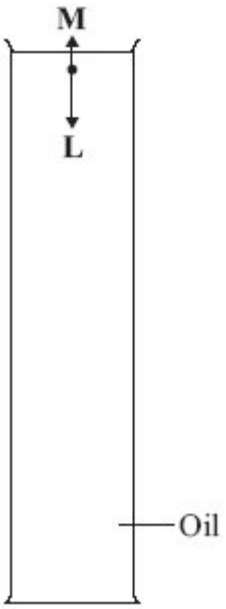
_____

_____

(2)

(Total 7 marks)

4 (a) The diagram shows a steel ball-bearing falling through a tube of oil. The forces, **L** and **M**, act on the ball-bearing.

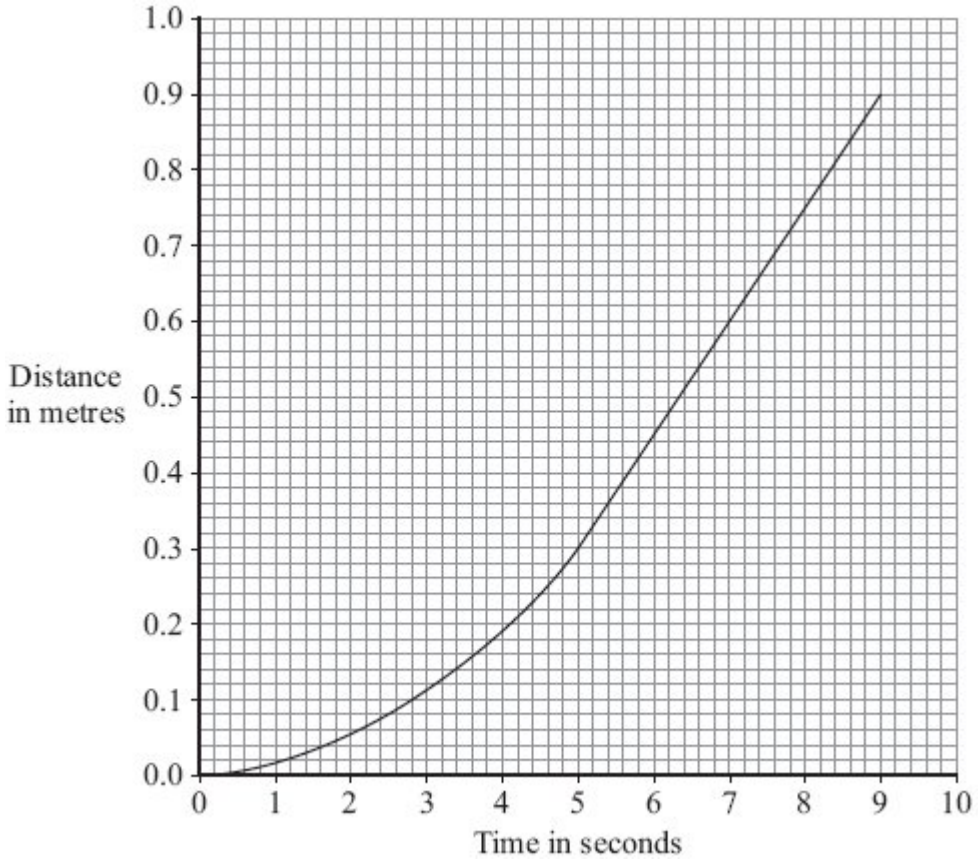


What causes force **L**?

_____

(1)

(b) The distance – time graph represents the motion of the ball-bearing as it falls through the oil.



(i) Explain, in terms of the forces, **L** and **M**, why the ball-bearing accelerates at first but then falls at constant speed.

_____

_____

_____

_____

_____

_____

(3)

(ii) What name is given to the constant speed reached by the falling ball-bearing?

_____

(1)

(iii) Calculate the constant speed reached by the ball-bearing.

Show clearly how you use the graph to work out your answer.

_____

_____

_____

Speed = _____ m/s

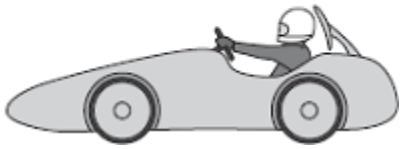
(2)

(Total 7 marks)

5 (a) Some students have designed and built an electric-powered go-kart. After testing, the students decided to make changes to the design of their go-kart.

First design **X**

Final design **Y**



The go-kart always had the same mass and used the same motor.

