Explaining motion – 2021/20 GCSE 21st Physics B

1. Nov 2021/Paper_J259/01/No.1

Nina is a mountain climber.

(a) Calculate the increase in her stored gravitational energy when she climbs a mountain which has a vertical height of 750 m.

Her mass is 70 kg.

Gravitational field strength = 10 N / kg.

Use the equation: gravitational potential energy = mass × gravitational field strength × height

Gravitational potential energy = ...J **[2]**

(b) **(i)** What is the useful energy store in Nina's muscles **before** she climbs the mountain?

Tick (✓) **one** box.

Chemical energy store ☐

Elastic energy store ☐

Electromagnetic energy store ☐

Gravitational energy store ☐

[1]

(ii) Nina returns to her starting point at the bottom of the mountain and stops.

Which **two** energy stores have increased when Nina reaches the bottom of the mountain and stops?

Tick (✓) **two** boxes.

Gravitational energy store in Nina's body ☐

Elastic energy store in the surroundings ☐

Nuclear energy store in the surroundings ☐

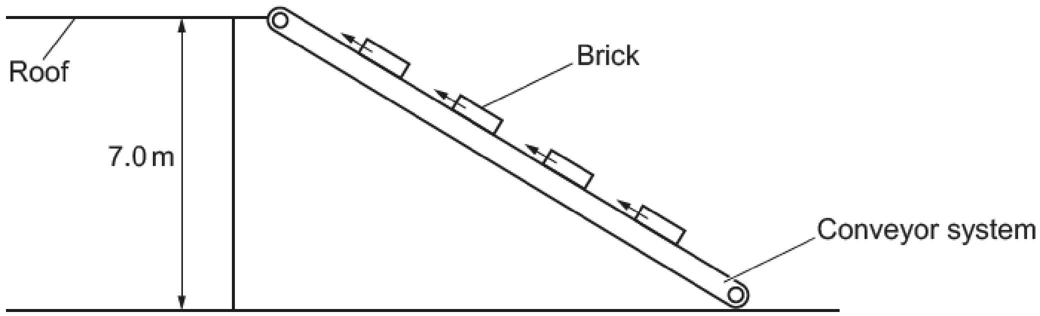
Thermal energy stored in Nina's body ☐

Thermal energy stored in the surroundings ☐

[2]

2. Nov 2021/Paper_J259/01/No.7

Kai is a builder. He uses a conveyor system to lift bricks up to the roof of a house, as shown in the diagram.



(a) The conveyor system is powered by an electric motor, which is connected to a petrol generator.

The petrol used by the generator is a store of chemical energy.

Describe **two** changes in stored energy as the bricks are lifted to the roof of the house.

1. ....

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2. ....

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[2]

(b) Calculate the work done by the electric motor to lift a brick with a weight of 35 N to the roof.

Use the equation: work done = force × distance

Give the correct **unit** for your answer.

Work done = ... **Unit** = ... **[3]**

(c) Kai considers using a conveyor system with a higher power rating.

(i) Explain what is meant by the **power** of the conveyor system.

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.... **[1]**

(ii) Suggest how a **higher power** conveyor system could help Kai lift bricks up to the roof of a house.

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.... **[1]**

3. Nov 2021/Paper_J259/01/No.8

Sarah investigates the effect of frictional forces on a sliding object. She uses a block of wood which is on a table, as shown in **Fig. 8.1**.

She pushes the block with her hand to start it moving. She then releases it and waits for it to come to rest.

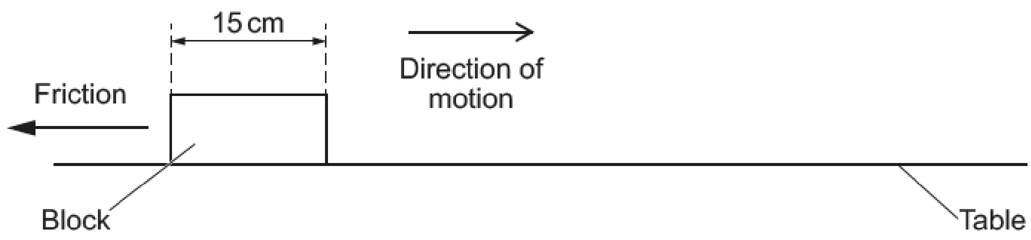

Fig. 8.1

(a) **(i)** One of the forces acting on the block is friction. This friction force acts to the left, as shown in **Fig. 8.1**.

Describe one **other** force acting on the block **after** Sarah has released it.

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.... **[2]**

(ii) Why does the block slow down when it is released?

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.... **[1]**

(b) To measure the speed of the block, Sarah uses a light gate, as shown in **Fig. 8.2**.

