

PHYSICS



EXAM QUESTION PACK

P2.1 MOTION

SCORE

/253

PERCENTAGE

%

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Gateway Physics A (9-1)

Motion

Please note that you may see slight differences between this paper and the original.

Candidates answer on the Question paper.

OCR supplied materials:

Additional resources may be supplied with this paper.

Other materials required:

- Pencil
- Ruler (cm/mm)

Duration: Not set

Candidate
forename

Candidate
surname

Centre number

Candidate number

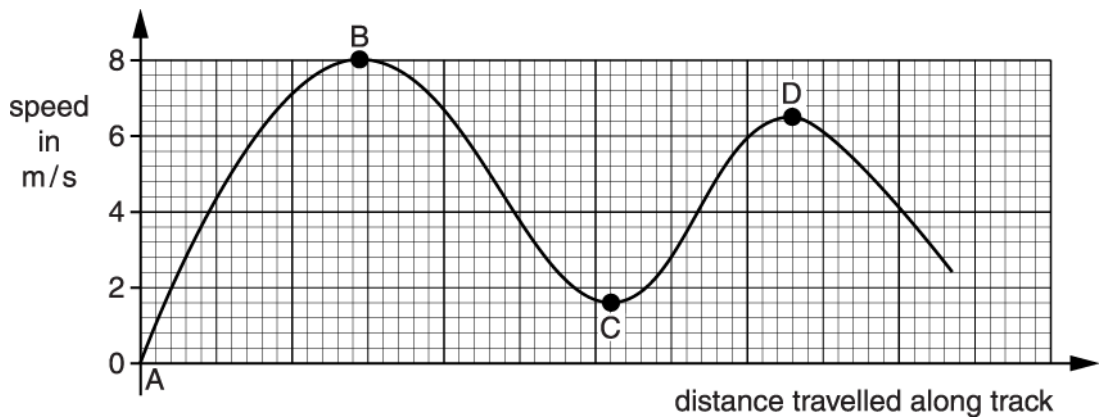
INSTRUCTIONS TO CANDIDATES

- Write your name, centre number and candidate number in the boxes above. Please write clearly and in capital letters.
- Use black ink. HB pencil may be used for graphs and diagrams only.
- Answer **all** the questions, unless your teacher tells you otherwise.
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Where space is provided below the question, please write your answer there.
- You may use additional paper, or a specific Answer sheet if one is provided, but you must clearly show your candidate number, centre number and question number(s).

INFORMATION FOR CANDIDATES

- The quality of written communication is assessed in questions marked with either a pencil or an asterisk. In History and Geography a *Quality of extended response* question is marked with an asterisk, while a pencil is used for questions in which *Spelling, punctuation and grammar and the use of specialist terminology* is assessed.
- The number of marks is given in brackets [] at the end of each question or part question.
- The total number of marks for this paper is **253**.
- The total number of marks may take into account some 'either/or' question choices.

1



The graph shows how the speed of a 400 kg roller coaster car changes as it goes along part of a roller coaster track.

Describe how the kinetic energy of the car changes as it moves from A to D and calculate the kinetic energy of the car at B.

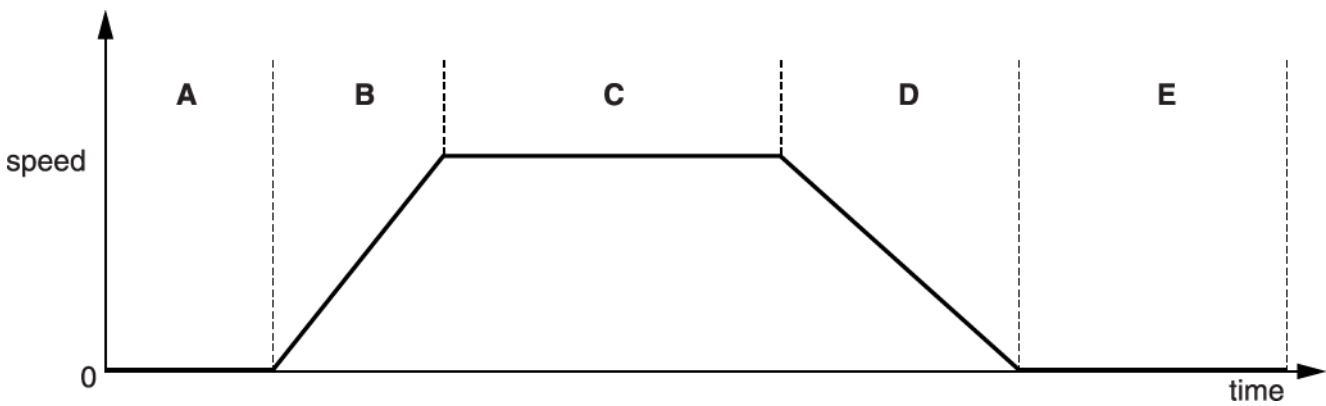


The quality of written communication will be assessed in your answer to this question.

[6]

2 This question is about a car journey.

Look at the simple speed-time graph for the journey.



(i) Which part of the graph shows an increase in speed?

Choose from A B C D E

answer _____

[1]

(ii) Which part of the graph shows the car moving at a constant speed?

Choose from A B C D E

answer _____

[1]

3(a) Police can use average speed cameras to check the **average** speed of a car on many roads.

Explain how average speed cameras work.

[2]

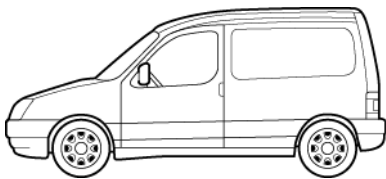
(b) A car travelling along a motorway takes 25 seconds to travel a distance of 800 metres.

Calculate the speed of the car.

answer ----- m/s

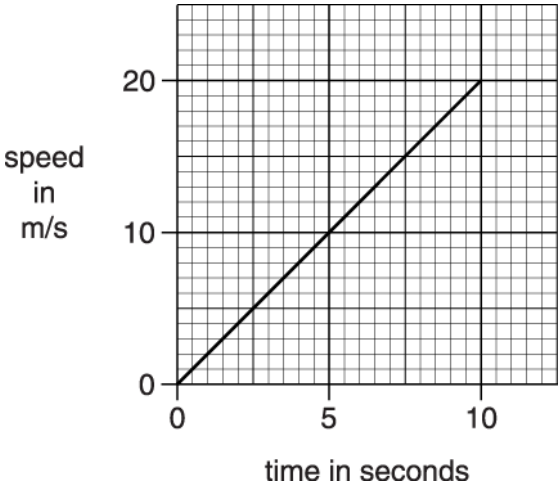
[2]

4(a) Emily has a van.



The van has a mass of 1400 kg.

Look at the speed–time graph for the first 10 seconds of her journey in the van.



Calculate the acceleration of the van in the first 10 seconds.

Choose your answer from:

- 0.5 m/s²
- 2 m/s²
- 10 m/s²
- 100 m/s²
- 200 m/s²

answer _____ m/s²

[1]

(b) The accelerating force on the van is 2800 N.

Use this force and information from the graph to calculate the work done to accelerate the van in the first 10 seconds.

answer ----- J

[3]

(c) The van now travels at a steady speed of 20 m/s.

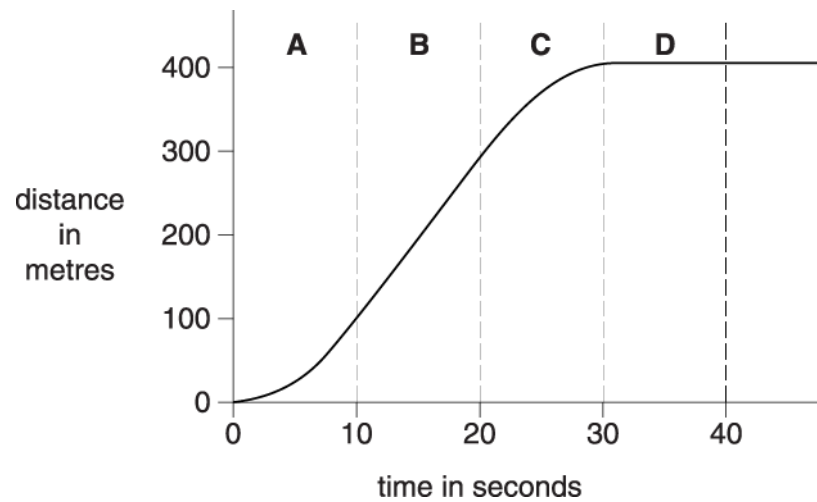
Use the force given in (b) to calculate the power developed by the engine when travelling at this speed.

answer ----- W

[2]

5 Dan travels on a bus to school each day.

Look at the distance–time graph of part of his journey between two bus stops.



Describe in detail what this graph shows about the speed and acceleration of the bus for the first 40 seconds of the journey.

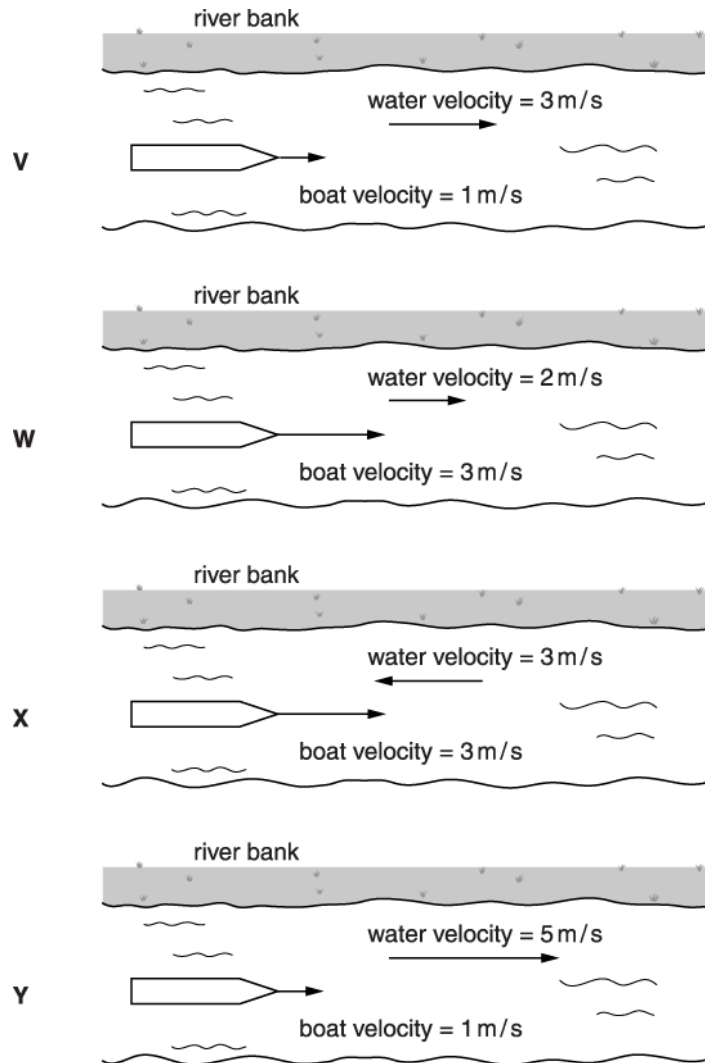
You may use a calculation in your answer.



The quality of written communication will be assessed in your answer to this question.

[6]

7 Look at the diagrams, V, W, X and Y, each showing a rowing boat on different parts of a flowing river.



The diagrams show the **velocities** of the boat and the water flow.

(i) What is the **difference** between speed and velocity?

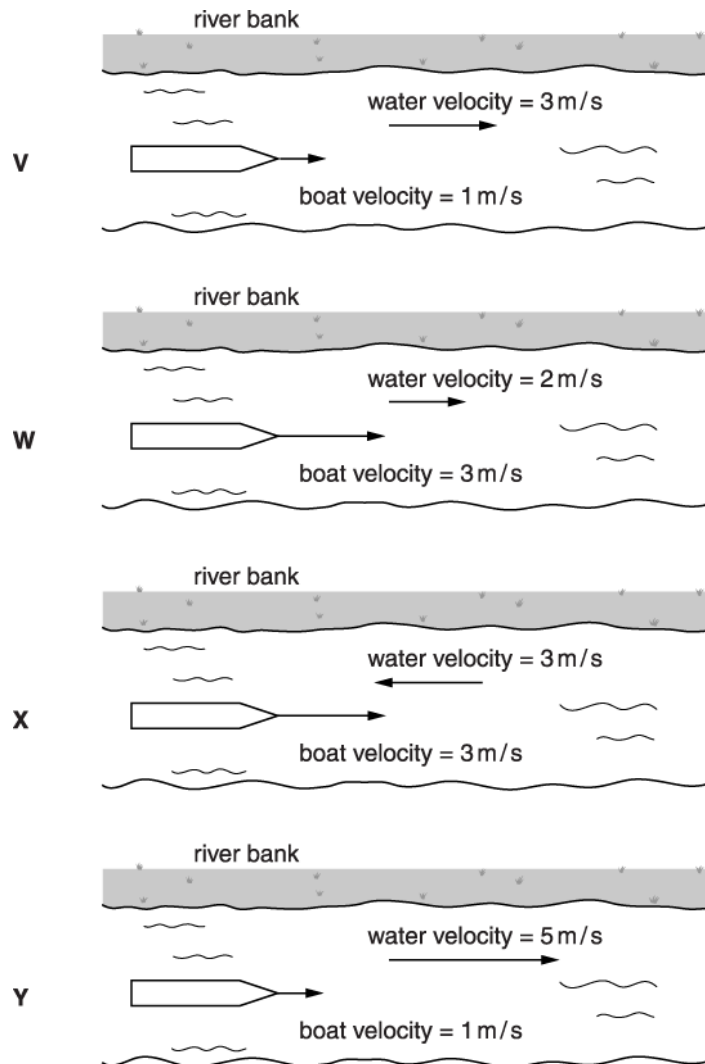
----- [1]

(ii) Which boat has the largest **resultant** velocity as seen from the river bank?

Choose from V, W, X or Y.

Explain your answer.

- 8 Look at the diagrams, V, W, X and Y, each showing a rowing boat on different parts of a flowing river.



A horse and rider are training for a race in a field.

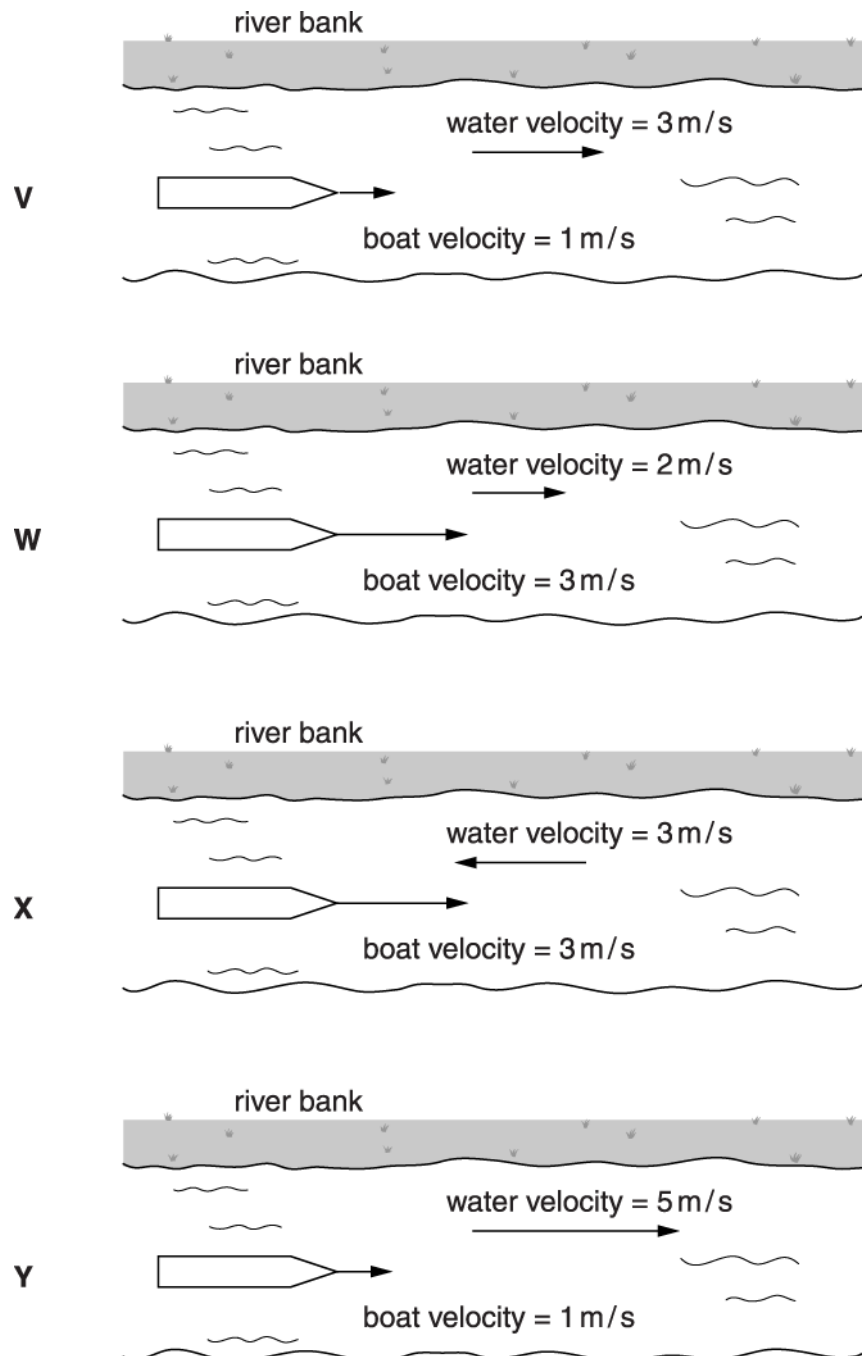
The horse accelerates steadily from 2 m/s to 6 m/s over a distance of 28 m .



Calculate the time taken for the horse to accelerate over this distance.

answer s [2]

9(a) Look at the diagrams, V, W, X and Y, each showing a rowing boat on different parts of a flowing river.



The diagrams show the **velocities** of the boat and the water flow.

(i) What is the **difference** between speed and velocity?

----- [1]

(ii) Which boat has the largest **resultant** velocity as seen from the river bank?

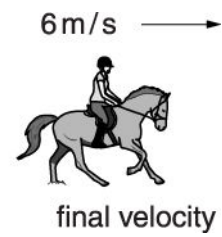
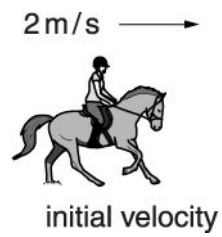
Choose from **V, W, X** or **Y**.

Explain your answer.

----- [2]

(b) A horse and rider are training for a race in a field.

The horse accelerates steadily from 2 m / s to 6 m / s.



It takes 7 s for the horse to accelerate.