The change in shape from the first design (**X**) to the final design (**Y**) will affect the top speed of the go-kart.

Explain why.

_____

_____

_____

_____

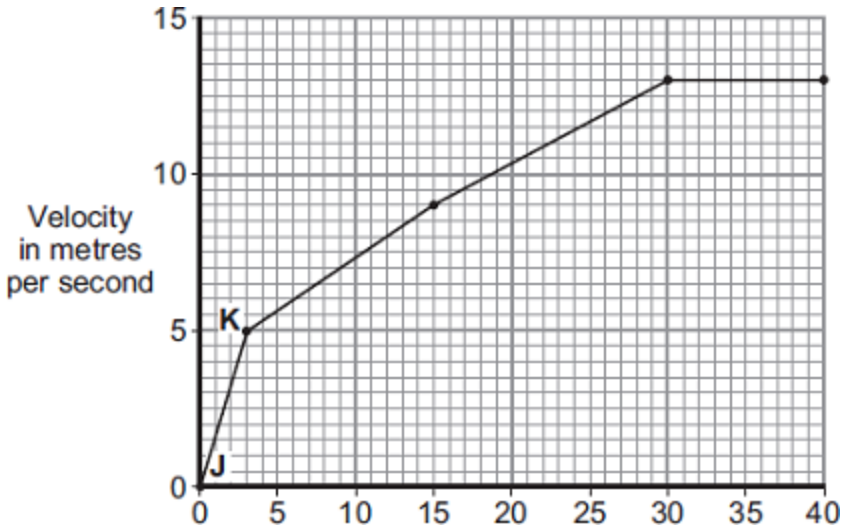
_____

_____

(3)

(b) The final design go-kart, **Y**, is entered into a race.

The graph shows how the velocity of the go-kart changes during the first 40 seconds of the race.



(i) Use the graph to calculate the acceleration of the go-kart between points **J** and **K**.

Give your answer to **two** significant figures.

Acceleration = _____ m/s^2

(2)

(ii) Use the graph to calculate the distance the go-kart travels between points **J** and **K**.

Distance = _____ m

(2)

(iii) What causes most of the resistive forces acting on the go-kart?

(1)

(Total 8 marks)

6 When two objects interact, they exert forces on each other.

(a) Which statement about the forces is correct?

Tick (✓) **one** box.

	Tick (✓)
The forces are equal in size and act in the same direction.	
The forces are unequal in size and act in the same direction.	
The forces are equal in size and act in opposite directions.	
The forces are unequal in size and act in opposite directions.	

(1)

(b) A fisherman pulls a boat towards land.

The forces acting on the boat are shown in **Diagram 1**.

The fisherman exerts a force of 300 N on the boat.
The sea exerts a resistive force of 250 N on the boat.

Diagram 1

(i) Describe the motion of the boat.

_____

_____

_____

_____

(2)

(ii) When the boat reaches land, the resistive force increases to 300 N.
The fisherman continues to exert a force of 300 N.

Describe the motion of the boat.

Tick (✓) **one** box.

Accelerating to the right ☐

Constant velocity to the right ☐

Stationary ☐

(1)

(iii) Explain your answer to part **(b)(ii)**.

_____

_____

_____

_____

(2)

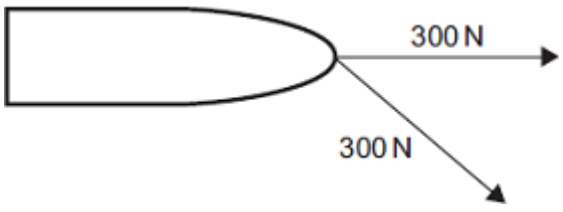
(iv) Another fisherman comes to help pull the boat. Each fisherman pulls with a force of 300 N, as shown in **Diagram 2**.

Diagram 2 is drawn to scale.

Add to **Diagram 2** to show the single force that has the same effect as the two 300 N forces.

Determine the value of this resultant force.

Diagram 2



Resultant force = _____ N

(4)

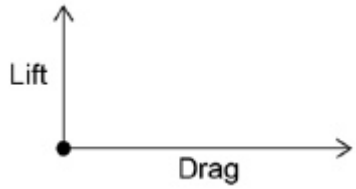
(Total 10 marks)

7 (a) **Figure 1** shows an aircraft flying at a constant velocity and at a constant height above the ground.