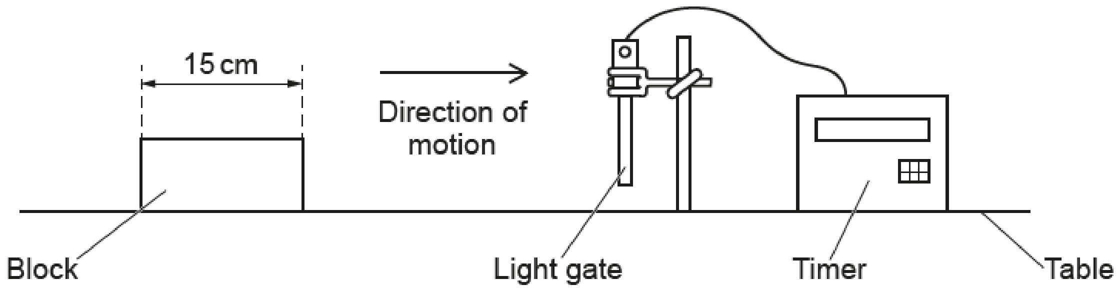

Fig. 8.2

The light gate measures the time that the block takes to pass through it.
In one test, the block takes 0.60 seconds to pass through the light gate.

The length of the block is 15 cm.

Calculate the average speed of the block as it passes through the light gate.

Use the equation: average speed = distance ÷ time

Average speed = ... m/s **[3]**

(c) Sarah wants to do an experiment to investigate how the initial speed of the block affects the distance the block travels before stopping.

Suggest how Sarah could do this experiment.

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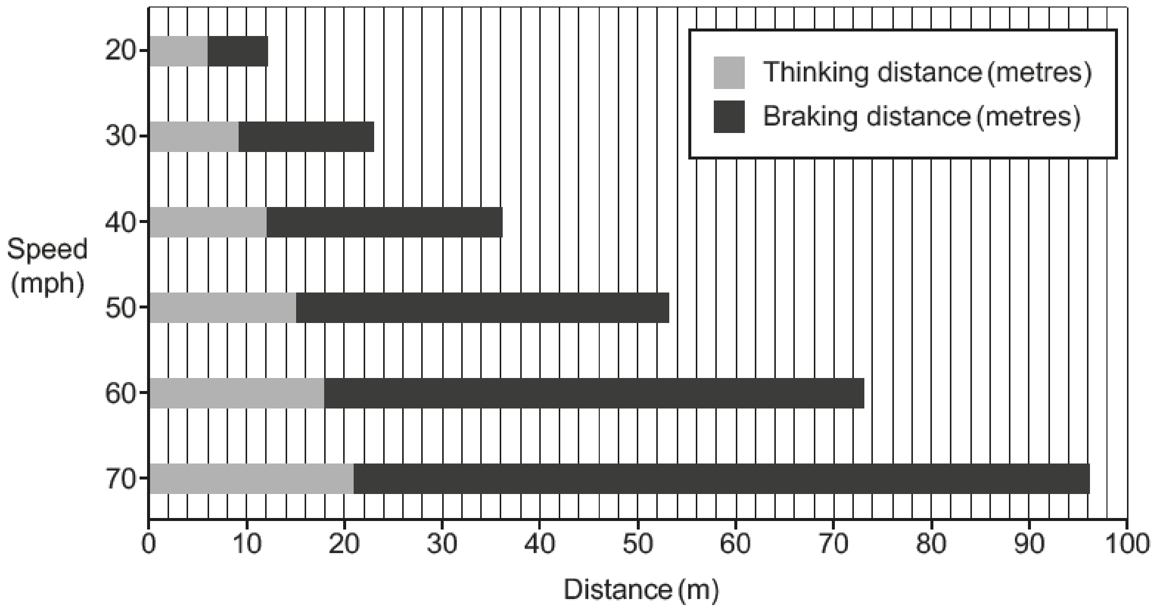
.... **[2]**

4. Nov 2021/Paper_J259/01/No.10

The chart shows typical thinking distances and braking distances for a car in normal driving conditions.



(a) Estimate the total stopping distance of a car travelling at a speed of **45 mph**, using the chart.

Total stopping distance = thinking distance + braking distance

Total stopping distance = ... m **[1]**

(b) Some residential areas are reducing their speed limits from 30 mph to 20 mph.

Explain why reducing the speed limit improves road safety.

Use data from the chart in your answer.

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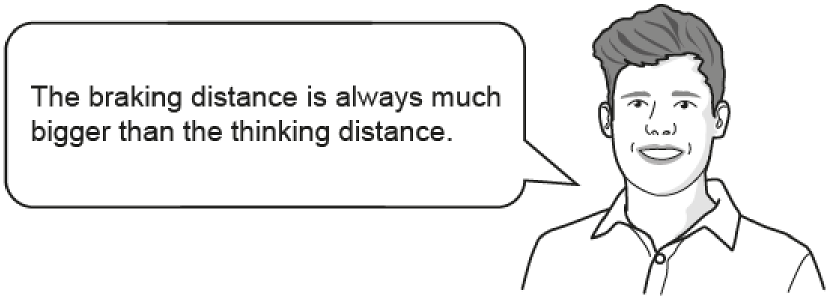
.... **[2]**

(c) Ben looks at the chart.