Calculate the distance travelled by the horse for this acceleration.

answer ----- M [2]

10 Look at the information about four athletes.

	Nick	Steve	Sue	Julie
mass in kg	85	80	60	55
height in metres	1.7	1.9	1.6	1.5

They all run at the same speed.

Which athlete has the **greatest** kinetic energy?

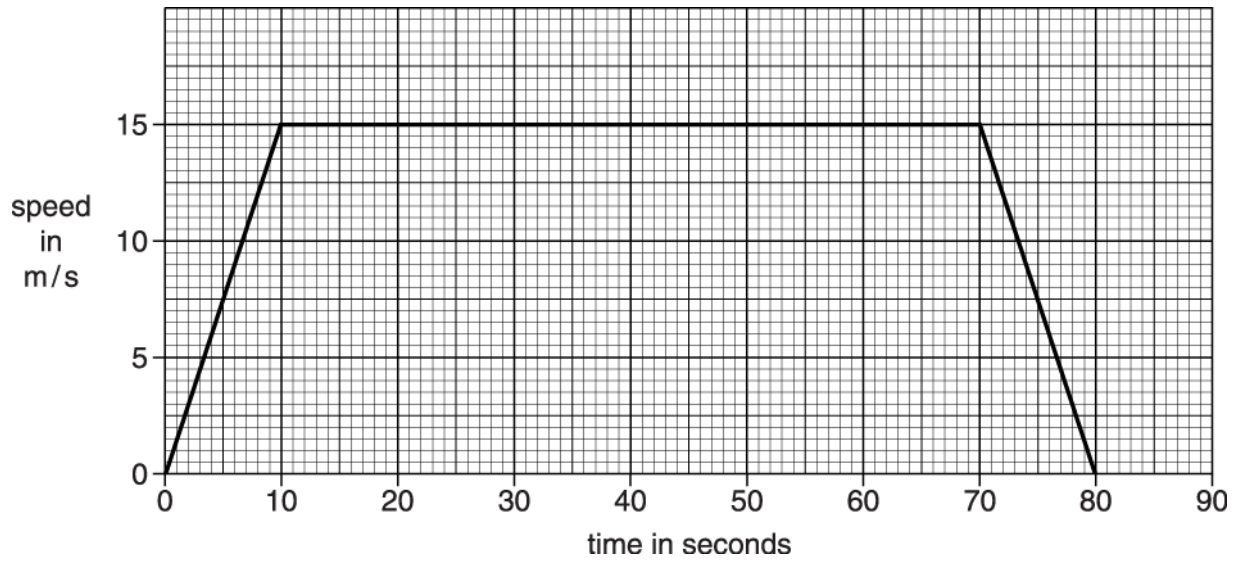
Choose from: Nick Steve Sue Julie

answer _____

[1]

11

Look at the speed–time graph of her journey between two bus stops.



Describe in detail the journey shown by the graph in terms of speed and acceleration over time.



The quality of written communication will be assessed in your answer to this question.

[6]

12(a) Adrian runs a 100 m race.

It takes him 12 seconds to run the race.

Calculate his average speed.

Give your answer to two significant figures.

answer ----- m/s

[2]

(b) At the start of the race it takes him 4 seconds to increase his speed by 10 m/s.

(i) Calculate his average acceleration.

answer ----- units -----

[3]

(ii) Adrian has a mass of 60 kg.

Calculate the average force needed at the start of the race to cause this acceleration.

answer ----- N

[2]

13(a) Alex drives her car.

Alex wants to overtake the lorry in front of her.

She needs to accelerate to overtake the lorry in front.

As she overtakes the lorry, Alex accelerates steadily from 13 m/s to 27 m/s in a time of 6 s.

Calculate the distance travelled as she overtakes.

distance travelled _____ m

[2]

(b) Alex now drives her car on a road which has a speed limit of 27 m/s.

She starts from rest at some traffic lights.

The car steadily accelerates at 3 m/s^2 for 10 seconds.

Calculate the car's final speed to see if she goes faster than the speed limit.

Final speed _____ m/s

Does she go faster than the 27 m/s speed limit?

[2]

14(a) Artificial satellites are put into space for scientific research.

The satellites are carried into space by rockets.

A rocket accelerates steadily from rest and reaches 8000 m/s after travelling 1 680 000 m.

Calculate the time, in minutes, it takes the rocket to reach this speed.

answer ----- minutes

[3]

(b)

- (i) The rocket is now in a stable orbit.

To keep the rocket in this orbit its speed needs to stay at 8000 m/s.

Suggest, by using ideas about gravitational and centripetal forces, why this speed needs to be maintained to keep it in this stable orbit.

[3]

- (ii) The rocket re-enters the Earth's atmosphere safely.

In the final part of the descent its speed reduces steadily from 2000 m/s to 120 m/s just before touchdown. This takes place over a distance of 5×10^5 m.

Calculate the average **deceleration** over this distance.

answer _____ m/s^2

[3]

15 Artificial satellites are put into space for scientific research.

The satellites are carried into space by rockets.

A rocket accelerates steadily from rest and reaches 6000 m/s after 5 minutes.

Calculate the average speed and the distance travelled in this time.

average speed ----- m/s

distance ----- m

[3]

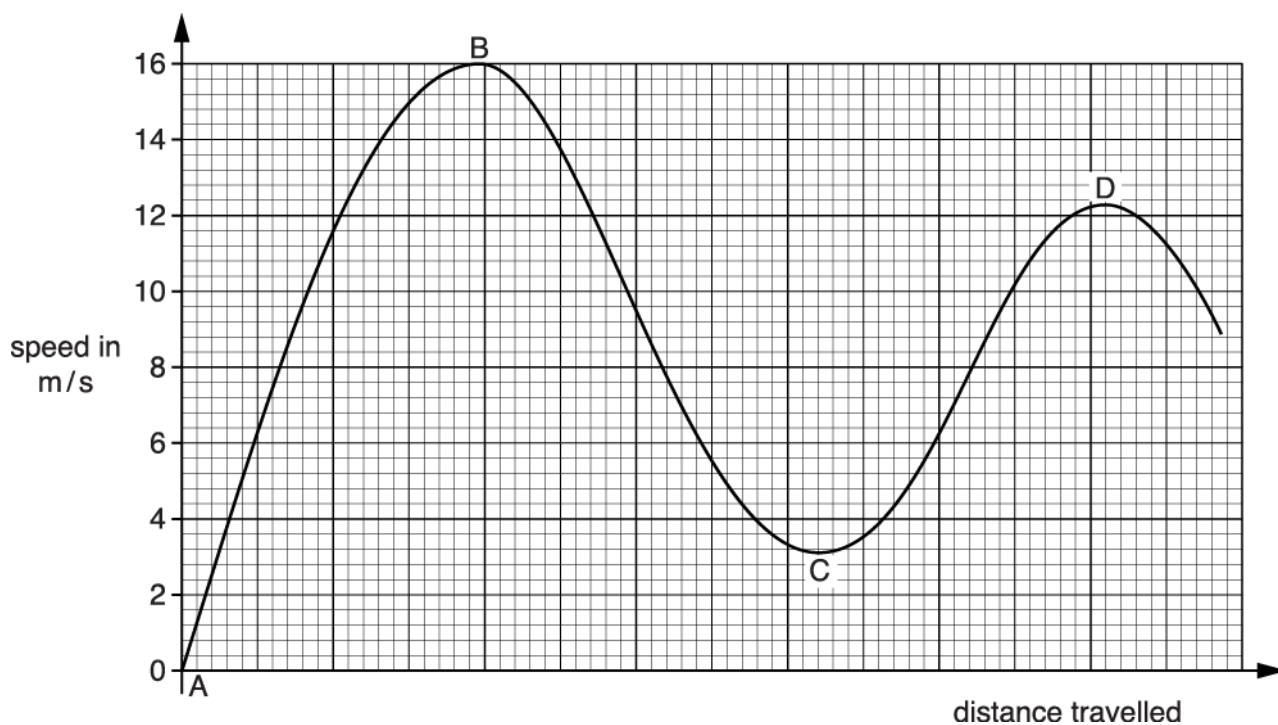
16 This question is about kinetic and gravitational potential energy.

Look at the graph.

It shows how the speed of a roller coaster car changes with the distance travelled along part of the track.

The roller coaster car starts from rest at the top of the track at A.

The car and its passengers have a total mass of 400 kg.



Describe how the kinetic energy and the gravitational potential energy of the car change in sections AB and BC of the journey, and calculate the difference in height of the roller coaster between A and B assuming no energy is lost.

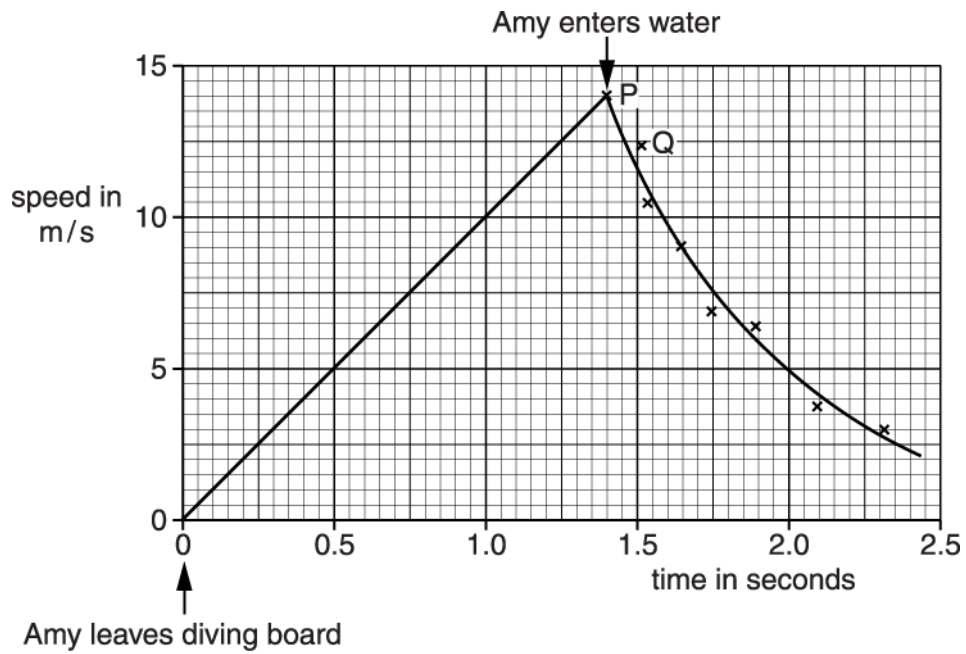
The acceleration due to gravity is 10 m/s^2 .



The quality of written communication will be assessed in your answer to this question.

[6]

17(a) Amy dives from the high diving board at a swimming pool.
Look at the graph of her motion.



Calculate the height of the diving board above the water.

answer ----- m

[2]

(b)

- (i) John thinks that he can find Amy's deceleration just after she enters the water by using points P and Q on the graph.

Elaine thinks it is better to find Amy's deceleration just after she enters the water by using the gradient of the graph at point P.

Explain why Elaine's method is better than John's to find the deceleration.

----- [2]

- (ii) Amy has a mass of 60 kg.

Amy's deceleration as she enters the water is 20 m/s^2 .

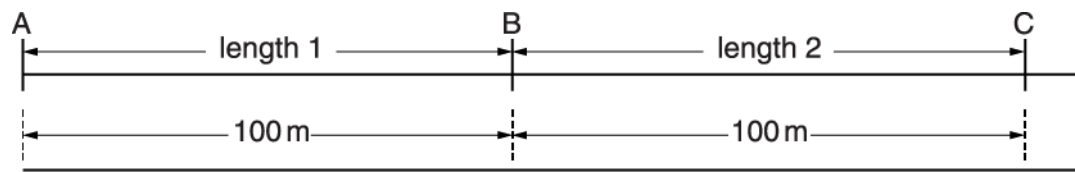
Calculate the decelerating force on Amy just as she enters the water.

answer ----- N [1]

18 This question is about speed.

Pupils at a school measure the time cars take to travel two 100 m lengths.

Look at the diagram.



Look at the results that they collect for four cars passing the school.

Type of car	Time taken to travel length 1	Time taken to travel length 2
	in seconds	in seconds
Golf	9	8
Fiat	8	8
Jaguar	8	9
Skoda	7	7

(i) Which car's speed is increasing as it travels from A to C?

answer _____

[1]

(ii) The speed limit on the road in front of the school is 13 m/s.

Calculate the time it takes for a car travelling at a speed of 13 m/s to travel 100 m.

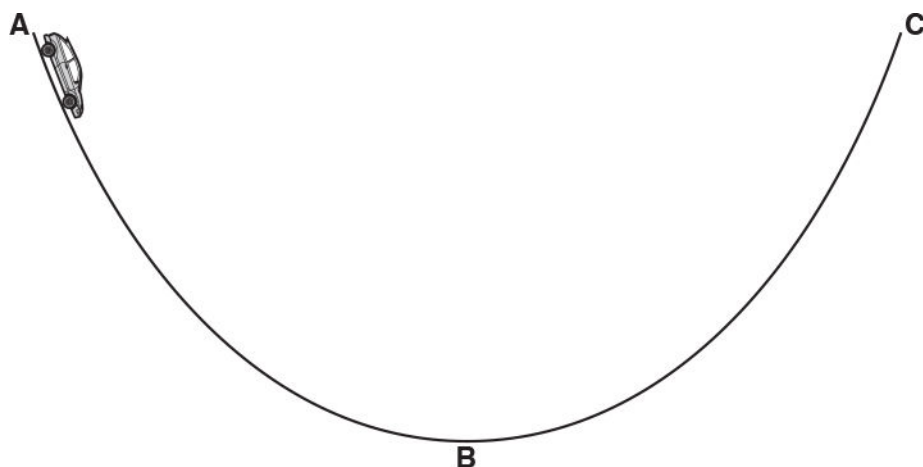
Use your answer to explain if any of the cars are travelling faster than the speed limit.

[2]

19 Rosie investigates the motion of a toy car along a curved track.

Rosie releases the toy car from A.

Look at the diagram of the curved track.



Describe how the kinetic energy and the potential energy of the toy car change as it moves from **A** to **B** and from **B** to **C**.

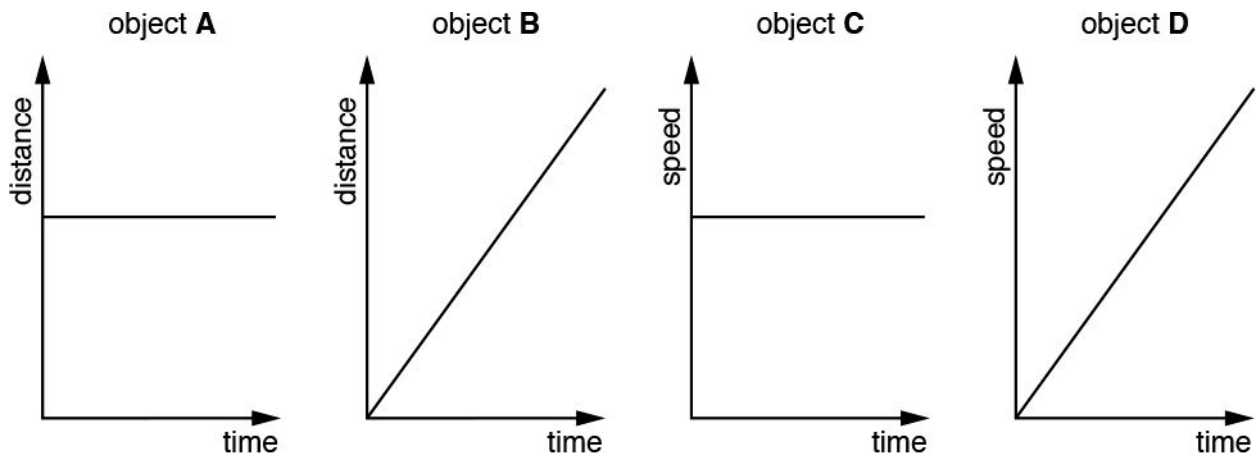


The quality of written communication will be assessed in your answer to this question.

[6]

20(a) Gio draws motion graphs for objects A, B, C and D.

Look at her four graphs.



Which **two** objects move with constant speed?

----- and ----- [1]

(b) Which object increases speed?

----- [1]

(c) Which object is **not** moving?

----- [1]

21 A ball is dropped from a cliff 20 m high.

Calculate the speed of the ball just before it hits the ground.

Acceleration due to gravity = 10 m/s².

Answer ----- m/s [2]

22(a) Speed and velocity are measurements.

Tick (✓) the **two** correct sentences about speed and velocity.

Direction is **not** important when measuring speed. ☐

Relative speed does **not** depend on the direction of movement. ☐

Speed and velocity are vector quantities. ☐

Speed is a scalar quantity. ☐

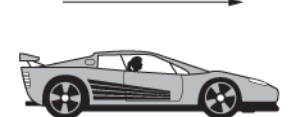
Velocity is always higher than speed. ☐ [2]

(b) The diagram shows a car accelerating.

starting velocity (u) = ?



final velocity (v) = 11 m/s



The car accelerates at 0.6 m / s^2 for 10 s.

The car has a final velocity of 11 m / s.

Calculate the starting velocity.

answer ----- m/s

[2]

23(a) Velocity is a vector quantity.

It can be calculated by using equations or by drawing scale diagrams.

Describe the difference between scalar and vector quantities.

----- [1]

(b) The diagram shows a car accelerating.

starting velocity (u) = ?



final velocity (v) = 11 m/s



The car accelerates at 0.6 m/s^2 for 10 s.

The car has a final velocity of 11 m/s.

Calculate the starting velocity.

answer m/s [2]

24 Jim investigates the acceleration of his new car.

His car starts from rest and reaches 26 m/s in 13 seconds.

(i) Calculate the acceleration of his car.

Include the unit for acceleration with your answer.

Answer ----- unit ----- [3]

(ii) Jim finds that the acceleration of his car is less than advertised by the maker.

Why is it important that the person testing the car is **independent** from the maker?

----- [2]

25(a) Sami rides a scooter at different speeds.

He calculates the kinetic energy of the scooter at four different speeds.

Look at the table.

Speed in metres per second	Kinetic energy in joules
5	1 250
10	5 000
15	11 250
20	20 000

Describe the pattern between the speed and the kinetic energy of the scooter.

-----[2]

(b) Kinetic energy depends on speed.

Write down one **other** thing kinetic energy depends on.

-----[1]

(c) Sami rides his scooter on a road with ‘average speed cameras’.

Explain how average speed cameras work.

-----[3]

26 An object travelled 800 m in 40 seconds.

Use the equation: distance travelled (m) = speed (m/s) $\times$ time (s)

What is the speed of the object?