Figure 1

Complete the free body diagram in **Figure 2** to show the other two forces acting on the aircraft.

Figure 2



(2)

(b) A small aircraft accelerated down a runway at 4.0 m/s^2

The aircraft started from rest and reached a speed of 34 m/s just before take-off.

Calculate the distance the aircraft travelled while accelerating.

Give your answer to 2 significant figures.

_____

_____

_____

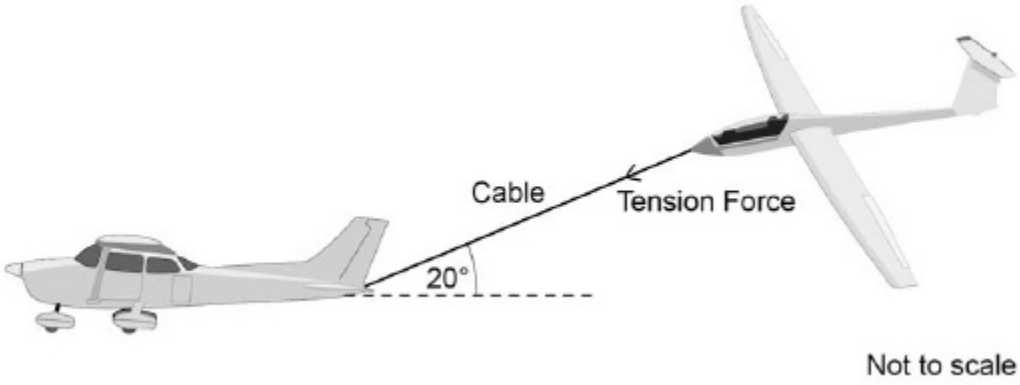
_____

Distance = _____ m

(4)

(c) **Figure 3** shows the small aircraft being used to tow a glider.

Figure 3



The tension force in the cable can be resolved into a horizontal component and a vertical component.

The tension in the cable is 2000 N

The cable makes an angle of 20° with the horizontal.

Draw a vector diagram to determine the magnitude of the two components of the tension force in the cable.

Magnitude of the horizontal component = _____ N

Magnitude of the vertical component = _____ N

(1)

(Total 10 marks)

8 Quantities in physics are either scalars or vectors.

(a) Use the correct answers from the box to complete the sentence.

acceleration	**direction**	**distance**	**speed**	**time**

Velocity is _____ in a given _____ .

(2)

(b) Complete the table to show which quantities are scalars and which quantities are vectors.

Put **one** tick (✓) in each row.

The first row has been completed for you.

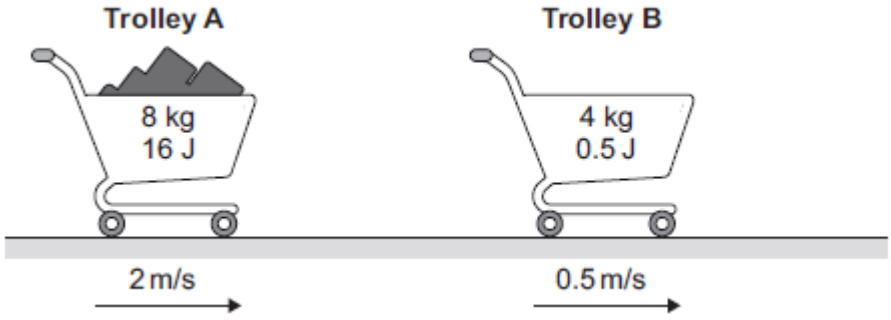
Quantity	Scalar	Vector
Momentum		✓
Acceleration		
Distance		
Force		
Time		

(3)

(c) The diagram shows two supermarket trolleys moving in the same direction.

Trolley **A** is full of shopping, has a total mass of 8 kg and is moving at a velocity of 2 m / s with a kinetic energy of 16 J.

Trolley **B** is empty, has a mass of 4 kg and is moving at a velocity of 0.5 m / s with a kinetic energy of 0.5 J.



(i) Calculate the momentum of both trolley **A** and trolley **B**.

Give the unit.

_____

_____

Momentum of trolley **A** = _____

Momentum of trolley **B** = _____

Unit _____

(4)

(ii) The trolleys in the diagram collide and join together. They move off together.

Calculate the velocity with which they move off together.

_____

_____

_____

_____

Velocity = _____ m / s

(3)

(iii) In a different situation, the trolleys in the digram move at the same speeds as before but now move towards each other.