Discuss Ben's statement.

Use data from the chart in your answer.

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(d) Speed is a factor which affects the total stopping distance of a car in an emergency.

State **one other** factor, and explain why it affects the total stopping distance.

Factor ....

Explanation ....

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[2]

5. Nov 2021/Paper_J259/01/No.12

Sundip wants to measure Alex's reaction time.

Their teacher gives them a 30 cm ruler, and the table shown.

Reading on ruler (cm)	Reaction time (s)
12	0.15
15	0.17
18	0.19
21	0.20
24	0.22
27	0.23
30	0.24

(a) Explain how to use the ruler and the table to measure Alex's reaction time.

You can draw a diagram to support your answer.

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.... **[3]**

(b) Suggest why the table does **not** include values below 12 cm.

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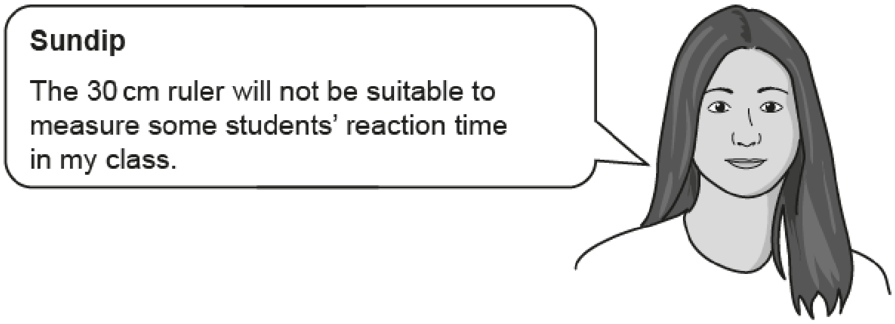
.... **[1]**

(c) Sundip wants to use the 30 cm ruler to measure the reaction times of her class.



Explain why Sundip is correct and suggest **one** solution to this problem.

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.... **[2]**

6. Nov 2021/Paper_J259/02/No.3

Jamal drives a go-cart around one lap of a 500 m oval track.

(a) It takes him 125 seconds to complete one lap of the track.

Calculate Jamal's average speed for the lap.

Average Speed = ... m/s **[3]**

(b) Distance is a scalar quantity.

Which statement defines a scalar quantity?

Tick (✓) **one** box.

It has both size and direction. ☐

It has direction but not size. ☐

It has either size or direction. ☐

It has size but not direction. ☐

[1]

7. Nov 2021/Paper_J259/02/No.9(b)

(b) **Fig. 9.2** shows a crane in a scrap metal yard fitted with an electromagnet.
The electromagnet can be lowered so that it can pick up and move scrap metal across the yard.

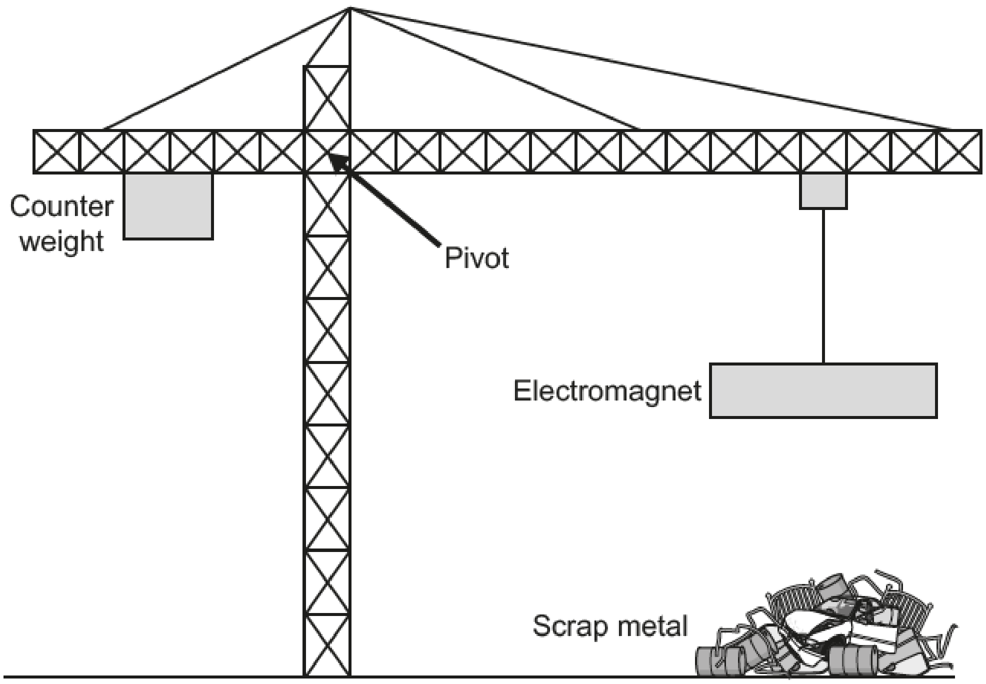

Fig. 9.2

(i) Explain why the electromagnet needs to be brought closer to the scrap metal to pick the scrap metal up.