- A 0.05 m/s
- B 20 m/s
- C 840 m/s
- D 32 000 m/s

Your answer

[1]

27 Which is a scalar?

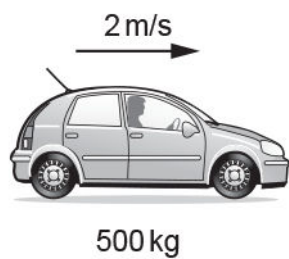
- A Acceleration
- B Displacement
- C Force
- D Speed

Your answer

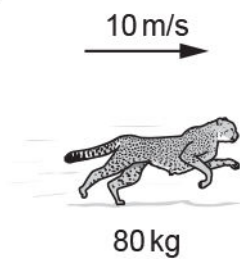
[1]

28 Which of the following has the **most** kinetic energy?

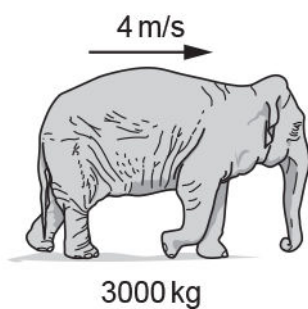
A



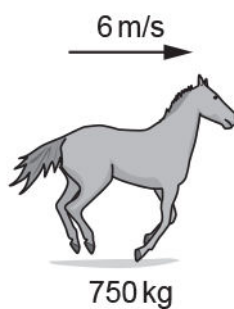
B



C



D



Your answer

[1]

29 Which distances are the **same**?

A 1×10^{-3} m and 1 μ m

B 1×10^{-6} m and 1 mm

C 1×10^{-9} m and 1 nm

D 1×10^{-12} m and 1 Gm

Your answer

[1]

31 A presenter on a car TV programme says:

“The car maker has reduced the mass of this car and it now has better acceleration.”

(i) Explain why the presenter is correct.

----- [2]

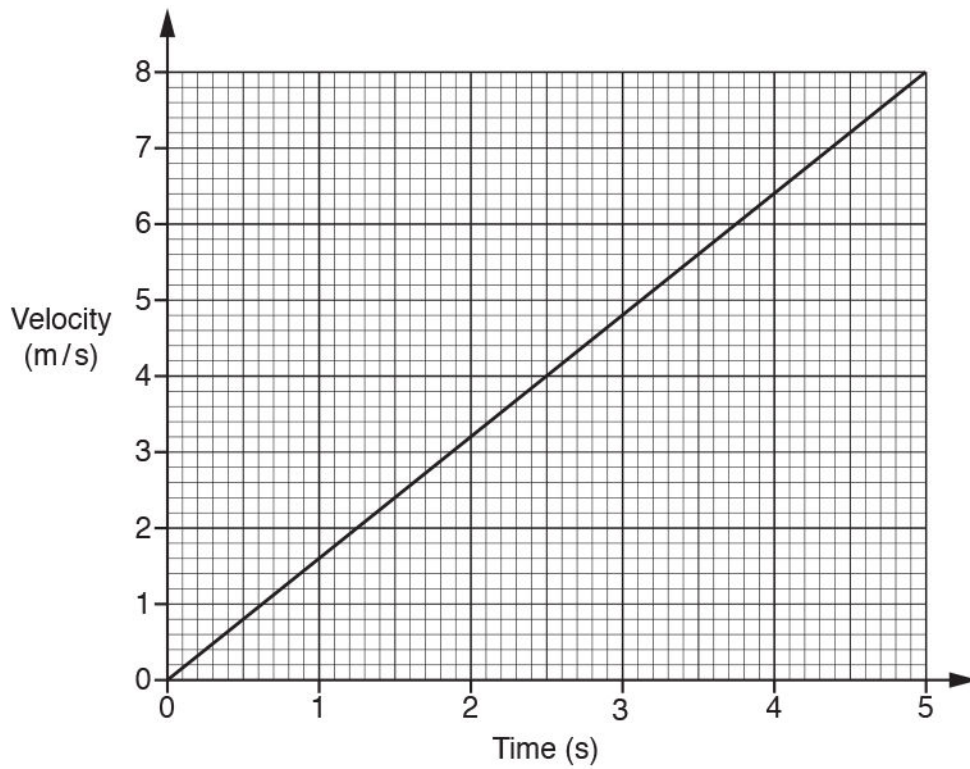
(ii) A car accelerates from 5 m/s to 25 m/s in 4 seconds.

Calculate the acceleration of the car.

Use the equation: Acceleration = Change in speed ÷ Time taken

Answer = ... m/s² [3]

32 Look at the velocity-time graph of an object.



What is the distance travelled by the object in 5s?

- A 0.63 m
- B 1.6 m
- C 20 m
- D 40 m

Your answer

[1]

33 Two cars head towards each other on a road.



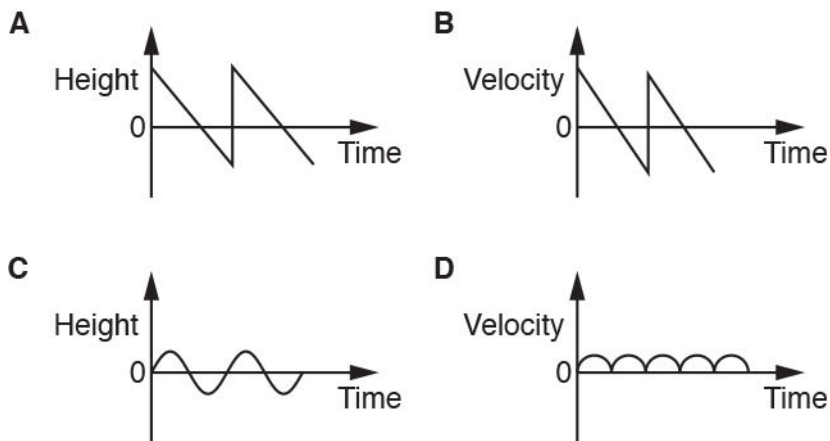
What velocity does the driver of car Q see car P travelling towards him at?

- A 10 m/s
- B 15 m/s
- C 25 m/s
- D 40 m/s

Your answer

[1]

34 Which graph shows a bouncing ball?



Your answer

[1]

35 A student wants to find out the depth of a well.

She thinks that she can calculate this by dropping a stone into the well and timing how long it takes to hear the stone splash at the bottom.

(i) Explain how she could use this measurement to find the depth of the well.

----- [3]

(ii) It takes 2.2 seconds for the stone to drop from rest and splash into the water at the bottom.

What is the speed of the stone when it hits the water?

Answer = ... m/s [2]

36 A student watches a ball game on the school field.

The student sees the ball being hit with a bat but he hears the sound a short time after. This is because the speed of light is much greater than the speed of sound.

Describe an experiment which measures the speed of **sound** in air. In your answer describe the measurements, calculations and procedures needed to gather **accurate** and **reliable** results.

You may draw a diagram as part of your answer.

[5]

37(a) A scientist uses different drivers to test the stopping distances of the same car.

Look at the results.

Driver	Speed (m/s)	Thinking distance (m)	Braking distance (m)
A	8	6	6
B	16	13	24
C	32	24	96
D	16	12	22
E	8	5	6
F	32	30	120

Which driver has the **quickest** reaction time?

Driver has the **quickest** reaction time.

Calculate their reaction time.

Answer = ... s [3]

(b) Give two drivers that have the **same** reaction time.

Drivers have the **same** reaction time.

Explain your answer.

-----[2]

(c) Driver C travels at 32 m/s on the road and then stops. The car has a mass of 1200 kg.

(i) Show that the kinetic energy stored by the car at 32 m/s is 614 000 J.

[3]

(ii) Describe what happens to the kinetic energy of the car as it brakes and stops.

[2]

(iii) The braking distance of the car is 96 m.

Calculate the braking force on the car.

Give your answer to 4 significant figures.

Answer = ----- N [3]

38 A lorry has a mass of 3500 kg. It travels at a speed of 30 m/s.

Use the equation: Kinetic Energy = $0.5 \times \text{Mass} \times \text{Speed}^2$

Calculate the kinetic energy of this lorry.

- A 10 500 J
- B 52 500 J
- C 1 575 000 J
- D 3 150 000 J

Your answer

[1]

39(a) A student watches a ball game on the school field.

The student sees the ball being hit with a bat but he hears the sound a short time after. This is because the speed of light is greater than the speed of sound.

He decides to do an experiment to measure the speed of sound waves in air.

Describe which measurements he needs to measure this speed.

----- [2]

(b) Which equation is used to calculate speed?

----- [1]

(c) Describe one way he could get valid results for this experiment.

----- [1]

40 Fig. 20.1 shows thinking, braking and stopping distances for the same car travelling at different speeds.

Speed (m/s)	Thinking distance (m)	Braking distance (m)	Stopping distance (m)
8	6	6	12
16	12	24	36
32	24	96	120

Fig. 20.1

Calculate the reaction time of the person driving the car.

Answer = ----- s [3]

41 This question is about force, mass and acceleration.

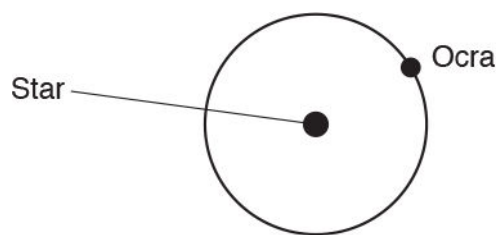
A car starts from rest and accelerates at 3 m/s².

Use the equation: Acceleration = Change in velocity ÷ Time taken

Calculate the **velocity** of the car after 4 s.

Answer = ----- m/s [2]

42 Planet Ocra is in a circular orbit around a star.



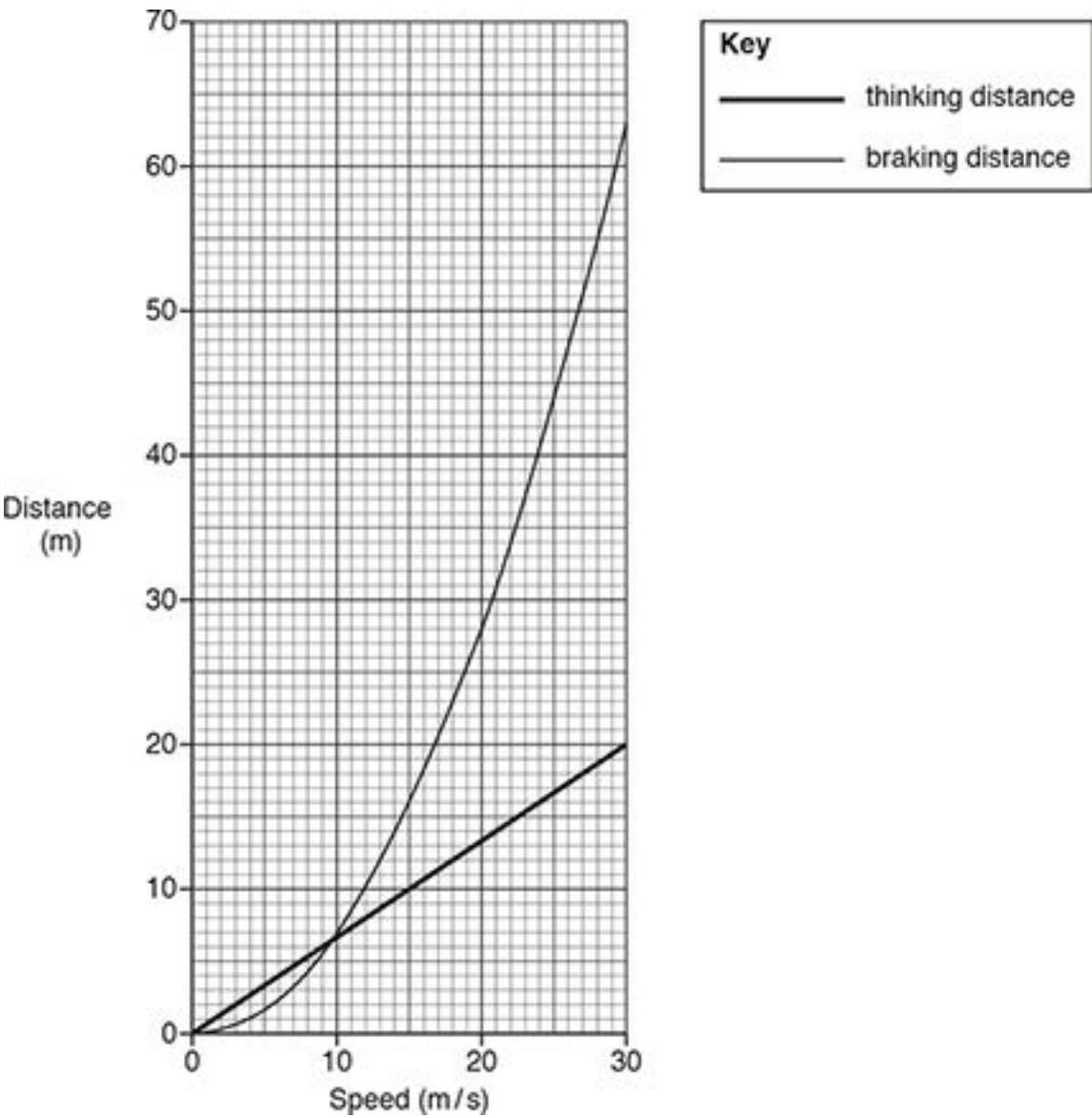
Which statement is correct?

- A The acceleration of Ocra is zero.
- B The speed of Ocra is changing.
- C The velocity of Ocra is changing.
- D The velocity of Ocra is zero.

Your answer

[1]

43 The graph shows thinking and braking distances for a car at different speeds.



(i) Use the graph to find the **thinking distance** at 24 m / s.

Thinking distance =..... m [1]

(ii) Calculate the **thinking time** at 24 m / s.

Use your answer to (i) and the equation: distance travelled = speed × time

Give your answer to 2 decimal places.

Thinking time = ... s [3]

The driver of car P reacts to a traffic light at time = 0.00 s, then presses the brakes at time = 0.50 s.

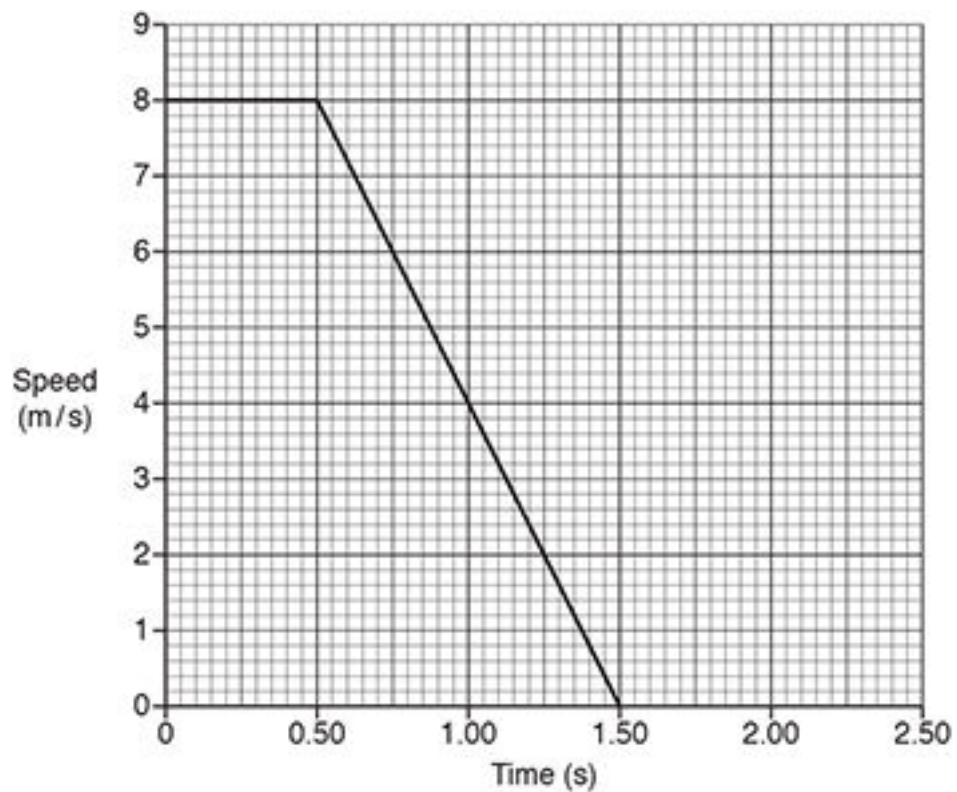


Fig. 21.1

- (i) The braking distance is the same size as the thinking distance.

Explain how the graph in Fig. 21.1 shows this.

[1]

- (ii) Add another line to the graph in Fig. 21.1 to show the journey of car Q.

- Car Q is travelling at 8 m / s.
- The driver of car Q reacts, then presses the brakes after 0.75 s.
- Car Q decelerates at the same rate as car P.

[2]

45 Some students try to measure the speed of sound, as shown in Fig. 24.1.

One student makes a loud sound by clapping her hands.

The sound of the clap reflects from the gym wall causing an echo.

Another student measures the time between hearing the clap and hearing the echo.

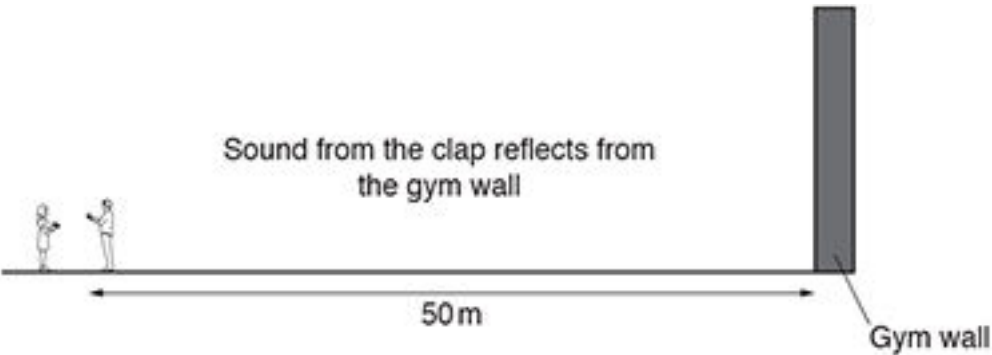


Fig. 24.1

They repeat the experiment three times and record their results in the table below.

Distance to wall (m)	Time 1 (s)	Time 2 (s)	Time 3 (s)	Mean time (s)
50	0.28	0.32	0.54	

(i) The student did not pay attention when recording time 3.

Calculate the **mean** time taken for the sound of the clap to return, using suitable values from the table.

Mean time taken = ... s [1]

(ii) Calculate the speed of sound for the clap.

Use your answer to (i) and the equation: distance travelled = speed × time

Give your answer to significant figures.

Speed of sound = ... m / s [4]

(iii) Describe **two** ways to improve and develop their method.

1

.....

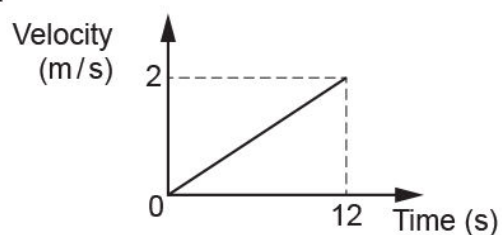
2

.....