Calculate the total momentum and the total kinetic energy of the two trolleys before they collide.

_____

_____

Total momentum = _____

_____

_____

Total kinetic energy = _____ J

(2)

(Total 14 marks)

9 The stopping distance of a car is the sum of the thinking distance and the braking distance.

The table below shows how the thinking distance and braking distance vary with speed.

Speed in m/s	Thinking distance in m	Braking distance in m
10	6	6.0
15	9	13.5
20	12	24.0
25	15	37.5
30	18	54.0

(a) What is meant by the braking distance of a vehicle?

_____

_____

(1)

(b) The data in the table above refers to a car in good mechanical condition driven by an alert driver.

Explain why the stopping distance of the car increases if the driver is very tired.

_____

_____

_____

_____

(2)

(c) A student looks at the data in the table above and writes the following:

thinking distance ∝ speed

braking distance ∝ speed

Explain whether the student is correct.

_____

_____

_____

_____

(2)

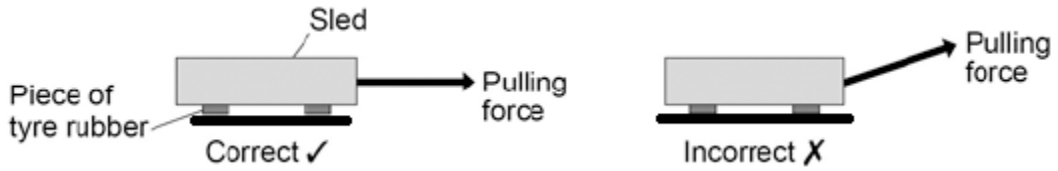
(d) Applying the brakes with too much force can cause a car to skid.

The distance a car skids before stopping depends on the friction between the road surface and the car tyres and also the speed of the car.

Friction can be investigated by pulling a device called a 'sled' across a surface at constant speed.

The figure below shows a sled being pulled correctly and incorrectly across a surface.

The constant of friction for the surface is calculated from the value of the force pulling the sled and the weight of the sled.



Why is it important that the sled is pulled at a constant speed?

Tick **one** box.

If the sled accelerates it will be difficult to control. ☐

If the sled accelerates the value for the constant of friction will be wrong. ☐

If the sled accelerates the normal contact force will change. ☐

(1)

(e) If the sled is pulled at an angle to the surface the value calculated for the constant of friction would not be appropriate.

Explain why.

_____

_____

_____

_____

(2)

(f) By measuring the length of the skid marks, an accident investigator determines that the distance a car travelled between the brakes being applied and stopping was 22 m.

The investigator used a sled to determine the friction. The investigator then calculated that the car decelerated at 7.2 m/s^2.

Calculate the speed of the car just before the brakes were applied.

Give your answer to two significant figures.

Use the correct equation from the Physics Equation Sheet.

_____

_____

_____

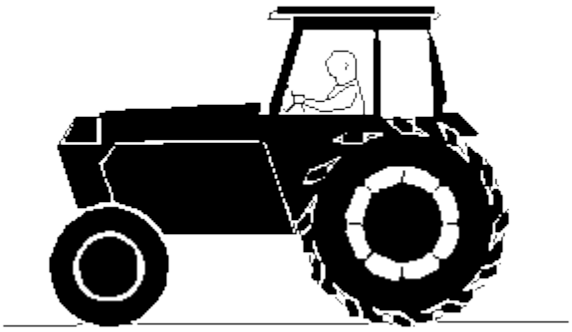
_____

Speed = _____ m/s

(3)

(Total 11 marks)

10 (a) The diagram below shows a moving tractor. The forward force from the engine exactly balances the resisting forces on the tractor.



(i) Describe the motion of the tractor.

_____

(ii) The tractor comes to a drier part of the field where the resisting forces are less. If the forward force from the engine is unchanged how, if at all, will the motion of the tractor be affected?