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.... **[2]**

(ii) When the electromagnet picks up the scrap metal the counter weight is moved further away from the pivot.

Explain how this prevents the crane from tipping over.

Use ideas about moments in your answer.

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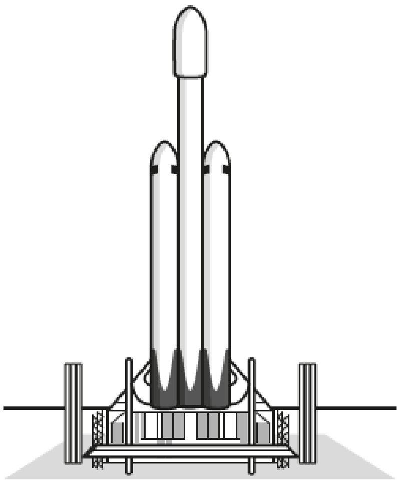
.... **[2]**

8. Nov 2021/Paper_J259/02/No.12

A space company is testing a rocket that may eventually take humans to Mars.



The mass of the rocket before lift-off is 1 420 000 kg including the fuel.
During lift-off the rocket's engines provide a maximum upward thrust of 23 000 000 N.

Explain how the forces and acceleration of the rocket change **before**, **during** and **after** lift-off.

Gravitational field strength = 10 N / kg

Use the equation: force = mass × acceleration

Use the equation: weight = mass × gravitational field strength

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.... **[6]**

9. Nov 2020/Paper_J259/01/No.5

Kai sees this information in an advert for a plane ticket.

> **Weight limit for bags = 20 kg**

Kai thinks this information is wrong.

> The advert does not show weight limits.
> It shows mass limits.

(a) Define **weight**.

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.... **[1]**

(b) Kai wants to know if his bag is too heavy to take on the plane. He needs to find its weight.

(i) Name a measuring instrument he could use to find its weight.

.... **[1]**

(ii) Describe how he can use your answer to **(b)(i)** to find the weight of the bag.

.... **[1]**

(c) Kai finds that the weight of his bag is 240 N.

Calculate the mass of the bag.

Gravitational field strength = 10 N/kg

Mass = ... kg **[3]**

10. Nov 2020/Paper_J259/02/No.3

Beth is a skydiver. Skydivers freefall before opening a parachute.

(a) **(i)** After falling for a small period of time, balanced forces act on Beth.

Describe Beth's movement when these balanced forces act.

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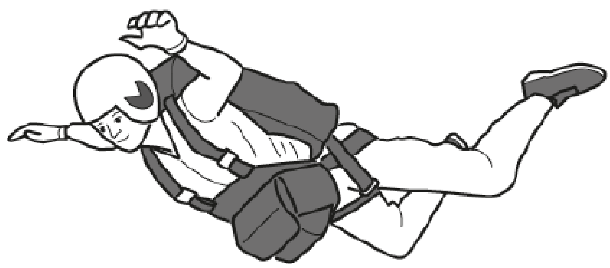
.... **[1]**

(ii) Draw **two** labelled arrows on the diagram to identify these balanced forces acting on Beth.



[2]

(b) Beth has a mass of 60 kg.

Calculate Beth's weight.

Use the equation: weight = mass × gravitational field strength

Gravitational field strength = 10 N/kg

Weight = ... N **[2]**

(c) Mass is a scalar quantity. Weight is a vector quantity.

(i) Give **one** other example of a vector quantity.

.... **[1]**

(ii) What is the difference between a vector quantity and a scalar quantity?

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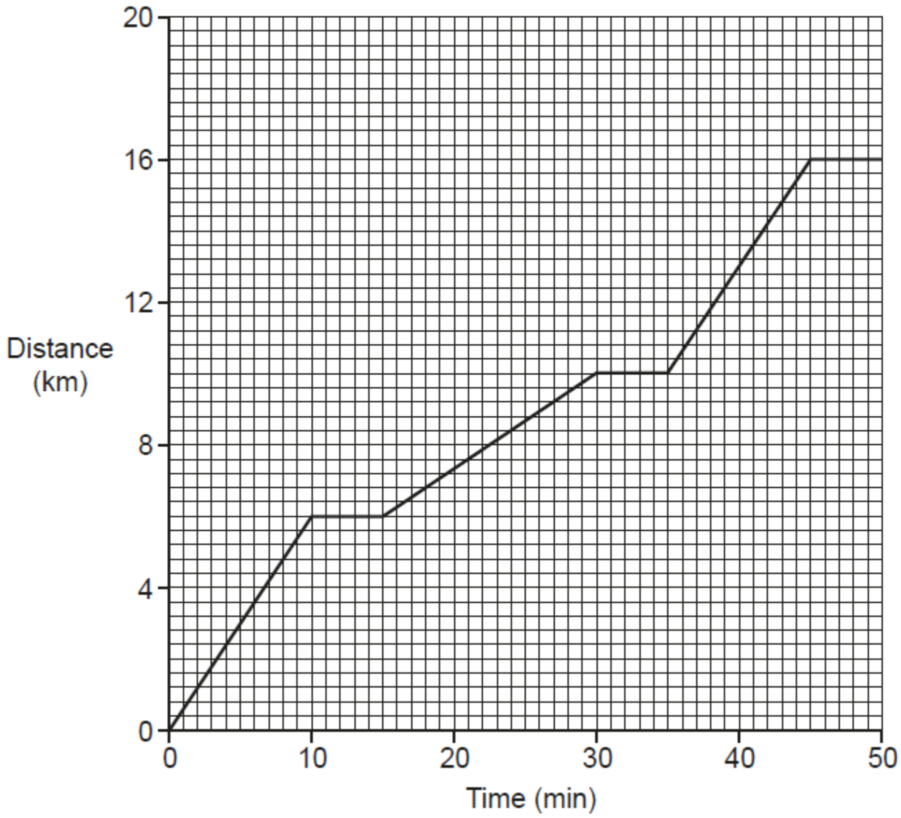
.... **[1]**