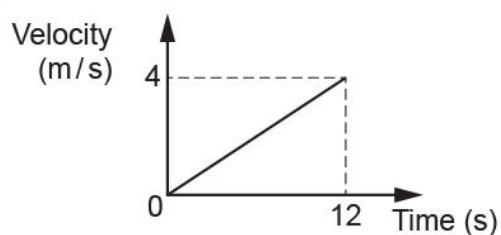
[2]

46 Look at the motion graphs.

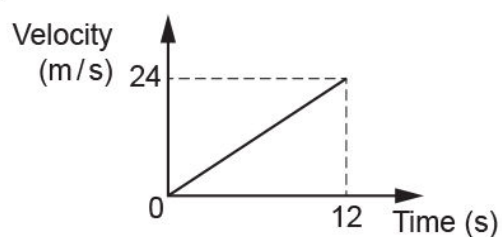
A



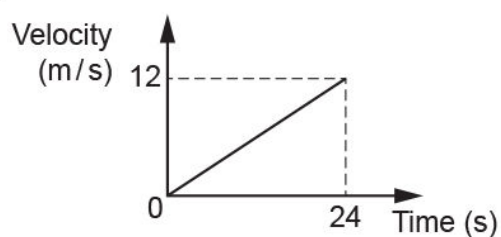
B



C



D



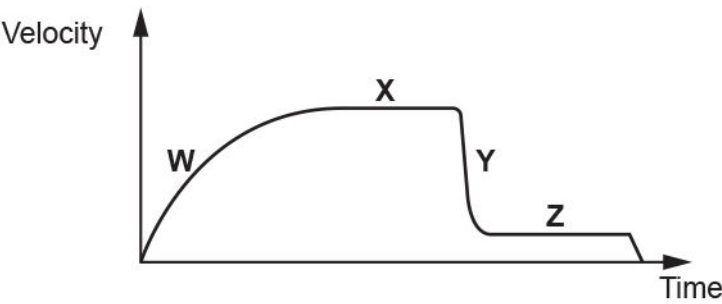
Which graph shows a journey with a distance of 24 m?

Your answer

[1]

47 A skydiver falls from a plane. His parachute opens and he lands safely.

Look at the velocity-time graph of his journey.



Which parts of the graph show balanced forces on the skydiver?

- A X only
- B Y and Z
- C X and Z
- D Y only

Your answer

[1]

48(a) A student investigates how the angle of a ramp affects the final speed of a trolley.

He uses light gates to record the speed of the trolley at the bottom of the ramp.

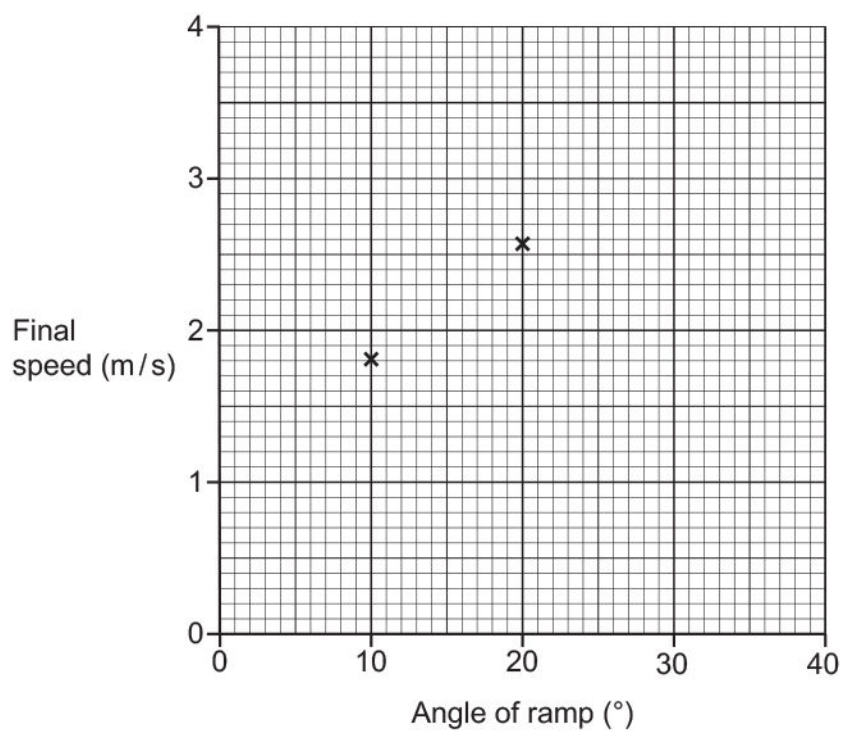
The student releases the trolley from rest at the same point on the ramp each time.

Look at his results.

Angle of ramp (°)	Final speed (m / s)			
	Attempt 1	Attempt 2	Attempt 3	Mean
10	1.81	1.80	1.81	1.81
20	2.58	2.56	2.57	2.57
30	3.1	3.11	3.11	3.11
40	3.52	3.51	3.50	3.51

- (i) Plot the results on the graph and draw a line of best fit.

Two results have been plotted for you.



[2]

- (ii) Describe the pattern shown by the results.

Use data from the table or graph in your answer.

- (iii) Explain why the final speed changes when the angle of the ramp increases.

In your answer use ideas about energy.

- (iv) The student made a mistake when recording one of his results.

Identify the mistake **and** explain what he should have done.

- (v) The student thinks this data shows that his results are **reproducible**.

He is **not** correct.

Explain why.

(b)

- (i) The mean final velocity for the ramp at a 40° angle is 3.51 m / s . The distance from the top of the ramp to the light gate at the bottom is 1.0 m .

Calculate the acceleration of the trolley when the ramp is at a 40° angle.

Give your answer to decimal places.

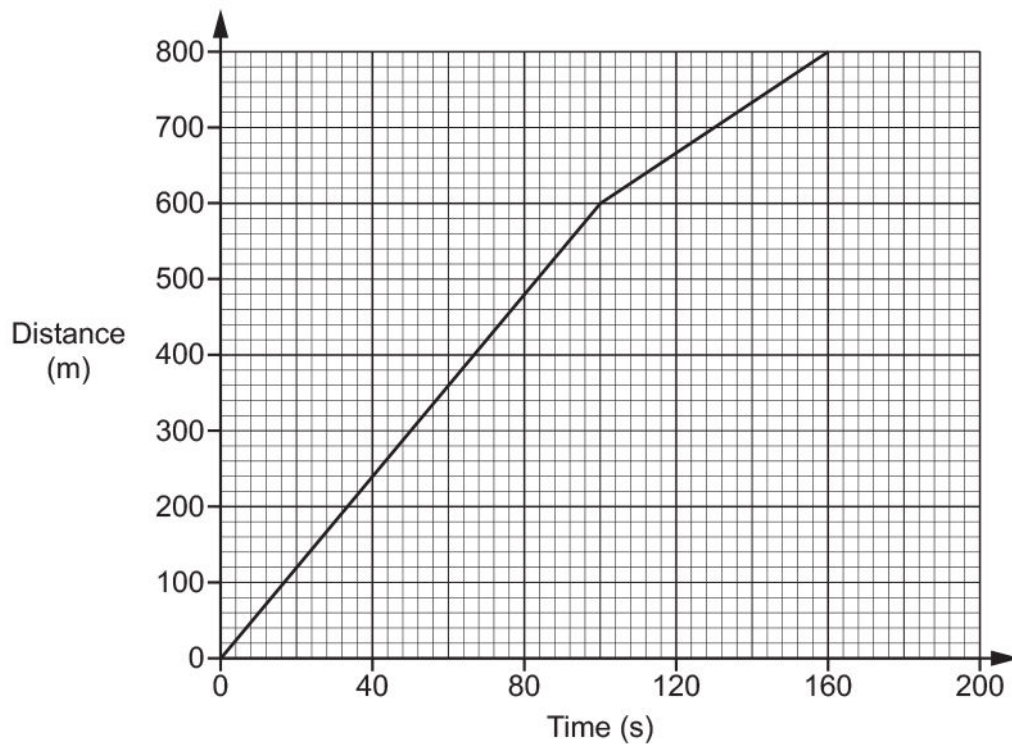
Acceleration = ... m / s^2 [5]

- (ii) The trolley has a mass of 2.0 kg .

Calculate the kinetic energy of the trolley at a speed of 3.0 m / s .

Kinetic energy = ... J [3]

49 Look at the distance-time graph for a journey to school.



What is the average speed for the journey?

Use the equation: average speed = distance travelled $\div$ time

A 0.2 m/s

B 5.0 m/s

C 6.0 m/s

D 50 m/s

Your answer

[1]

50 A car travels at 72 km / h.

How fast is this in metres per second (m / s)?

A 1.2 m/s

B 20 m/s

C 120 m/s

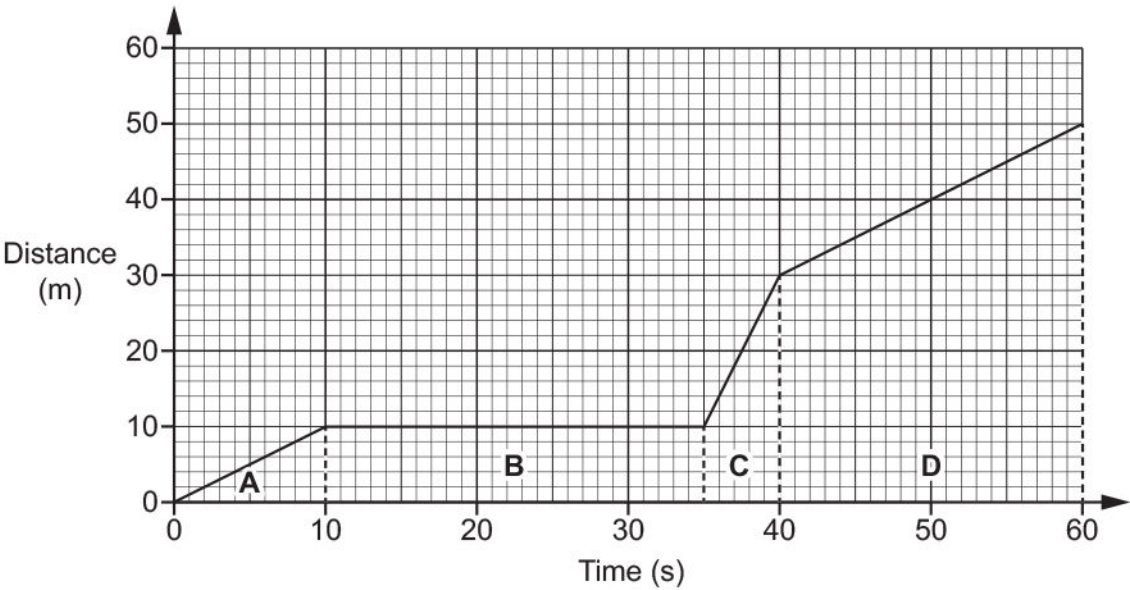
D 1200 m/s

Your answer

[1]

51(a) A student investigates motion graphs.

Look at a distance-time graph for the movement of a dog in a park.



(i) How far did the dog move in the park?

Distance = ... m [1]

(ii) How long was the dog in the park?

Time = ... s [1]

(iii) Name a piece of apparatus the student could use to accurately measure the distance the dog moved.

..... [1]

(b) The distance-time graph has four sections: A, B, C and D.

(i) Which section of the graph shows the **greatest** speed?

Tick (✓) **one** box.

A ☐

B ☐

C ☐

D ☐

Explain your answer.

[2]

(ii) Which section of the graph shows **zero** speed?

Tick (✓) **one** box.

A

☐

B

☐

C

☐

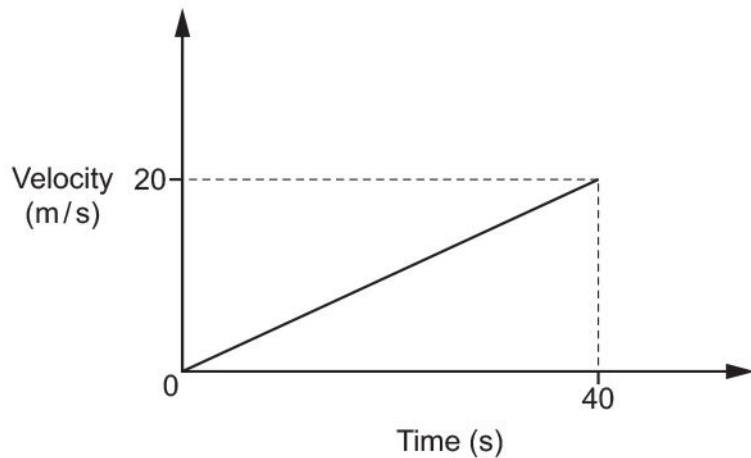
D

☐

Explain your answer.

[2]

(c) The student draws a velocity-time graph for a boat accelerating.



Acceleration is the gradient of a velocity-time graph.

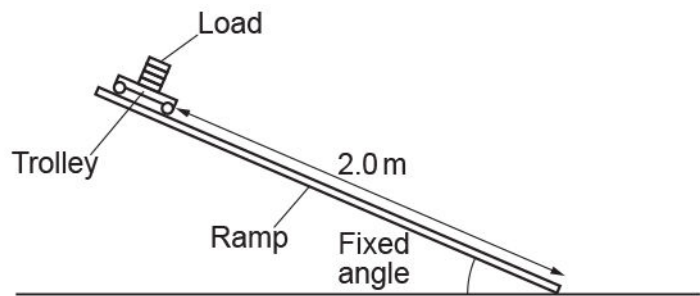
Calculate the acceleration of the boat.

Use the equation: acceleration = change in velocity ÷ time

Acceleration = ... m/s² [2]

52(a) A student investigates the average speed at which a trolley with different loads travels down a ramp.

Look at the diagram of her experiment.



She calculates the average speed. Look at her results.

Load (N)	Time taken (s)	Average speed (m / s)
20	2.3	0.87
40	2.4	0.83
60	2.3	0.87
80	2.4	0.83

[illegible]

[6]

(b) For one experiment the trolley starts from rest and reaches a final speed of 2 m / s.

The ramp length is 2.0 m.

Calculate the acceleration of the trolley.

Acceleration = ... m / s² [4]

53 A teacher measures the speed of water waves in a ripple tank.

What apparatus should she use?

A Ammeter and stopwatch

B Newton-meter and ruler

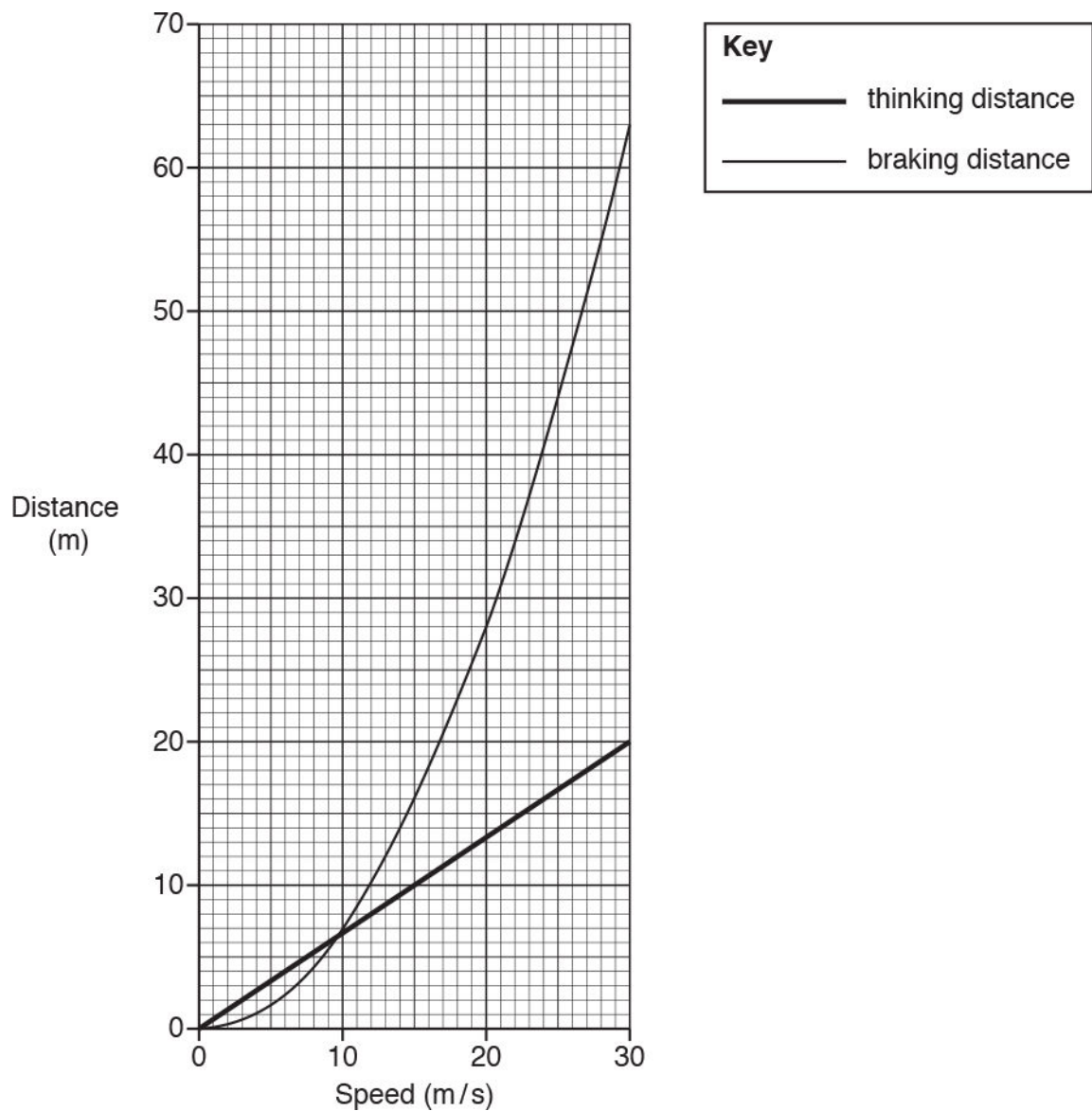
C Ruler and protractor

D Ruler and stopwatch

Your answer

[1]

54 The graph shows thinking and braking distances for a car at different speeds.



(i) State **one** factor that could **increase** thinking distance.

----- [1]

(ii) Calculate the **stopping distance** at 15 m / s.

Use the graph to help you.

Stopping distance = ... m [2]

55 The kinetic energy of motorbike X is 10 kJ.

Motorbike Y has the same speed but double the mass.

What is the kinetic energy of motorbike Y?