_____

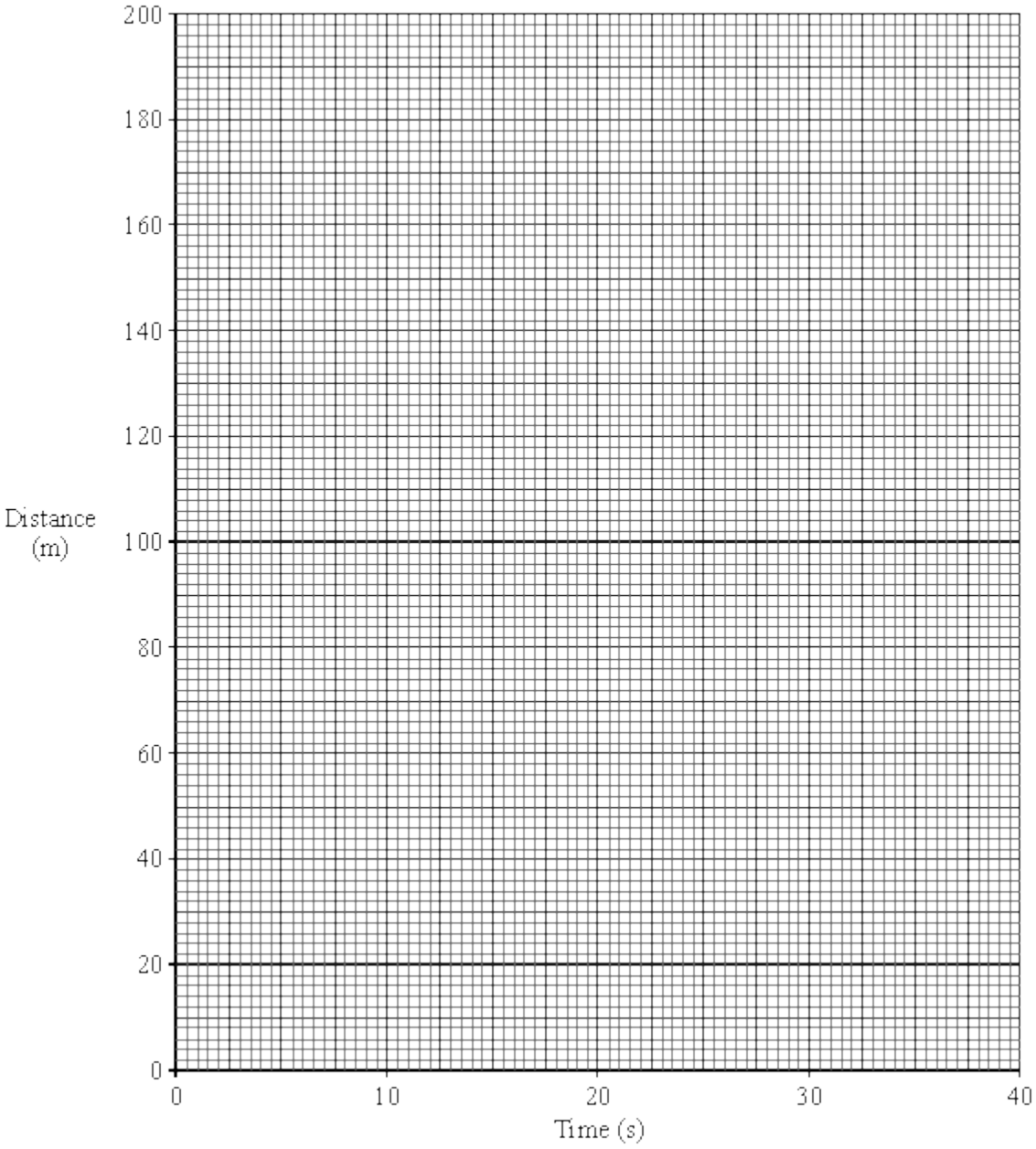
_____

(3)

(b) Two pupils are given the task of finding out how fast a tractor moves across a field. As the tractor starts a straight run across the field the pupils time how long it takes to pass a series of posts which are forty metres apart. The results obtained are shown in the table below.

Distance travelled (m)	0	40	80	120	160	200
Time taken (s)	0	8	16	24	32	40

(i) Draw a graph of distance travelled against time taken using the axes on the graph below. Label your graph line A.



(2)

(ii) Calculate the speed of the tractor.

_____

_____

(3)

(c) In another, wetter field there is more resistance to the movement of the tractor. It now travels at 4 m/s.

(i) Calculate the time needed to travel 200m.

_____

_____

_____

(ii) On the graph in part (b) draw a line to represent the motion of the tractor across the second field. Label this line B.

(4)

(d) On a road the tractor accelerates from rest up to a speed of 6 m/s in 15 seconds.

Calculate the acceleration of the tractor.

_____

_____

_____

_____ Acceleration = _____ m/s^2

(3)

(Total 15 marks)