11. Nov 2020/Paper_J259/02/No.9

Layla took a bus journey to a town 16 km away.

The distance–time graph shows her bus journey.



(a) **(i)** How many times during the journey was the bus stationary?

.... **[1]**

(ii) How does the graph show that the bus was slower between 15–30 minutes than 35–45 minutes?

.... **[1]**

(b) Calculate the average speed of the bus between 35 and 45 minutes.

Use the equation: distance = speed × time

Show your working on the graph.

Average speed = ... km/min **[2]**

12. Nov 2021/Paper_J259/03/No.1

Sundip wants to measure Alex's reaction time.

Their teacher gives them a 30 cm ruler, and the table shown.

Reading on ruler (cm)	Reaction time (s)
12	0.15
15	0.17
18	0.19
21	0.20
24	0.22
27	0.23
30	0.24

(a) Explain how to use the ruler and the table to measure Alex's reaction time.

You can draw a diagram to support your answer.

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.... **[3]**

(b) Suggest why the table does **not** include values below 12 cm.

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.... **[1]**

(c) Sundip wants to use the 30 cm ruler to measure the reaction times of her class.

Sundip

The 30 cm ruler will not be suitable to measure some students' reaction time in my class.

Explain why Sundip is correct and suggest **one** solution to this problem.

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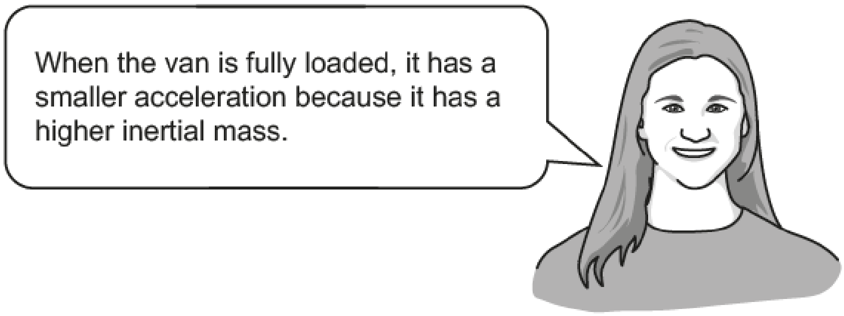
.... **[2]**

13. Nov 2021/Paper_J259/03/No.7

Layla uses a van to deliver parcels.

(a)



Explain what is meant by inertial mass **and** how it can be calculated.

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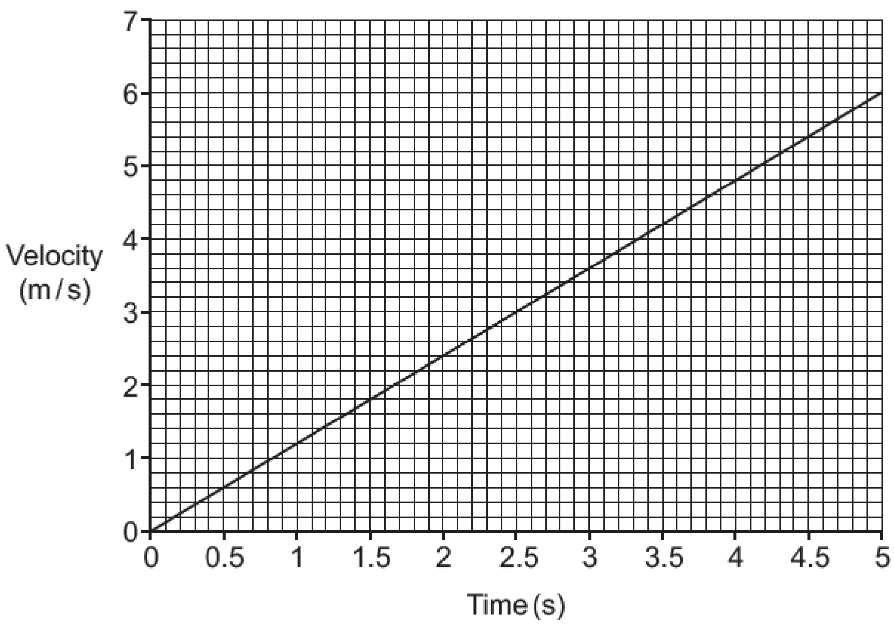
.... **[2]**

(b) This is a velocity-time graph for the first 5 seconds of the van's motion.