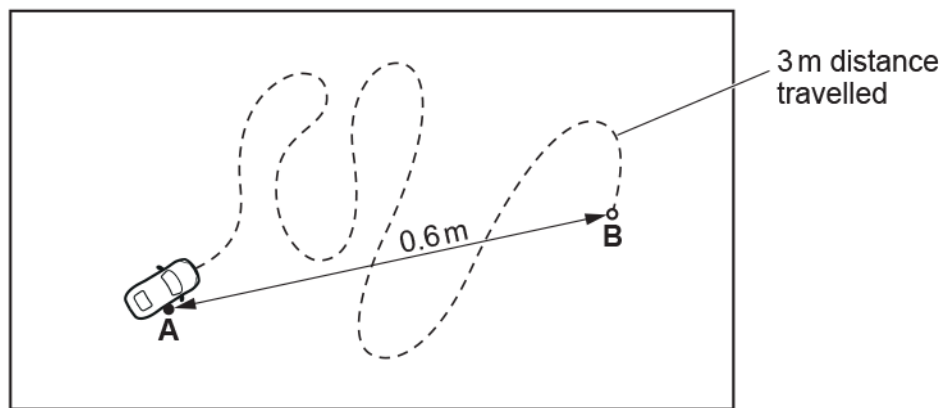
Use the equation: kinetic energy = $0.5 \times \text{mass} \times (\text{speed})^2$

- A 5 kJ
- B 10 kJ
- C 20 kJ
- D 40 kJ

Your answer

[1]

56 * A toy car moves randomly on a table.



It moves from position A to position B in 0.5 minutes, covering a distance of 3.0 m. The start and finish positions are 0.6 m apart.

Explain why the average speed and average velocity of the moving toy car are different from one another.

You should include calculations in your answer.

[6]

57 A boy of mass 70 kg stands on the end of a diving board.

The boy dives vertically into the swimming pool. The water in the pool is 3.2 m below the diving board.

Calculate the velocity of the boy when he enters the water.

Use an equation from the data sheet to help you.

Gravitational field strength on Earth = 10 N / kg .

Velocity = ... m / s [4]

58 A car has a mass of 1000 kg and is travelling at a speed of 20 m / s.

Calculate the kinetic energy of the car.

- A 10 000 J
- B 20 000 J
- C 200 000 J
- D 400 000 J

Your answer

[1]

59 A car travels at a speed of 70 mph (miles per hour).

1 mile is approximately 1600 metres.

Convert 70 mph into m / s (metres per second).

- A 2.6 m / s
- B 31 m / s
- C 112 m / s
- D 160 m / s

Your answer

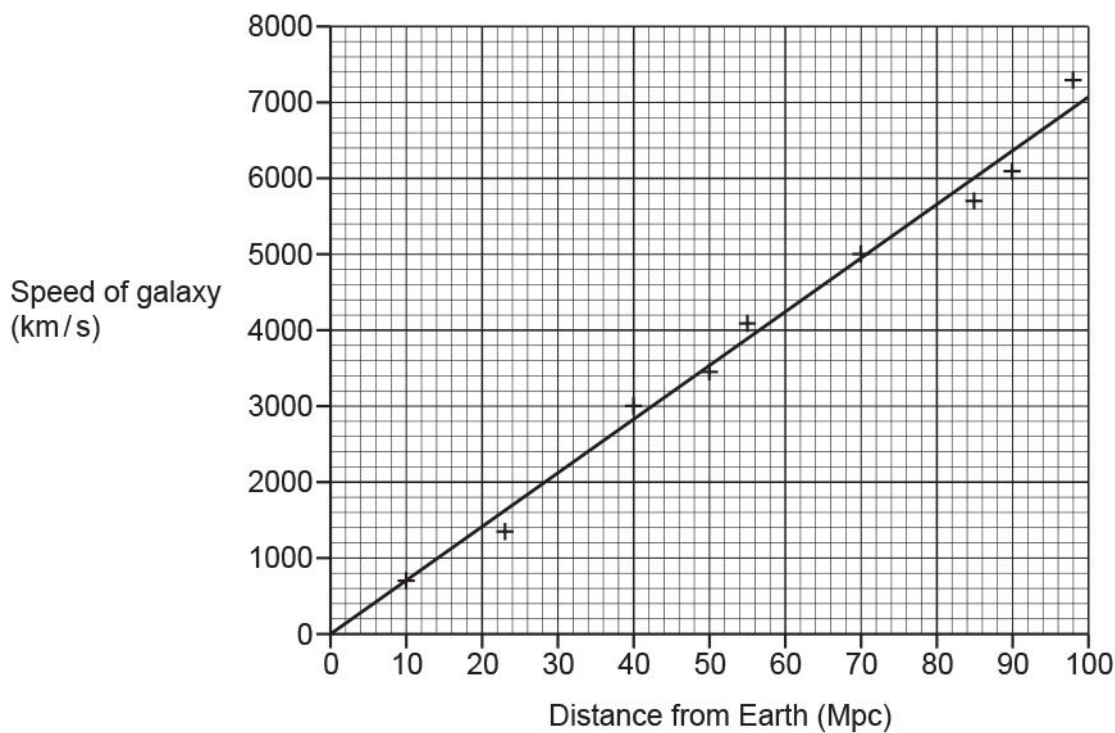
[1]

60(a) Edwin Hubble discovered that all distant galaxies were moving away from the Earth.

Explain how he could tell that all distant galaxies were moving away from the Earth.

[2]

(b) This graph shows how the speed of a galaxy changes with distance from the Earth.



(i) Use data from the graph to show that the speed of the galaxy is proportional to the distance from the Earth.

[2]

(ii) Explain how data from the graph provides evidence for the Big-Bang.

[1]

(c) Before Edwin Hubble could publish his results, his work was peer reviewed.

Suggest why peer review is important.

----- [1]

(d) The parsec (pc) is a unit used for measuring large distances in the Universe.

(i) A galaxy is at a distance of 82 Mpc from the Earth.

Use the graph to determine the speed of this galaxy.

Give your answer in metres per second (m / s).

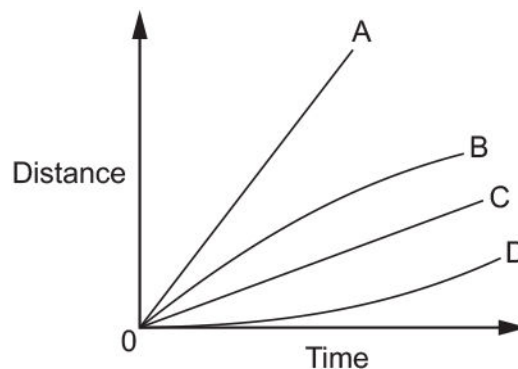
Speed = ... m / s [2]

(ii) Calculate the time it takes for the galaxy to travel 2.53×10^{24} m.

Use your answer to (i) to help you.

Time = ... s [3]

61 Look at the distance-time graph.



Which line shows the largest average speed?

Your answer

[1]

62 A cyclist travels 750 m in 50 seconds.

Calculate the speed of the cyclist.

Use the equation: speed = distance / time

A 0.015 m / s

B 15 m / s

C 37.5 m / s

D 375 m / s

Your answer

[1]

63 A girl runs twice around a 400 m circular track. What is the final displacement of the girl from her starting point?

A 0 m

B 200 m

C 400 m

D 800 m

Your answer

[1]

64 A toy car travels around a race track. After one lap it is back at the start position.

Explain why the velocity of the toy car is different from its speed as it travels around the track.

[2]

END OF QUESTION PAPER

Mark Scheme

Question	Answer/Indicative content	Marks	Guidance
1	[Level 3] Describes changes in KE over whole journey AND Correctly calculates KE at B Quality of written communication does not impede communication of the science at this level. (5–6 marks) [Level 2] Describes changes in KE over whole journey. OR Calculates KE of car at B Quality of written communication partly impedes communication of the science at this level. (3–4 marks) [Level 1] Realises that the KE depends on speed OR gives an indication of what is happening to KE over part of the journey. Quality of written communication impedes communication of the science at this level. (1–2 marks) [Level 0] Insufficient or irrelevant science. Answer not worthy of credit. (0 marks)	6	This question is targeted at grades up to C Indicative scientific points at levels 2 and 3 may include: • KE increases between A and B • KE decreases between B and C • KE increases between C and D • KE at B is greater than the KE at D • At B $KE = \frac{1}{2} \times 400 \times 8 \times 8$ • KE at B = 12800 J Indicative scientific points at level 1 may include: • KE increases as speed increases • KE increases between A and B • KE decreases between B and C • KE increases between C and D • KE greatest at B • KE zero at A • KE equation involving speed (correct or not) Use the L1, L2, L3 annotations in Scoris; do not use ticks. <u>Examiner's Comments</u> This was a six-mark question about a roller-coaster. A common mistake by candidates was to think that the graph showed a height distance graph. Examiners had taken care in setting the question to emphasize speed in the first sentence of the question. Weaker candidates managed level 1 by showing that kinetic energy depended on speed. The better candidates were able to calculate KE at B correctly and gained level 2. Only a few candidates answered the question in full by describing the change in KE throughout the full journey and calculating the KE at B.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
			Total	6	
2		i	B (1)	1	mark answer on line first allow answer ringed, underlined or ticked if no answer on the answer line <u>Examiner's Comments</u> Candidates correctly identified B as the part of the graph showing an increase in speed.
		ii	C (1)	1	mark answer on line first allow answer ringed, underlined or ticked if no answer on the answer line <u>Examiner's Comments</u> Candidates correctly identified C as the part of the graph showing constant speed.
			Total	2	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
3	a		any two from idea of two cameras used [1] cameras are set / known distance apart (1) time measured between two pictures / over fixed distance (1) $\text{speed} = \frac{(\text{fixed}) \text{ distance}}{\text{time}}$ (1)	2	Eg. Two photos taken [1] Eg distance between lines known [1] allow measure time between start and end of journey (1) <u>Examiner's Comments</u> Candidates were asked to explain how average speed cameras work. The majority of candidates explained how ordinary speed cameras work. The candidates were able to score marks because they were credited with statements such as 'two photos taken' and speed = distance travelled/time taken. Centres should ensure that candidates understand the difference between a momentary speed camera and an average speed one.
	b		32(m/s) (2) but If incorrect $\frac{800}{25}$ (1)	2	<u>Examiner's Comments</u> The majority of candidates correctly calculated speed of the car.
			Total	4	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
4	a		$2 \text{ (m/s}^2\text{)}$ [1]	1	NOT 2m/s Examiner's Comments This motion, acceleration and power question gave the opportunity for candidates to give some good answers. Most correctly calculated the acceleration from the graph.
	b		280000 (J) [3] but if incorrect 2800×100 [2] but if incorrect distance = 100(m) OR $2800 \times \text{distance}$ OR evidence of using work done = force x distance [1]	3	Eg 2800×200 or 560000 [1] Examiner's Comments This was generally poorly done as many did not obtain the correct distance from graph and simply read off a speed. Most candidates identified the correct formula (work done = force x distance) to use but were unable to calculate an appropriate distance to gain one mark for a reasonable substitution into the correct formula.
	c		56000 (W) [2] but if answer incorrect 2800×20 [1]	2	The power was correctly calculated by many.
			Total	6	

Mark Scheme

Question	Answer/Indicative content	Marks	Guidance
5	[Level 3] Answer describes correctly what happens in all 4 sections AND calculates / states one (average) speed from section A or B or C or over whole journey. Quality of written communication does not impede communication of the science at this level. (5 – 6 marks) [Level 2] Answer describes correctly what happens in all 4 sections OR describes correctly 2 sections and calculates / states one (average) speed from section A or B or C or over whole journey. Quality of written communication partly impedes communication of the science at this level. (3 – 4 marks) [Level 1] Answer describes correctly what happens in 2 sections / times OR calculates /states one (average) speed from any section or over whole journey. Quality of written communication impedes communication of the science at this level. (1 – 2 marks) [Level 0] Insufficient or irrelevant science. Answer not worthy of credit. (0 marks)	6	This question is targeted at grades up to A Section A • accelerates / speeding up • (average) speed = 10m/s Section B • constant speed / zero acceleration • (average) speed = 20m/s Section C • deceleration / negative acceleration / slowing down • (average) speed = 10m/s Section D • Stationary or (average) speed = 0m/s Whole journey (average) speed = 13.3m/s Use the L1, L2, L3 annotations when useful. Do not use ticks. Examiner's Comments This was a 6-mark level of response question using a distance – time graph. Many scored well but the quality of communication was often poor. Many were confused by the graph and often answers clearly showed that candidates were answering as if it was a velocity / time graph. Common was ‘accelerating at a steady speed’. For a simple graph, this was not answered as carefully as it should. Many candidates had the wrong descriptions for each section, or and a large number kept attempting to calculate the acceleration for each section. Basically greater initial thought from candidates about the axes would have clarified subsequent answers. This question however, was a very good discriminator at grade C and grade A. Good answers

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
					described A as accelerating, B as steady speed, C as decelerating and D as stationary. This alone gained level 2 with [4] marks. Often in addition, the average speeds for at least one of the sections was calculated correctly to gain all [6] marks. Even at this level there were some uncertainties in the communication such as 'part B – accelerating at a steady speed'.
			Total	6	

Mark Scheme

Question	Answer/Indicative content	Marks	Guidance
6	Level 3: (5 – 6 marks) Answer explains that there is no horizontal acceleration but there is vertical acceleration AND shows a successful calculation for the time taken. Quality of written communication does not impede communication of the science at this level. Level 2: (3 – 4 marks) Answer describes EITHER that there is no horizontal acceleration but there is vertical acceleration AND shows partial success at calculating the time taken OR gives the correct calculation. Quality of written communication partly impedes communication of the science at this level. Level 1: (1 – 2 marks) Answer describes EITHER that the path has vertical acceleration OR has no horizontal acceleration OR a simple attempt at a relevant calculation with numbers Quality of written communication impedes communication of the science at this level. Level 0: (0 marks) Insufficient or irrelevant science. Answer not worthy of credit.	6	This question is targeted up to grade A* Indicative scientific points may include: Level 3: - constant speed / no horizontal acceleration BUT there is vertical acceleration BECAUSE gravity acts vertically $t = 0.447 / 0.4 / 0.45 \text{ (s)}$ $t = ?0.2$ or $t = \frac{1}{\sqrt{5}}$ or $t = \frac{\sqrt{5}}{3}$ Level 2: - constant (horizontal) speed / no horizontal acceleration AND vertical acceleration / increasing speed $t^2 = 0.2$ $1 = \frac{1}{2} \times 10 \times t^2$ - appreciation that $u = 0$ - correct substitution into equation $s = ut + \frac{1}{2}at^2$ Level 1: - no horizontal acceleration / constant (horizontal) speed - vertical acceleration / increasing speed - quote an equation of motion with values. Use the L1, L2, L3 annotations if needed; do not use ticks. Examiner's Comments This 6-mark level of response question on projectiles was challenging for many as it was targeted at up to grade A*. It did discriminate clearly at these higher grades. Candidates were asked to explain the horizontal and vertical accelerations and do a calculation of time. Often candidates interchanged or confused speed or velocity with acceleration. They

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
					said constant horizontal acceleration when they perhaps really meant velocity. Vertical acceleration was more often given credit. Higher grade answers referred to the force of gravity. Some candidates did not appreciate that the vertical acceleration was constant. Many thought that acceleration increased (or did they mean speed increased) the nearer you got to the ground. Four marks for calculating t was the saving grace for a large number. (Calculations were generally good all through this paper). Weaker candidates on this challenging question went for speed = distance / time, often using the value of g as speed. About a fifth of candidates could explain it well enough with a correct calculation to get 5 or 6 marks.
			Total	6	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
7		i	speed is scalar / velocity is vector [1] or velocity gives direction / speed does not have direction / AW [1]	1	allow one is scalar and the other is vector [1] allow speed only has size / magnitude [1] Examiner's Comments This part of the question was common with the foundation paper (B752-01). It asked candidates to describe the difference between velocity and speed. Three quarters of candidates could correctly describe velocity as being a vector quantity or having direction [1]. Weaker answers thought that speed was on land and velocity was in water. Other confusions were about 'speed is speed but velocity has force too'.
		ii	Y [1] Maximum of one mark for the (idea that): - same direction so add velocities [1] - opposite direction so subtract velocities [1] - (resultant is) 6m/s [1]	2	more than one letter = 0 marks if V, W or X is chosen then [0] (see advice below) if no letter is chosen one mark is still available ----- In the unusual circumstances that a candidate misinterprets the information such that boat velocity is taken as the resultant velocity then award a maximum of [1] mark for W and X. Examiner's Comments This part of the question was also common with the foundation paper (B752-01). About two thirds of answers gained both marks for 'Y' and '6m/s'. X was often given incorrectly. Other answers were fewer and often missed the idea of the same direction (so velocities are added).