(i) Calculate the acceleration of the van during the first 5 seconds of its motion.

Acceleration = ... m/s^2 **[3]**

(ii) What does the velocity-time graph show about the resultant force acting on the van in the first 5 seconds of its motion?

Use Newton's second law to explain your answer.

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.... **[2]**

(iii) After 4.0 seconds the kinetic energy of the van is 40 000 J.

Calculate the mass of the van.

Use the equation: kinetic energy = 0.5 × mass × $(\text{speed})^2$

Use the graph.

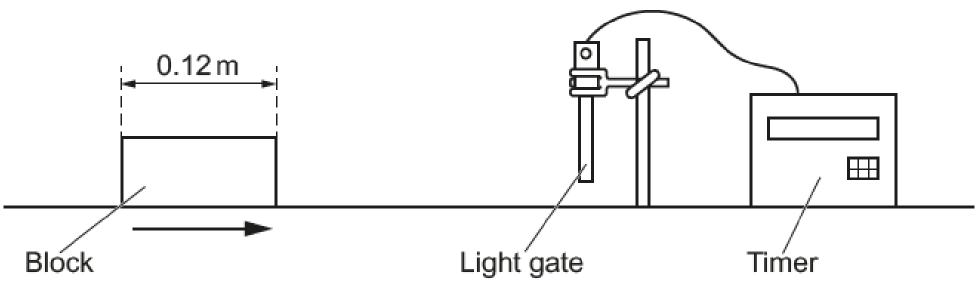
Mass = ... kg **[2]**

14. Nov 2021/Paper_J259/03/No.11

Nina investigates the effect of frictional forces on a sliding object. She uses a block of wood which is on a table, as shown in the diagram.

She pushes the block with her hand to start it moving. She then releases it and waits for it to come to rest.

To measure the speed of the block, she uses a light gate, as shown in the diagram.



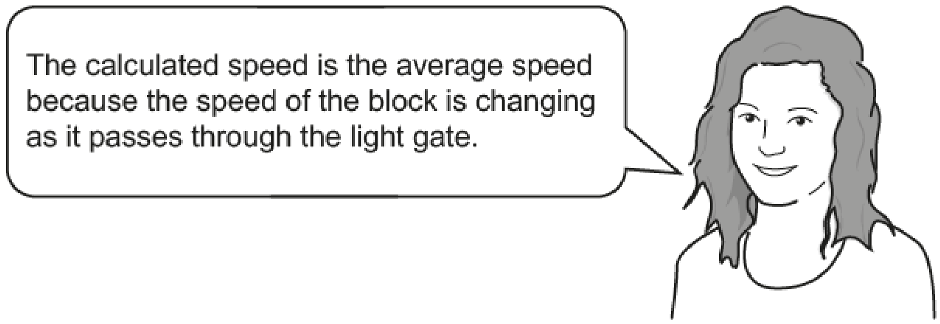
(a) The light gate measures the time that the block takes to pass through it. In one test, the block takes 0.64 seconds to pass through the light gate.

The length of the block is 0.12 m.

(i) Calculate the average speed of the block as it passes through the light gate.

Average speed = ... m/s **[3]**

(ii) Nina comments on the average speed calculated in **(a)(i)**.



Explain why the speed of the block changes, as it passes through the light gate.

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.... **[2]**

(b) Nina wants to do an experiment to investigate how the mass of the block affects the distance travelled by the block before it stops.

Suggest how Nina could do this experiment.

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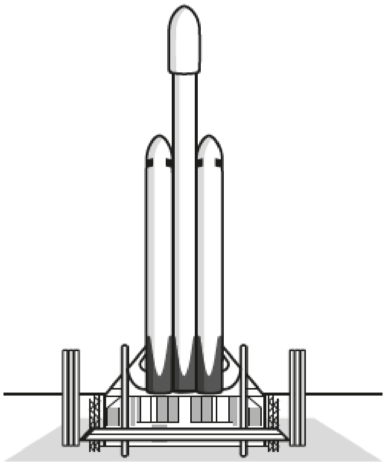
.... **[3]**

15. Nov 2021/Paper_J259/04/No.2

A space company is testing a rocket that may eventually take humans to Mars.



The mass of the rocket before lift-off is 1 420 000 kg including the fuel.
During lift-off the rocket's engines provide a maximum upward thrust of 23 000 000 N.

Explain how the forces and acceleration of the rocket change **before**, **during** and **after** lift-off.

Gravitational field strength = 10 N / kg

Use the equation: force = mass × acceleration

Use the equation: weight = mass × gravitational field strength

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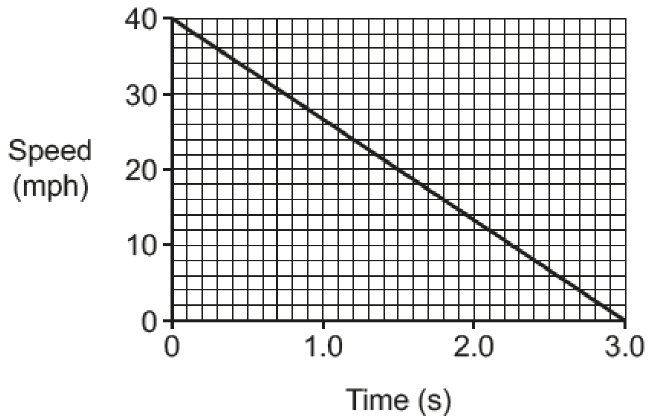
.... **[6]**

16. Nov 2021/Paper_J259/04/No.7

Ben drives a car along a straight road at 40 mph.

The graph shows how long it takes the car to stop from 40 mph when the brakes are applied.



(a) Ben sees an obstacle in the road and puts his foot on the brakes until the car stops.

(i) Calculate the resultant force on the car as it slows from 40 mph to 0 mph.

Use the data sheet and the graph.

The change in momentum of the car is 21 600 kg m/s

Resultant force = ... N **[3]**

(ii) The obstacle is 30.0 m away when Ben puts his foot on the brakes.

Determine if the car hits the obstacle.

Use the graph.

40 mph = 18 m/s

[3]

(b) (i) The speed limit on the road outside a school is 15 mph.

Explain why reducing the speed of cars is an important factor in reducing injuries on roads.

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.... **[3]**

(ii) Stopping distance is the sum of the thinking distance and the braking distance.

Ben

At 40 mph, my store of kinetic energy will be double compared to driving at 20 mph. Therefore, my total stopping distance will also be double.

Evaluate Ben's claim about his total stopping distance.

Use the equation: kinetic energy = 0.5 × mass × $(\text{speed})^2$

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.... **[4]**

17. Nov 2020/Paper_J259/03/No.4

Planets outside our solar system have been discovered orbiting a star called Kepler-106.

Table 4.1 shows the properties of these planets. Assume that the planets move in **circular** orbits.

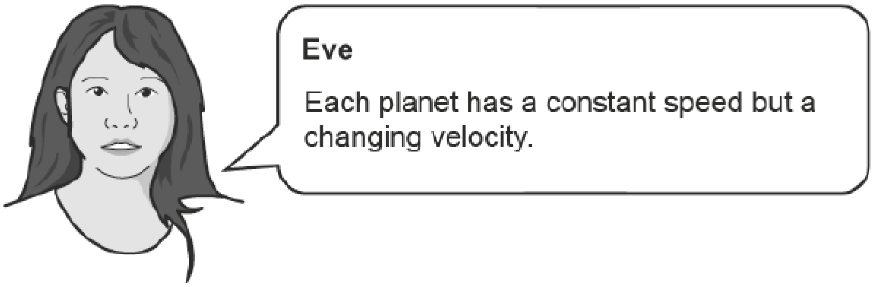
Planet	Radius of orbit (km)	Time to complete one orbit (s)	Speed (m/s)	Mass (kg)
1	9.87×10^6	5.36×10^5	116000	2.73×10^{24}
2	1.66×10^7	1.18×10^6	89000	6.26×10^{25}
3	3.59×10^7	3.80×10^6	59000	3.87×10^{25}

Table 4.1

(a) Calculate the momentum of planet **1**.

Momentum = ... kg m/s **[3]**

(b) Eve and Kai look at the information in **Table 4.1**.



(i) Explain why Eve is correct.

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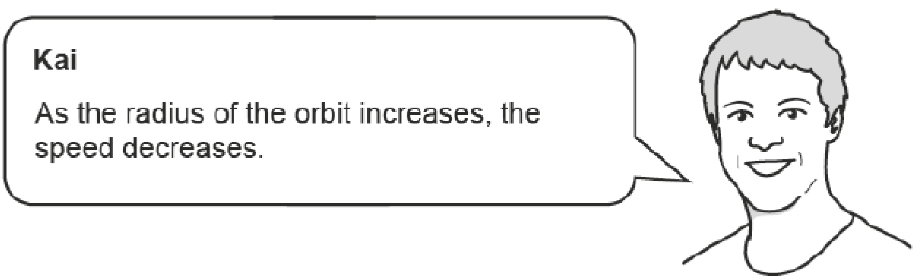
[2]



(ii) Suggest why Kai is correct.