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
			Total	3	
8			7 (s) [2] but if answer is incorrect or incomplete then either $\frac{28}{4}$ or $\frac{28 \times 2}{2+6}$ [1]	2	allow correct substitution into an appropriate equation of motion eg. $28 = 4 \times t$ [1] Examiner's Comments About two thirds of candidates calculated this correctly to get 7 [2].
			Total	2	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
9	a	i	speed is scalar / velocity is vector [1] or velocity gives direction / speed does not have direction / AW [1]	1	allow one is scalar and the other is vector [1] allow speed only has size / magnitude [1] Examiner's Comments This question was describing and interpreting uniform motion in two different contexts Few candidates knew the difference between velocity and speed
		ii	Y [1] Maximum of one mark for the (idea that): - same direction so add velocities [1] - opposite direction so subtract velocities [1] - (resultant is) 6m/s [1]	2	more than one letter = 0 marks if V, W or X is chosen then [0] (see advice below) if no letter is chosen one mark is still available ----- In the unusual circumstances that a candidate misinterprets the information such that boat velocity is taken as the resultant velocity then award a maximum of [1] mark for W and X. Examiner's Comments This question was describing and interpreting uniform motion in two different contexts Unsurprisingly this question on interpreting the addition of velocities of a boat and river from the perspective of the bank proved to be challenge across the full range.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
	b		28 (m) scores [2] but if answer is incorrect or incomplete then either 4×7 or $\frac{8 \times 7}{2}$ or $\frac{2+6}{2} \times 7$ [1]	2	allow alternative approach using $s=ut + \frac{1}{2}at^2$ Examiner's Comments This question calculating distance travelled for an object increasing speed uniformly discriminated very well and higher ability candidates on the whole successfully chose used the equation accurately
			Total	5	
10			Nick [1]	1	Examiner's Comments Only about one third of the candidates identified Nick as having the greatest kinetic energy. There was evidence that candidates were in some way confusing this with potential energy and multiplied the person's height by their mass.
			Total	1	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
11			[Level 3] Describes the correct trend in speed AND acceleration using numerical figures from the graph. Quality of written communication does not impede communication of the science at this level. (5 – 6 marks) [Level 2] Describes the correct trend in speed using numerical figures from the graph. Quality of written communication partly impedes communication of the science at this level. (3 – 4 marks) [Level 1] Describes the correct trend in the speed. Quality of written communication impedes communication of the science at this level. (1 – 2 marks) [Level 0] Insufficient or irrelevant science. Answer not worthy of credit. (0 marks)	6	This question is targeted at grades up to C Indicative scientific points at level 3 may include: • acceleration for 10 seconds • steady speed / no change in acceleration for 60 seconds • deceleration for 10 seconds • acceleration is same as deceleration • acceleration = 1.5 m/s^2 allow higher level calculations of acceleration Indicative scientific points at level 2 may include: • speeds up (steadily) for 10 seconds • steady speed for 60 seconds • slows down (steadily) for 10 seconds Indicative scientific points at level 1 may include: • speeds up • steady speed • slows down Use the L1, L2, L3 annotations; do not use ticks. Examiner's Comments Most candidates were able to score marks on this question by giving a simple description in terms of speeding up and slowing down. More able candidates used the figures on the graph to give a more detailed description. The most able candidates calculated the acceleration and deceleration and some attempted to calculate the distance travelled and the average speed.
			Total	6	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
12	a		8.3 (m/s) [2] but if incorrect $\frac{100}{12} [1]$	2	allow 8.333 (m/s) [1] <u>Examiner's Comments</u> Most candidate calculated average speed correctly to two significant figures. Very few candidates did not follow the instruction and used more than two figures.
	b	i	2.5 [2] but if incorrect $\frac{10}{4} [1]$ m/s² [1]	3	allow m/s/s [1] <u>Examiner's Comments</u> Whilst the majority of candidates correctly calculated the acceleration as 2.5 few gave the correct units of ms⁻².
		ii	150 (N) [2] but if incorrect 60 x 2.5 [1]	2	allow ecf answer to b x 60 correctly calculated [2] allow ecf answer to b x 60 uncalculated [1] <u>Examiner's Comments</u> Candidates had no problem with calculating the force as 150N.
			Total	7	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
13	a		120 [2] But if answer is incorrect or incomplete: $\frac{13+27}{2} \times 6$ scores [1]	2	Examiner's Comments Few candidates could calculate average speed and therefore distance travelled. The majority simply multiplied one of the two given speeds by the time taken
	b		30 (m/s) and yes [2] But if answer is incorrect or incomplete up to 1 mark from: 30 OR $0 + 3 \times 10$ OR 3×10	2	allow higher level answers e.g. 'she has gone 3m/s over the speed limit'. [2] '3×10 and yes' [1] Examiner's Comments Many scored [2] on this calculation of final speed.
			Total	4	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
14	a		7 minutes scores [3] but if answer incorrect or incomplete then: $\frac{1,680,000 \times 2}{8,000}$ or 420 scores [2] but if no marks scored then: either use of correct average speed, 4000 or 210 or 3.5 minutes scores [1]	3	7 seconds scores [2] Ignore units <u>Examiner's Comments</u> This was a complex calculation involving a change of units. It discriminated well with high-grade candidates (about a fifth) giving 7 [3] as the answer. Two marks were awarded for 420 (failed to cover to minutes) or 3.5 minutes or 210s [1].
	b	i	lower speed (than 8000 m/s) then: –centripetal / gravitational force too high (to stay in this orbit) [1] –rocket may fall / move or spiral to Earth [1] higher speed (than 8000 m/s) then: –centripetal / gravitational force too low (to stay in this orbit) [1] –rocket may move away from Earth / spiral out of orbit [1] (idea of) higher stable orbits experience lower gravitational force or lower speed / ORA [1]	3	Eg. rocket may fall as centripetal / gravitational force is too big [2] Eg. rocket may move away as centripetal / gravitational force is too small [2] allow any idea that correct speed needed to allow correct angle of re-entry to avoid overheating [1] <u>Examiner's Comments</u> This was an intentionally challenging question, which required both confidence in the physics and some skill in its communication. Few referred correctly in terms of the forces. The idea that lower speeds would cause the satellite to spiral to Earth was reasonably common. Less common was the idea that at higher speeds the satellites would spiral into space.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		ii	(+/-) 4 (m/s²) scores [3] but if answer is incorrect then: (+/-) $\frac{(120^2 - 2000^2)}{2 \times 5 \times 10^5}$ [2] Or if no other marks scored then evidence of correct substitution into $v^2 = u^2 + 2as$ or evidence of rearranged formula: $\frac{v^2 - u^2}{2s}$ [1]	3	allow 3.99 / 3.9856 (m/s²) [3] <u>Examiner's Comments</u> The calculation of deceleration was challenging but it discriminated well with about a quarter gaining full marks.
			Total	9	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
15			(average speed) 3000 (m/s) (1) (distance travelled) 900000 (2) OR correct calculation of ecf average speed $\times$ 300 (2) BUT if distance answer incorrect 5 minutes converted to 300 seconds (1)	3	Allow $3000 \times 5 (= 15000)$ OR ecf average speed $\times 5$ (1) <u>Examiner's Comments</u> ??Most candidates were not able to work out the average speed when given the final speed of an object accelerating steadily from rest. Most scored one mark for calculating the distance travelled by multiplying average speed by the time in minutes and higher ability candidates scored two marks for doing the same calculation but correctly converting the time taken to seconds.
			Total	3	

Mark Scheme

Question	Answer/Indicative content	Marks	Guidance
16	[Level 3] Describes how KE changes in both sections AND describes how GPE changes in both sections AND calculates the maximum KE or difference in height. Quality of written communication does not impede communication of the science at this level. (5–6 marks) [Level 2] Describes how KE AND how GPE changes for both sections OR describes correctly how KE changes over both sections and calculates maximum KE OR describes correctly how GPE changes over both sections and calculates maximum KE OR calculates difference in height. Quality of written communication partly impedes communication of the science at this level. (3–4 marks) [Level 1] Realises that KE depends on speed and describes changes over part of journey OR describes how GPE changes over part of journey OR attempts to calculate maximum KE / height OR loss in KE = gain in PE (on either section) ORA Quality of written communication impedes communication of the science at this level. (1–2 marks) [Level 0] Insufficient or irrelevant science. Answer not worthy of credit. (0 marks)	6	This question is targeted at grades up to A* Ignore points after C Indicative scientific points at all levels may include: • KE increases from A to B • KE decreases from B to C • GPE decreases from A to B • GPE increases from B to C • loss in GPE = gain in KE • $KE = \frac{1}{2}mv^2$ • maximum KE = 51200J • $GPE = mgh$ • $51200 = mgh = 400 \times 10 \times h$ • height = 12.8m Use the L1, L2, L3 annotations in Scoris; do not use ticks. <u>Examiner's Comments</u> This six-mark level of response question proved to be the most challenging of the three on the paper. It did involve a data-handling element to the question. The graph, for many looked like a roller coaster track, so about a third of students described the motion along this track. A sizeable minority scored low marks for having the whole thing the wrong way round. Many thought that A to B was climbing and B to C was falling. The more able calculated the height correctly. Again this question discriminated well at the higher grades with approximately 10% scoring five or six marks. About 10% also failed to attempt this question at all.
	Total	6	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
17	a		9.8 (m) or $\frac{1}{2} \times 14 \times 1.4$ (2) but if incorrect allow attempt at calculating area under the graph (1)	2	E.g. shown on graph by shading / AW [1] If no other marks scored then allow 14×1.4 or 19.6 [1] Examiner's Comments This question was set in the context of diving into water from a diving board. Most answers showed the over-simplistic idea of distance = speed x time. So 19.6 gained one mark. Better candidates realising that the speed changed either worked out the area under the graph or used a calculation to get the correct answer of 9.8 [2]. Less than 20% gained both marks here showing that this calculation discriminated effectively at the highest grades.
	b	i	instantaneous deceleration at point P is (more representative of) when diver enters water [1] idea of ignoring anomalous results / point Q is not on the line / (1) Elaine's method covers more data / more appropriate data / AW [1] (gradient gives a more) accurate result (1)	2	allow Q is (some time) after diver enters water [1] allow deceleration / acceleration changes (after P) [1] eg point Q is anomalous [1] Examiner's Comments This question was set in the context of diving into water from a diving board. In part (i), there were a few good answers described in terms of Elaine and these discriminated well. Usually the idea of more data or gradient showing the real or more accurate deceleration gave candidates a route into successful answers. It was a challenging question, which gave a good range of responses.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		ii	1200 (N) (1)	1	Allow ? 1200 (N) [1] <u>Examiner's Comments</u> This question was set in the context of diving into water from a diving board. In part (ii), most gave 1200N as the correctly calculated answer.
			Total	5	
18		i	Golf (1)	1	
		ii	7.7 (s)(1) Skoda (because it takes less than 7.7 seconds) (1)	2	allow 7.69..... (1) allow 'Skoda' [1] (even if working incomplete or incorrect) <u>Examiner's Comments</u> The first question on section C module P1 was about speed and has 10 marks in total. Perhaps pre-conceived ideas tempted some to assume that the Jaguar was the fastest. About 40% said Jaguar and 60% the correct answer of Golf. It discriminated well for a one-mark question. Also rather more candidates thought that the times of 8s then 9s indicated an increase in speed rather than a decrease. This misconception was also evident in part (ii) where the speed was usually calculated correctly [1] by most with the Golf, Fiat and Jaguar incorrectly accused of speeding by many. The lowly but guilty Skoda often escaped identification and candidates gave away a mark as a result. This two-mark question also discriminated well.
			Total	3	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
19			Level 3: 5–6 marks Explains fully the changes in KE and GPE between A and B or B and C. Quality of written communication does not impede communication of science at this level. Level 2: 3–4 marks Gives a partial explanation of the changes in GPE and KE between A and B or B and C Quality of written communication partly impedes communication of science at this level. Level 1: 1–2 marks Simple statement about KE and GPE. Quality of written communication impedes the communication of science at this level Level 0: 0 marks Insufficient or irrelevant science. Not worthy of credit.	6	This question is targeted up to grade C Indicative scientific points may include (but are not limited to) the following: <u>KE Statements</u> at A kinetic energy is zero / a minimum at B kinetic energy is a maximum at C kinetic energy is zero / a minimum allow correct changes e.g. KE increases from zero to a maximum between A and B / decreases from maximum to zero between B and C <u>GPE Statements</u> (allow PE for GPE) at A gravitational potential energy is a maximum at B gravitational potential energy is a minimum / zero at C gravitational potential energy is a maximum allow correct changes e.g. GPE decreases from maximum to minimum between A and B / increases from minimum to maximum between B and C allow GPE for gravitational potential energy allow just potential energy for GPE as this is in the question allow KE for kinetic energy allow PE at C is less than PE at A simple statements include: car has KE at B Car has PE at A or C KE depends on speed PE depends on / increases with height
			Total	6	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
20	a		B and C (1)	1	Both required in either order for the mark
	b		D (1)	1	
	c		A (1)	1	
			Total	3	
21			20 or -20 (m/s) (2) if incorrect or incomplete then: $v = \sqrt{2gh}$ or 400 (1)	2	Allow answers using other valid equations of motion: Eg. $v^2 = u^2 + 2as$ $v = \sqrt{2as}$ (1)
			Total	2	
22	a		Direction is not important when measuring speed. ☒ Relative speed does not depend on the direction of movement. ☐ Speed and velocity are vector quantities. ☐ Speed is a scalar quantity. ☒ Velocity is always higher than speed. ☐ (2)	2	
	b		5 (m/s) (2) but if answer is incorrect or incomplete then 11 – 6 (1) or 11 – (0.6 × 10) (1) or 11 = u + (0.6 × 10) (1)	2	Ignore all units
			Total	4	

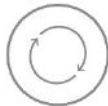
Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
23	a		vector has size and direction / scalar has size only / scalar has no direction / ORA (1)	1	Allow (difference is that) vector (also) has direction (1)
	b		5 (m / s) (2) but if answer is incorrect or incomplete then 11 – 6 (1) or 11 – (0.6 × 10) (1) or 11 = u + (0.6 × 10) (1)	2	
			Total	3	
24		i	2 (2) if incorrect allow 26/13 (1) m/s ² (1)	3	allow 2.0 mark units independently allow m/s/s or ms ⁻² (1)
		ii	any two from: avoid bias / AW (1) to allow (accurate) comparisons (1) level playing field (1)	2	Eg so that the manufacturer does not influence the outcome. Idea of reliable data Eg all manufacturers / tests are treated / performed in the same way. Idea of fair testing
			Total	5	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
25	a		kinetic energy / KE increases as speed increases (1) but kinetic energy / KE quadruples when speed doubles / AW (2)	2	
	b		mass (1)	1	ignore weight
	c		any three from: take 2 images (1) a set distance apart (1) measure the time between the images (1) calculate average speed using distance / time (1)	3	If not average speed camera max 2 marks.
			Total	6	
26			B ✓	1 (AO2.1)	<u>Examiner's Comments</u> This proved to be the easiest question in Section A, with about 85% of all candidates getting it right. The commonest wrong answer was D.
			Total	1	
27			D ✓	1 (AO1.2)	
			Total	1	
28			C ✓	1 (AO2.1)	
			Total	1	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
29			C ✓	1 (AO1.2)	Examiner's Comments Nearly half of the candidates did get the right answer. However most of the other candidates appeared to have been just guessed which response was correct.  AfL Standard form is tricky for Foundation Tier candidates. Try using low stakes pop quizzes and starter exercises to embed concepts of standard form and the metric prefixes. See also the Mathematical Skills Handbook http://www.ocr.org.uk/Images/310651-mathematicalskills-handbook.pdf
			Total	1	

Mark Scheme

Question	Answer/Indicative content	Marks	Guidance
30	Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question. Level 3 (5–6 marks) Detailed description and comparison of the motion of all four students in terms of distance and time relating speed to distance run AND Calculates the speed of all four students. <i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i> Level 2 (3–4 marks) Description and comparison of the motion of three students of distance and time OR Calculates the speed of at least three students. <i>There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.</i> Level 1 (1–2 marks) Brief description of the motion of at least three students. OR Calculates the speed of at least one student. <i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.</i> 0 marks <i>No response or no response worthy of credit.</i>	6 (AO2 × 1.1) (AO2 × 2.2) (AO1 × 3.1a) (AO1 × 3.2b)	AO1.1 Demonstrate knowledge and understanding of the correct formulae • speed = distance ÷ time • $v = s \div t$ • evidence of calculation AO2.2 Apply knowledge and understanding of the motion of the four students • Race B is a longer distance than race A • Race B and C are the same distance • Students B & C take different amounts of time • Student D takes the longest time • Race D is the longest distance • Race A is the shortest distance • Student A speed = $15 \div 6 = 8.3\text{m/s}$ • Student B speed = $100 \div 15 = 6.7\text{m/s}$ • Student C speed = $100 \div 14 = 7.1\text{m/s}$ • Student D speed = $200 \div 31 = 6.5\text{m/s}$ AO3.1a & AO3.2b Analyse information to interpret and draw conclusions about the motion of the four students • Race B is twice the length of race A, but time is more than twice that of race A • C is faster than B as the time is shorter (for the same distance) • As race length increases, average speed decreases <u>Examiner's Comments</u> There were many excellent answers, with the mean speeds of all four runners calculated with comments about how they had run different races (apart from B and C). Many candidates helped themselves by annotating the calculated speeds next to

Mark Scheme

Question	Answer/Indicative content	Marks	Guidance
			the table). The most able candidates discussed the effect of running a longer race on the mean speed of the runner (see Exemplar 7 below). Less able candidates compared the times of each runner but did not calculate speeds (see Exemplar 5 below).  OCR support About one in ten candidate did not attempt to answer this question. Level of Response (LoR) questions are designed to open up the potential answers so that candidates at all levels of ability have an opportunity to show their scientific understanding. Every candidate should be encouraged to answer LoR questions as even a weak but relevant answer will be credited. The 'How to answer 6 mark LoR questions' resource can be used to help candidates prepare for this style of question http://www.ocr.org.uk/Images/374902-how-to-answer-6-mark-lor-activity.doc Exemplar 5 Use the information in the table to describe and compare the motion of the four students. Use the data in your answer. The less motion the student had completed the race quicker as to student A the race distance is 50m then did the race in 6s and student D the race resistance was 20.0 and did the race in 31s. However student B and C race resistance was the same ^{15m} and student B did the race in 15s and C did the race in 14s. [6] A Level 1 candidate response. They describe the data in the table with no attempt to process data and calculate the speed of each runner. The information is relevant to the question but there is no real attempt to compare the motion of the four students.