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.... **[2]**

18. Nov 2020/Paper_J259/03/No.6

Jane is learning to drive.

(a) In a driving lesson, Jane's car is moving at 25 mph when she is asked to stop.

The car comes to a stop in a total time of 2.5 s.

Calculate the deceleration of the car as it stops.

Use the approximation: 1 mph ≈ 0.5 m/s

Deceleration = ... m/s^2 **[4]**

(b) In the driving test, Jane's car is moving at a speed of 16 m/s when she is asked to complete an emergency stop.

The car comes to a stop in a total time of 2.2 s.

Estimate the force acting on the car during the emergency stop.

Use your own estimate of the mass of the car to complete the calculation.

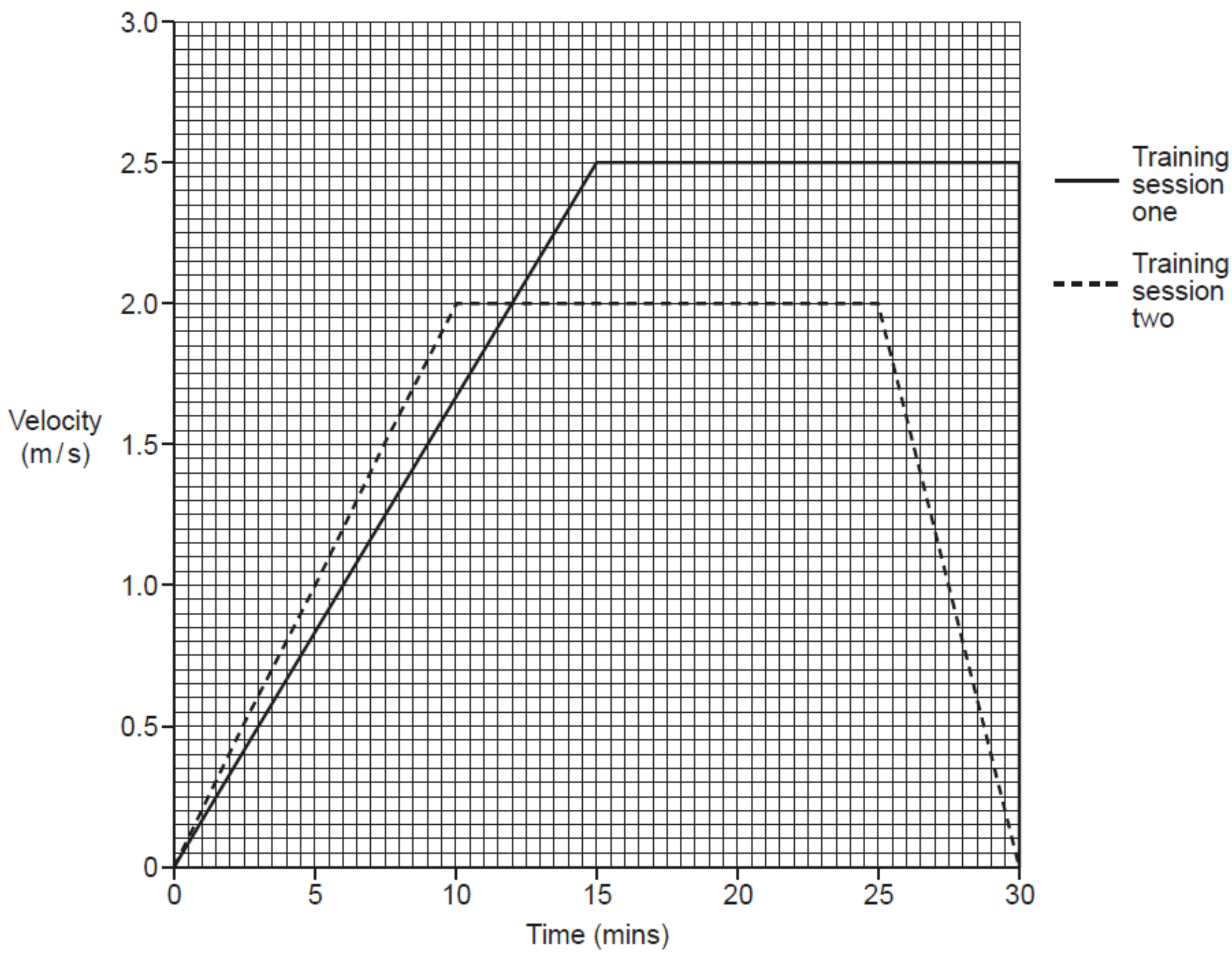
Force = ...N **[4]**

19. Nov 2020/Paper_J259/04/No.8

Layla is training for a long distance race. She follows two different training sessions in preparation for running the race, and collects some information on her performance in each training session.

Each training session lasts 30 minutes.

The graph shows her motion for both training sessions.



Give the **similarities** and **differences** between Layla's performance in the two training sessions.

Use calculations from the graph to support your answer.

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.... **[6]**