Mark Scheme

Question	Answer/Indicative content	Marks	Guidance																				
			Exemplar 6 Use the information in the table to describe and compare the motion of the four students. Use the data in your answer. Student A raced 50 m in 6s which means they were racing at roughly 8.3 m/s. This shows that their motion of this student is very fast. Students B and C ran 100m. However, student B ran 100m in 15 seconds while student C ran 100m in 14 seconds. This shows that student B was a slower motion than student C. Student D races 200m in 31 seconds, which is around 6.5 m/s. This shows that the motion of student A is faster than the motion of student D. A Level 2 candidate response. They have calculated and compared the speeds of A and D, but only compared the relative motions of B and C. There is a structured line of reasoning and the reporting of data is linked by sentences that offer some interpretation of the facts. Exemplar 7 <table border="1"> <thead> <tr> <th>Student</th><th>Race distance (m)</th><th>Time (s)</th><th>Speed = $\frac{\text{distance}}{\text{time}}$</th></tr> </thead> <tbody> <tr> <td>A</td><td>50</td><td>6</td><td>8.3 m/s</td></tr> <tr> <td>B</td><td>100</td><td>15</td><td>6.6 m/s</td></tr> <tr> <td>C</td><td>100</td><td>14</td><td>7.1 m/s</td></tr> <tr> <td>D</td><td>200</td><td>31</td><td>6.5 m/s</td></tr> </tbody> </table> Use the information in the table to describe and compare the motion of the four students. Use the data in your answer. From looking at the table student A covered the smallest distance of 50m in the smallest time of 6s but at the greatest speed of 8.3 m/s. Students B and C both covered 100m during the race but student C was one second quicker than student B ($15 - 14 = 1\text{ s}$). Therefore student C had a greater speed of 7.1 m/s compared to student B at 6.6 m/s. Even though student D covered the largest overall distance of 200m they moved at the smallest speed of 6.5 m/s. This could be due to the fact student D took the largest amount of time of 31s. A Level 3 candidate response. They first calculated the speed of each student and then annotated the data table. This allowed them to be more focused and precise in their response. They have offered some explanation of the relative motions of the students. This answer is logical and all the content is relevant. The word counts for all	Student	Race distance (m)	Time (s)	Speed = $\frac{\text{distance}}{\text{time}}$	A	50	6	8.3 m/s	B	100	15	6.6 m/s	C	100	14	7.1 m/s	D	200	31	6.5 m/s
Student	Race distance (m)	Time (s)	Speed = $\frac{\text{distance}}{\text{time}}$																				
A	50	6	8.3 m/s																				
B	100	15	6.6 m/s																				
C	100	14	7.1 m/s																				
D	200	31	6.5 m/s																				

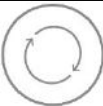
Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
					three exemplars are similar and demonstrating that a well thought out answer is better than a very long answer.
			Total	6	

Mark Scheme

Question	Answer/Indicative content	Marks	Guidance
31	i $F = ma$ / force equals mass times acceleration ✓ so reducing mass means the same engine force will cause greater acceleration ✓	2 (AO1.2) (AO2.2)	Must start with Newton II NOT less force for same acceleration Examiner's Comments Few candidates identified that this question was about the implications of the equation $F = ma$. Candidates did not recognise that the force would be the same for both the heavier and the lighter model of car. Most candidates discussed the effects of friction on the car. For the order of magnitude for changes in mass between different models of a car frictional forces would have no measurable effect on acceleration. Exemplar 12 (i) Explain why the presenter is correct. ...if the car is heavier the weight on the wheels ...can affect the acceleration if the mass is less ...there will be less weight on the wheels so the acceleration will be lower This answer only considers the marginal changes in friction caused by a very small increase in the contact area of the tyres but ignores the more significant effect that the same force applied to a smaller mass will have on acceleration. Exemplar 13 (i) Explain why the presenter is correct. As Force = mass x acceleration and Force is more so acceleration is greater. Mass is less so acceleration is greater. So the acceleration will be greater. This candidate's answer shows very clearly why using a more mathematical approach in physics saves time and increases understanding. They have identified the appropriate equation ($F=ma$), changed the subject to acceleration and then drawn the correct conclusion. Using this approach their answer was shorter, clearer and more relevant than exemplar 12. AfL

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
					 As a starter exercise show students the question and ask them to select the equation that will answer the question. Helping students to be more comfortable using equations will help them overcome their reluctance to answer physics questions using maths.
		ii	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 5 (m/s²) award 3 marks change in speed = $25 - 5 = 20$ (m/s) ✓ acceleration = $20 \div 4$ (m/s²) ✓ = 5 (m/s²) ✓	3 (AO2.1) (AO2.1) (AO2.1)	e.c.f. incorrect change in speed if subtraction attempted <u>Examiner's Comments</u> This calculation was well done with most candidates being credited with all three marks.
			Total	5	
32			C ✓	1 (AO2.2)	<u>Examiner's Comments</u> About half of the candidates could correctly calculate the distance travelled from the graph (by area or calculation) and gave C as the answer. Working out was often seen on this question and answer D was a frequently chosen distractor (velocity × time, $8 \times 5 = 40\text{m}$).
			Total	1	
33			D ✓	1 (AO2.1)	<u>Examiner's Comments</u> About 40% of candidates gave the correct answer D. A common incorrect response (the differences in speeds rather than velocities with direction) was 'A'.
			Total	1	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
34			B ✓	1 (AO2.1)	<u>Examiner's Comments</u> This was an intentionally challenging question AO2 question and about a quarter of candidates gave the correct answer B. A common incorrect response was 'D'.
			Total	1	
35		i	initial speed is zero and • either acceleration due to gravity = 10 • or $g = 10$ ✓ use $a = (v-u) \div t$ to find the final speed / v ✓ use $v^2 - u^2 = 2as$ to find s ✓	3 (AO 3 × 1.1)	IGNORE the idea of echoes and speed of sound ALLOW answers using $g = 9.8$ or 9.81 ALLOW $v = u + at$ ✓ ALLOW credit for higher level answers: Eg. three marks for answer in terms of $s = ut + \frac{1}{2}at^2$ <u>Examiner's Comments</u> This was an intentionally challenging question where less than 10% did not score at all. Most of these wrote about $g = 10$ and the initial velocity was 0 and gained 1 mark. Very few successfully continued further.
		ii	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 22 (m/s) award 2 marks $10 = v (-0) / 2.2$ OR uses idea that stone gains 10m/s each second ✓ $V = 22$ (m/s) ✓	2 (AO 2 × 2.1)	ALLOW 21.56 or 21.58 or 21.6 (if $g=9.8$ or 9.81) ✓✓ <u>Examiner's Comments</u> Again this challenging calculation saw about 1/5th gaining both marks with 22 (m/s). A few correctly used $g = 9.8$ or 9.81 and still scored full marks. Many used speed = distance ÷ time and did not score.
			Total	5	

Mark Scheme

Question	Answer/Indicative content	Marks	Guidance
36	(Idea of) action to produce sound and seen by observer / received by receiver ✓ Measure an appropriate distance eg between source and observer or between microphone(s) / speaker ✓ Measure an appropriate time eg between seeing action and hearing sound or on CRO / or frequency from signal generator ✓ (Idea of) calculating speed = distance / time or velocity = frequency x wavelength ✓ (Idea of) improvements to experiment eg repeat and average readings / retake readings if they are anomalous / use a different method / use different equipment / use longer distances ✓	5 (AO1.1) (AO2.2) (AO2.2) (AO3.2b) (AO3.3b)	ALLOW marks to be awarded from a clear diagram ALLOW higher level methods eg using standing waves ALLOW equation in any form <u>Examiner's Comments</u> This question assessed AO1, AO2 and AO3 and discriminated well between the lower and higher ability candidates. Many correct experiments were suggested, for example practical improvements to the ball being hit by a bat making use of echoes, microphones and oscilloscope, as well as less practical suggestions in a school setting involving the use of fireworks and explosions. Some candidates made vague references to 'using a computer' that could not be credited. Most candidates realised that it was necessary to measure a time, but did not clearly specify what time they should measure. Almost every candidate gained some credit, many for stating the correct equation to calculate speed or for the idea of taking multiple readings and then using the average value. Exemplar 2 Two students with a stop clock and measuring tape could stand to each other over a distance of around 200 metres (which they could measure and using a measuring tape). One student could then use some sort of body language (eg putting his thumb up) to show that he is going to start and to start the stop watch. As soon as the other student hears him he could stop the stopwatch. They could repeat this several times and swap roles to get more accurate results and decrease the chance of human error. They could then find an average time and do Distance ÷ time to find an average speed.

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Question			Answer/Indicative content	Marks	Guidance
					This candidate gained full credit. The response included: • a suitable experiment • an appropriate time and distance measured • an equation to calculate the speed • the improvement of repeating and averaging the readings in order to improve accuracy and reduce the effect of operator error on their observations.
			Total	5	

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Question			Answer/Indicative content	Marks	Guidance
37	a		E ✓ FIRST CHECK THE ANSWER ON THE ANSWER LINE If answer = 0.6 (s) award 2 marks $5 \div 8$ ✓ = 0.6 (s) ✓	3 (AO3.1a) (AO1.2) (AO2.2)	ALLOW 0.625 or 0.63 (s) <u>Examiner's Comments</u> Most candidates were able to identify that driver E had the quickest reaction time. Only the higher ability candidates were then able to correctly calculate the reaction time. Calculations were sometimes shown and a common error made by candidates when calculating the reaction time was to use (<i>thinking distance + braking distance</i>) $\div$ <i>speed</i>.
	b		Any two from: A, C or D ✓ Thinking distance / reaction time is proportional to speed / AW ✓	2 (AO3.2b) (AO3.2b)	ALLOW as speed doubles, thinking distance doubles / ratio of speed:distance or distance:speed is the same / both have reaction time of 0.75 (s) <u>Examiner's Comments</u> This question required candidates to identify two drivers from A, C and D and explain why their reaction times are the same. Over half of the candidates correctly identified two of the drivers. Most of these candidates proceeded to explain why, usually by calculating the reaction time of 0.75 s. A significant number of candidates did not gain any credit. A common error candidates made was to choose drivers A and E or B and D due to their braking distances being almost the same.
	c	i	AWARD ALL CANDIDATES 2 MARKS	2 (AO1 × 2.1) (AO1 × 1.2)	<u>Examiner's Comments</u> We have adjusted the mark scheme to allow for a typo within this question.

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Question			Answer/Indicative content	Marks	Guidance
		ii	KE transferred to thermal energy / heat in brakes / surroundings / AW ✓✓ OR (KE of car) is reduced / transferred ✓ Brakes gain / absorb thermal energy / heat ✓	2 (AO1.1) (AO1.2)	ALLOW surroundings gain thermal energy / heat dissipated to surroundings IGNORE just brakes get hot <u>Examiner's Comments</u> The majority of candidates knew that the kinetic energy store would decrease or be transferred and so were credited with one mark. Fewer candidates gained the second mark as although they referred to heat or thermal energy they did not specify that the energy was transferred to the brakes or surroundings (i.e. into a thermal energy store).
		iii	AWARD ALL CANDIDATES 3 MARKS	3 (AO2 × 2.1) (AO1.2)	
			Total	12	
38			C ✓	1 (AO 2.2)	<u>Examiner's Comments</u> Candidates were required to carry out a simple substitution into a given equation were generally answered well. The most common error was not squaring the speed and choosing distractor B.
			Total	1	

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Question			Answer/Indicative content	Marks	Guidance
39	a		Distance (between source and observer) ✓ Time (for sound to travel between source and observer) ✓	2 (AO 2 x 1.1)	Do not accept distance / time the ball travels Do not accept metres / seconds <u>Examiner's Comments</u> Some candidates wrote a list of quantities that could be measured with no description: speed, distance, time, frequency and wavelength. These candidates could not be credited with any marks as they had not answered the question. Candidates were expected to describe how the distance that the sound would travel and the time for the sound to travel were needed to calculate the speed. Many candidates ignored the context for the question and referred to measuring the distance the ball travels.
	b		Speed = distance ÷ time ✓	1 (AO 1.1)	ALLOW distance ÷ time <u>Examiner's Comments</u> This question was answered well by candidates. Some candidates quoted the wave equation which was not appropriate to the experiment. A significant number of candidates incorrectly gave the correct equation as <i>speed = distance × time</i> ..
	c		Takes several readings / take averages / increase distance ✓	1 (AO 3.3a)	ALLOW no wind IGNORE increase time <u>Examiner's Comments</u> Most candidates suggesting repeating the experiment and calculating an average. Some candidates suggested using different distances and then plotting a graph. Other candidates suggested increasing the distance to the observer.
			Total	4	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
40			FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 0.75 (s) award 3 marks Recall: (Reaction) time = (Thinking) distance ÷ Speed ✓ 6÷8 or 12÷16 or 24÷32 ✓ = 0.75 (s) ✓	3 (AO 1.2) (AO 2.1) (AO 2.1)	IGNORE correct substitutions if NOT rearranged Examiner's Comments 10% of candidates recalled the speed equation and rearrange it as <i>reaction time = thinking distance ÷ speed</i>. The majority of the candidates were unable to interpret the data from the table and very few realised that the reaction time depended on the thinking distance before calculating the answer.
			Total	3	
41			FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 12 (m/s) award 2 marks Rearrange formula - 4×3 ✓ 12 (m/s) ✓	2 (AO 2.1) (AO 2.1)	Examiner's Comments Higher ability candidates wrote out in a recognisable form that <i>change in velocity = acceleration × time = $3 \times 4 = 12$ (m/s)</i>. A common misconception was to divide the acceleration by time taken (i.e. $3 \times 4 = 0.75$). Candidates should be encouraged to put the numbers into the given equation which will help them to identify if they will need to rearrange the formula.
			Total	2	
42			C ✓	1 (AO 1.1)	Examiner's Comments This question assessed candidates' knowledge of how the force of gravity can change the velocity of a planet but its speed stays the same. Most candidates correctly chose option C.
			Total	1	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
43		i	16 (m) ✓	1 (AO 3.1a)	
		ii	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 0.67 (s) award 3 marks Rearrangement to give Time = distance / speed ✓ Time = 16 / 24 #x2713; Time = 0.67 (s) (2 decimal places) ✓	3 (AO 1.2) (AO 2.1) (AO 2.1)	ALLOW ECF from (b)(i) ALLOW 0.6 or 0.7 or 0.66(6...) (s) for 2 marks ALLOW one mark for any calculated answer to 2dp <u>Examiner's Comments</u> There were many excellent responses for this question with the majority of candidates gaining full credit. A few candidates could not rearrange the equation correctly and therefore did not score any marks. About one fifth of candidates did not give their answers to 2 decimal places as requested.  AfL A number of candidates gave two possible versions of rearranging the equation leading to two different answers. Candidates should be aware that marks cannot be awarded when they do this, even if one of the versions is correct. Exemplar 1 (ii) Calculate the thinking time at 24 m/s. Use your answer to (b)(i) and the equation: distance travelled = speed × time Give your answer to <u>2 decimal places</u>. $ \begin{aligned} \text{thinking time} &= \frac{\text{distance}}{\text{speed}} \\ &= \frac{16 \text{ m}}{24 \text{ m/s}} \\ &= 0.666... = 0.67 \\ \text{Thinking time} &= \dots\dots\dots 0.67 \text{ s [3]} \end{aligned} $ This is an excellent example of how the response should be set out. The candidate has clearly rearranged the equation, before substituting the correct values for distance and speed and writing down the answer. This would allow compensatory marks to be awarded if the candidate had then

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
					made an error such as mis-entered numbers into the calculator. Finally, the candidate has underlined the instruction to give their answer to 2 decimal places so that they do not forget to do this.
			Total	4	
44		i	Area (under line) for thinking (distance) is same as for braking (distance) / area under horizontal line = area under diagonal line / area of rectangle = area of triangle / AW ✓	1 (AO 3.1a)	ALLOW both areas show 4(m) <u>Examiner's Comments</u> This question was a good discriminator as only the more able candidates recognised that the braking distance and thinking distance could be calculated from the area under the graph and that both had the same value.
		ii	A line starting at (0.75, 8) ✓ Diagonal line drawn parallel to original line and finishing at the x axis ✓	2 (AO 2×1.2)	Mark independently
			Total	3	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
45		i	Mean = $(0.28 + 0.32) = 0.30$ (s) ✓	1 (AO 1.2)	ALLOW 0.3 (s) DO NOT ALLOW answers with all 3 readings used giving a mean of $(0.28+0.32+0.54) / 3 = 0.38$ (s) <u>Examiner's Comments</u>  AfL Candidates need to be aware that anomalous readings in a set of results, due to a mistake or lack of attention, are not included in calculations of the mean.

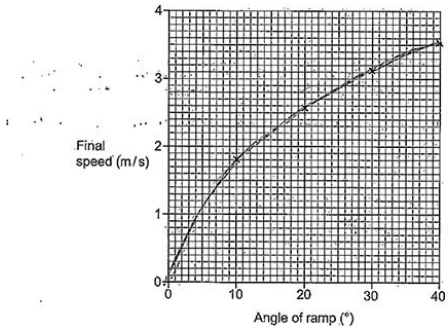
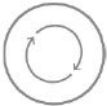
Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		ii	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 333 (m/s) award 4 marks Use of distance = 100 m ✓ Recall (s =) d / t ✓ 100 / 0.3 ✓ (s =) 333 (m/s) (3 sig. figs.)✓	4 (AO 2.1) (AO 1.2) (AO 2.1) (AO 2.1)	ALLOW ECF from 24(a)(i) ALLOW 100 ÷ 0.38 ✓✓✓ ALLOW 263 (m/s) ✓✓✓✓ ALLOW ECF for 3rd and 4th marking points if incorrect distance is used ALLOW 50 ÷ 0.3 or 166.7 ✓✓ ALLOW 50 ÷ 0.38 or 131.6 ✓✓ ALLOW 132 ✓✓✓ ALLOW 167 ✓✓✓ <u>Examiner's Comments</u> The majority of candidates could rearrange the equation provided, substitute values and give their answer to 3 significant figures. However, many candidates did not take into account that the sound travelled 100m to the wall and back again so used 50m in their calculations instead. AfL A number of candidates gave two possible versions of rearranging the equation leading to two different answers. Candidates should be aware that marks cannot be awarded when they do this, even if one of the versions is correct.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		iii	Any two from: Inconsistent results should be repeated ✓ More readings of time should be done and the mean calculated ✓ (Explanation of) clap-echo method ✓ Larger/different distances used ✓	2 (AO 2×3.3b)	Clap-echo method effectively may gain 2 marks as it also uses the idea of multiple readings. <u>Examiner's Comments</u> This Assessment Objective 3 question required candidates to analyse information in order to develop the experimental procedure of the students (in Question 24(a)). There is evidence that over half of the candidates did not read the question carefully as they suggested improvements relating to other methods such as videoing, using microphones etc. Many candidates suggested taking more readings but did not mention calculating the mean and therefore could not score the mark.
			Total	7	
46			B ✓	1 (AO2.1)	<u>Examiner's Comments</u> A very large number of candidates incorrectly chose A. Higher ability candidates worked out the area for each graph. Candidates should be encouraged to check each of the four responses.
			Total	1	
47			C ✓	1 (AO2.1)	<u>Examiner's Comments</u> This question was well answered. Candidates should be encouraged to consider each letter of the diagram, adding a small cross to the ones that are eliminated.
			Total	1	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
48	a	i	Both points correctly plotted ✓ Smooth curve correctly drawn ✓	2 (AO1.2)	ALLOW within ½ small square for plotting DO NOT ALLOW straight lines between data points IGNORE any line drawn for $<10^\circ$ <u>Examiner's Comments</u> Candidates needed to plot the last two data points before drawing the best fit line. Many candidates incorrectly drew a straight line through plots that appeared to lie on a curved trend. Other candidates did not draw smooth curves, or had many lines. Exemplar 5  This candidate has clearly indicated the correct positions of the two missing plots using two small crosses. The smooth line was not considered good enough in that there appeared to be more than one line in several places. This candidate has correctly assumed that the graph starts from the origin.  AfL Candidates should be encouraged to plot graphs using a sharp pencil. The points should be indicated with a small cross. It may help candidates to draw smooth curves by rotating the paper so that the

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
					curve can be drawn naturally with the arc of the candidates' arm. Candidates should be encouraged to check the plotting of their data points - particularly points which do not appear to fit a pattern. The line of best fit may not pass through every data point. There should be a balance of data points about the line of best fit.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		ii	Increase in angle of ramp increases speed (at bottom ramp) OR A✓ Increase is not linear/doubling angle does not double final speed / AW ✓ Reference to quantitative data for two calculations, for example, increase from 10° to 20° the speed increases by 0.76 whilst 20° to 30° the speed increases by 0.54 ✓	3 (AO3.1a) (AO3.1a) (AO3.1b)	IGNORE correlation ALLOW Not directly proportional / Not constant increase NOTE comparison of two increases required NOTE Speed increase from 0° to 10° is 1.81 and speed increase from 30° to 40° is 0.40 <u>Examiner's Comments</u> Most candidates correctly stated that the as the angle of the ramp increased the speed increased. It was essential that candidates included a comparison between the angle of the ramp and the speed. The next two marks were more challenging and required candidates to state that the angle of the ramp and the speed were not directly proportional or linear since there was not a constant increase in speed for the same increase in angle. Candidates were expected to demonstrate this by carrying out two calculations using data from the table or graph. AfL Understand how to test from a graph whether two quantities are directly proportional. 1 Take the quantity on the x-axis and double it and read off the y-axis values and see whether they double as well 2 See whether there is a straight line through the origin.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		iii	(Increase in angle) increases potential energy of the trolley/more work is done raising trolley to that point on the ramp ✓ This increases the / more kinetic energy at the bottom of the ramp ✓	2 (AO1.1 x2)	ALLOW more PE is transferred to KE <u>Examiner's Comments</u> Most candidates found this question challenging to gain two marks due to some vague answers relating to the transfer energy from the PE store to the KE store without specifically referring to the greater energy in the PE store being transferred so that there more energy in the KE store.
		iv	Attempt 1 at 30° (is only recorded to 1 decimal place)/ 3.1 ✓ Student should record data to a consistent number of decimal places or 2 dp / the reading should be recorded as 3.10 / AW ✓	2 (AO3.3a) (AO3.3b)	ALLOW only recorded to 2 significant figures ALLOW should be recorded to 3 significant figures NOT same accuracy <u>Examiner's Comments</u> Many candidates correctly identified that the first attempt (3.1) at an angle of 30° was only recorded to one decimal place. Most candidates then suggested that that the raw data should have been recorded to the same number of decimal places and the reading should have been recorded as 3.10. Some candidates referred to significant figures, which was allowed this year. Candidates need to understand that raw data should be recorded to the same number of decimal places while calculated data is recorded to a number of significant figures which is dependent on the number of significant figures in the raw data.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		v	Any two from: Reproducible means that the results can be reproduced by someone else ✓ Only one student has collected this data ✓ The experiment is repeatable (as the repeated readings are close together) ✓	2 (AO2.2 x2)	NOT experiment can be repeated <u>Examiner's Comments</u> Most candidates discussed apparatus details such as not indicating what sort of surface was used, etc. Few candidates realised that reproducible results would need to be reproduced by someone else. A few candidates did state that the experiment is repeatable since the repeated reading are close to each other. AfL Understand the terms used in the language of measurement. See the Glossary of terms on the OCR website at: https://www.ocr.org.uk/Images/467774-glossary-of-terms.doc
	b	i	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 6.16 (m/s²) award 5 marks $v^2 - u^2 = 2as$ (no mark – on formula sheet) $u = 0$ ✓ $a = v^2 \div 2s$ ✓ $a = 3.51^2 \div (2 \times 1.0)$ ✓ $a = 6.16005$ (m/s²) ✓ $a = 6.16$ (m/s²) (2 decimal places) ✓	5 (AO2.1) (AO1.2) (AO2.1) (AO2.1) (AO1.2)	NOTE must be rearranged ALLOW Any number which rounds to 6.16 ALLOW one mark for any calculated answer to 2dp <u>Examiner's Comments</u> About half the candidates gained full marks for this question. It was expected that candidates would

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
					select an appropriate equation from the data sheet, rearrange the equation and substitute in the numbers from the question before calculating the answer. It was expected that the initial speed of zero would be shown in any calculation. Many candidates who did not gain full marks attempted to gain the answer by using the definition of acceleration and the equation linking average speed with distance and time without realising the importance of the word "average". Candidates using this method often arrived with an incorrect answer of 12.32 m/s^2. Exemplar 6 $(final\ velocity)^2 - (initial\ velocity)^2 = 2 \times acceleration \times distance$ $acceleration = \frac{(final\ velocity)^2 - (initial\ velocity)^2}{2 \times distance}$ $= \frac{(3.5)^2 - (0)^2}{2 \times 1} = \frac{(3.5)^2}{2} = 6.16005$ Acceleration = 6.16 m/s² [5] This candidate has correctly selected the equation from data sheet. The candidate has then rearranged the equation before substituting in the values from the question. Helpfully the candidate has indicated that the initial velocity was zero. The candidate then correctly calculates the answer as 6.16005 before correctly rounding the answer to two decimal places.
		ii	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 9 (J) award 3 marks kinetic energy (J) = $0.5 \times \text{mass (kg)} \times (\text{speed (m/s)})^2$ / KE = $\frac{1}{2} mv^2$ / KE = $0.5mv^2$ ✓ KE = $0.5 \times 2.0 \times 3.0^2$ ✓ KE = 9 (J) ✓	3 (AO1.2) (AO2.1) (AO2.1)	Examiner's Comments Candidates who were able to recall the equation for kinetic energy scored well on this question. Candidates should be encouraged to show their working.
			Total	19	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
49			B ✓	1 (AO2.1)	
			Total	1	
50			B ✓	1 (AO1.2)	<u>Examiner's Comments</u> This involves two different unit conversions, km to m and h to s. Many successful candidates used the space to set out step-by-step intermediate calculations..
			Total	1	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
51	a	i	50 (m) ✓	1 (AO2.2)	<u>Examiner's Comments</u> 16(a) was a gentle introduction to the structured questions in Section B and almost all candidates were awarded all three marks.
		ii	60 (s) ✓	1 (AO2.2)	<u>Examiner's Comments</u> 16(a) was a gentle introduction to the structured questions in Section B and almost all candidates were awarded all three marks.
		iii	Any one from: Tape measure/ Measuring tape ✓ Trundle wheel ✓	1 (AO1.1)	ALLOW Metre ruler / metre stick / metre wheel / surveyors' wheel DO NOT ALLOW ruler ALLOW Fitbit/smartphone app <u>Examiner's Comments</u> 16(a) was a gentle introduction to the structured questions in Section B and almost all candidates were awarded all three marks.
	b	i	C ✓ It has the steepest line/gradient/slope / greatest change in distance per second / AW ✓	2 (AO 2.2) (AO 1.1)	ALLOW calculation of all 4 speeds NOT 'highest distance change in shortest amount of time' <u>Examiner's Comments</u> 16(b) provided the first questions where more than one mark was available, and this helped a number who could identify the important factor but had selected the wrong option A – D. In (i) a number calculated all four speeds (including 0) in order to identify C. Most candidates appreciated that it was the section with the highest gradient/steepness which they needed to identify.

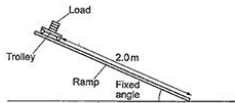
Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		ii	B ✓ The line is horizontal/flat /distance does not change/AW ✓	2 (AO 2.2) (AO 1.1)	<u>Examiner's Comments</u> 16(b) provided the first questions where more than one mark was available, and this helped a number who could identify the important factor but had selected the wrong option A – D. In (i) a number calculated all four speeds (including 0) in order to identify C. Most candidates appreciated that it was the section with the highest gradient/steepness which they needed to identify.
	c		FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 0.5 (m/s²) award 2 marks $v = 20 \div 40$ ✓ $v = 0.5$ (m/s²) ✓	2 (AO2.1) (AO2.1)	Mp2 dependent on correct substitution for mp1 <u>Examiner's Comments</u> The equation for acceleration was given and it required no rearrangement. Most candidates were credited with both marks here.
			Total	9	

Mark Scheme

Question		Answer/Indicative content	Marks	Guidance
52	a	Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question. Level 3 (5–6 marks) States that there is no clear trend. AND Detailed identification of at least two problems with the experiment with suggestions of detailed improvements. <i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i> Level 2 (3–4 marks) Recognises that the average speeds are similar. AND Identifies at least one problem with the experiment with a suggested improvement. <i>There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.</i> Level 1 (1–2 marks) Refers to data from the table. AND Suggests an improvement to the experiment or identifies one problem with the experiment. <i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.</i> 0 marks <i>No response or no response worthy of credit.</i>	6 (AO2×3.1 a) (AO2×3.2 a) (AO2×3.3 b)	AO3.1a Analyse information and ideas to describe trend in results For example: • No obvious/discernible trend • As loads increased time $\approx$ the same • As loads increased speeds $\approx$ the same • 20N and 60N mean speeds the same • 20N and 60N times the same • 40N and 80N mean speeds the same • 40N and 80N times the same AO3.2a Analyse information and ideas to make judgements and identify problems with the experiment For example: • Only 4 loads tested • Ramp distance too short • No repeated readings • Mass/weight of trolley ignored • Reaction times an issue for short times AO3.3b Analyse information and ideas to improve experimental procedures For example: • Test more loads • Include mass/weight of the trolley • Use a longer ramp • Have a smaller angle of ramp • Start higher up the ramp • Electronic timing method • Repeat readings and take a mean <u>Examiner's Comments</u> Because there was no systematic pattern in the data this was a demanding level of response question for a foundation tier candidates. Exemplar 5 is a candidate who scored Level 3, 6 marks for clearly identifying the absence of a trend and suggesting improvement to the experiment. Exemplar 6 is a Level 2 response, gaining 4 marks as the candidate has identified

Mark Scheme

Question	Answer/Indicative content	Marks	Guidance															
			that the times and speeds are essentially similar and suggested improvements to the procedure. Exemplar 7 is a Level 1 response. The candidate makes reference to the data and makes a suggestion for doing a better experiment. This was judged to fit the Level 1 criteria exactly and was given 2 marks. Exemplar 5 21 A student investigates the average speed at which a trolley with different loads travels down a ramp. Look at the diagram of her experiment.  She releases the trolley from a distance of 2.0m from the bottom of the ramp. The student uses a stop-clock to measure the time it takes to reach the bottom of the ramp. She calculates the average speed. Look at her results. <table border="1"><thead><tr><th>Load (N)</th><th>Time taken (s)</th><th>Average speed (m/s)</th></tr></thead><tbody><tr><td>20</td><td>2.3</td><td>0.87</td></tr><tr><td>40</td><td>2.4</td><td>0.83</td></tr><tr><td>60</td><td>2.3</td><td>0.87</td></tr><tr><td>80</td><td>2.4</td><td>0.83</td></tr></tbody></table> (a)* Describe the trend shown by the results, identify problems with the experiment and describe any improvements that you would make to the experiment. There is no clear trend. When the speed is higher it takes less time to cover the distance. The problem is that the ramp is too short so time is not allowed for it to accelerate meaning that all speeds are extremely similar and a correlation is not shown between the load and speed. To improve she could make the ramp longer she could experiment with different fixed angles in order to have a larger selection of results. If there was a bigger difference in the load, the time, it will be able to see a clear trend. They are all too close in time. [6] Exemplar 6 (a)* Describe the trend shown by the results, identify problems with the experiment and describe any improvements that you would make to the experiment. Firstly, the table shows a trend, that the time taken is a similar average speed. For example all the 2.3s have an average speed of 0.87m/s and 2.4s have an average speed of 0.83m/s. The student could lean something up against the ramp to make sure it stays in a fix angle. The student could also instead use a light gate and not a stop watch to reduce human error and blurring. [6]	Load (N)	Time taken (s)	Average speed (m/s)	20	2.3	0.87	40	2.4	0.83	60	2.3	0.87	80	2.4	0.83
Load (N)	Time taken (s)	Average speed (m/s)																
20	2.3	0.87																
40	2.4	0.83																
60	2.3	0.87																
80	2.4	0.83																

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
					Exemplar 7 (a)* Describe the trend shown by the results, identify problems with the experiment and describe any improvements that you would make to the experiment. • she could've done the experiment with the same load a few times to get a more accurate average speed • when the load was 40N and 80N it was slower than 20N and 60N but the average speed was ~~still~~ quicker.
	b		EITHER $v^2 - u^2 = 2as$ (no mark – on formula sheet) $u = 0$ ✓ $a = v^2 \div 2s$ ✓ $a = 2^2 \div (2 \times 2.0)$ ✓ $a = 1.0/1$ (m/s²) ✓ OR mean $v = \frac{1}{2} (0 + 2 \text{ m/s}) = 1 \text{ m/s}$ ✓ $t = s/\text{mean } v = 2 \text{ m} / 1 \text{ m/s} = 2 \text{ s}$ ✓ $a = \Delta v/t$ ✓ $= (2 \text{ m/s} - 0)/2 \text{ s} = 1 \text{ (m/s}^2\text{)} \checkmark$	4 (AO2.1) (AO2.1) (AO2.1) (AO2.1)	If no working shown and answer = 1 (m/s²), award all 4 marks. If wrong physics used, then award marks as appropriate for either approach. Examiner's Comments There were different possible approaches to the calculation: use of $v^2 = u^2 + 2as$ or finding the mean speed and hence t and using $a = (v-u)/t$. Both were seen. Many candidates just randomly multiplied or divided the numbers given, and two of these operations gave a response of 1 m/s². Where candidates used incorrect physics in their response (e.g. acceleration = speed/distance = 2/2 = 1) then they only gained marks for those parts of their workings that were appropriate. For fairness candidates who only wrote '1' on the answer line with no workings shown were given the benefit of the doubt and awarded all 4 marks.
			Total	10	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
53			D ✓	1 (AO1.2)	<u>Examiner's Comments</u> The majority of candidates correctly identified that a ruler and a stopwatch should be used to measure the speed of water waves. A common incorrect response was an ammeter and stopwatch.
			Total	1	
54		i	(Driver under influence of) alcohol / drugs / tired / (named) distraction / ill / <u>old</u> -age / intoxication / high(er) speed ✓	1 (AO 1.1)	IGNORE just age ALLOW increase in driver's reaction time <u>Examiner's Comments</u> Many candidates correctly answered this question. The common factors were alcohol, drugs and tiredness. Some candidates did not score the mark for factors related to braking distances. Other candidates did not give an appropriate direction for the change, e.g. 'speed' was not credited but 'increasing speed' was credited.
		ii	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 26 (m) award 2 marks (Stopping distance =) braking (distance) + thinking (distance) OR 16 OR 10 ✓ (sd =) 26 (m) ✓	2 (AO 2×2.2)	<u>Examiner's Comments</u> The majority of the candidates gained one mark for correctly reading off either the thinking distance or the braking distance. Many candidates did not read the question carefully to realise it was the stopping distance that was required. Higher ability candidates clearly showed both the values from the graph and the addition.
			Total	3	
55			C ✓	1 (AO2.1)	
			Total	1	

Mark Scheme

Question	Answer/Indicative content	Marks	Guidance
56	Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question. Level 3 (5–6 marks) Detailed explanation about why speed and velocity are different from each other AND Calculations of speed and velocity completed and are correct <i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i> Level 2 (3–4 marks) Detailed explanation about why speed and velocity are different from each other AND Calculation of speed OR velocity completed and is correct OR both equations stated/implied OR Explanation about why speed and velocity are different from each other AND Calculations of speed and velocity completed and are correct <i>There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.</i> Level 1 (1–2 marks) Explanation about why speed and velocity are different from each other. OR Calculation of speed or velocity completed and is correct OR Both equations stated/implied <i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.</i>	6 (AO1.1x4) (AO2.1x2)	AO1.1 Demonstrate knowledge and understanding of the difference between speed and velocity For example: • speed is a scalar • velocity is a vector • speed has magnitude only • velocity has magnitude and direction • speed depends on distance • velocity depends on displacement • speed is rate of change of distance • velocity is rate of change of displacement AO1.2 Recall of speed and velocity equations • speed = distance / time • velocity = displacement / time AO2.1 Apply knowledge and understanding of calculating speed and velocity For example: • speed = $3.0 / (0.5 \times 60)$ • speed = 0.10 (m/s) • velocity = $0.6 / (0.5 \times 60)$ • velocity = 0.02 (m/s)

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
			0 marks No response or no response worthy of credit.		
			Total	6	
57			FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 8 (m/s) award 4 marks $u = 0$ or $v^2 = (u^2 +) 2as$ ✓ $v^2 = 2 \times 10 \times 3.2$ or $v = \sqrt{2 \times 10 \times 3.2}$ ✓ $v^2 = 64$ ✓ $v = 8$ (m/s) ✓ OR alternative method: $mgh = \frac{1}{2} mv^2$ ✓ $(70 \times) 10 \times 3.2 = \frac{1}{2} (x 70) \times v^2$ ✓ $64 = v^2$ ✓ $v = 8$ (m/s) ✓	4 (AO1.2) (AO2.1) (AO2.1) (AO2.1)	$v^2 - u^2 = 2as$ does not score a mark
			Total	4	
58			C ✓	1 (AO2.1)	
			Total	1	
59			B ✓	1 (AO1.2)	
			Total	1	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
60	a		(All galaxies) showed <u>red-shift</u> ✓ (Hubble measured the) wavelength/frequency of <u>light</u> (from the galaxy) ✓	2 (AO2 × 1.1)	ALLOW (all galaxies) showed <u>light</u> with a longer wavelength/lower frequency for 2 marks
	b	i	Readings of speed taken for two different values of distance ✓ Working to show that the factor increase in speed is the same as distance ✓	2 (AO2 × 3.1a)	ALLOW +/- ½ a small square ALLOW a statement for the second mark e.g. as the distance doubles so does the speed. <u>Example:</u> At 20 Mpc, speed = 1400 km/s At 40 Mpc, speed = 2800 km/s $40/20 = 2 = 2800/1400$ ALLOW 1 mark maximum for it is a (straight) line of best fit through the origin (therefore it is proportional)
		ii	Any one from: The more distant galaxies are travelling faster ✓ The evidence suggests the universe is expanding ✓ The universe was smaller in the past ✓	1 (AO1.1)	ALLOW galaxies are moving away from each other
	c		To ensure results are reproducible / check the work is of high enough quality / claims are not false / for new theories to be accepted / to develop theories / AW ✓	1 (AO1.1)	ALLOW check validity / for mistakes/anomalies / AW ALLOW check that it's not biased / AW
	d	i	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 5 800 000 (m/s) award 2 marks (Reads off speed from graph =) 5800 (km/s) ✓ Speed = $5800 \times 1000 = 5\,800\,000$ (m/s) ✓	2 (AO2.2) (AO1.2)	ALLOW 5.8×10^6 (m/s) ALLOW ecf for their speed from graph x 1000

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		ii	FIRST CHECK THE ANSWER ON ANSWER LINE If answer = 4.36×10^{17} (s) award 3 marks time = distance / speed ✓ (time =) $2.53 \times 10^{24} / 5\,800\,000$ ✓ (time =) 4.36×10^{17} (s) ✓	3 (AO1.2) (AO2.1) (AO2.1)	ALLOW ecf from (i) ALLOW 4.4×10^{17} (s) ALLOW equation in any form
			Total	11	
61			A	1 (AO2.1)	
			Total	1	
62			B	1 (AO2.1)	
			Total	1	
63			A	1 (AO1.1)	
			Total	1	

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Question			Answer/Indicative content	Marks	Guidance
64			Any two from: Speed is a scalar ✓ Velocity is a vector ✓ Speed does not take direction into account / AW ✓ Velocity does take direction into account / AW ✓ Speed is calculated using distance ✓ Velocity is calculated using displacement ✓ Displacement depends on direction from start point / displacement takes into account direction ✓ Distance does not depend on direction from start point / distance does not take into account direction ✓	2 (AO1.1 x 2)	
			Total	2	