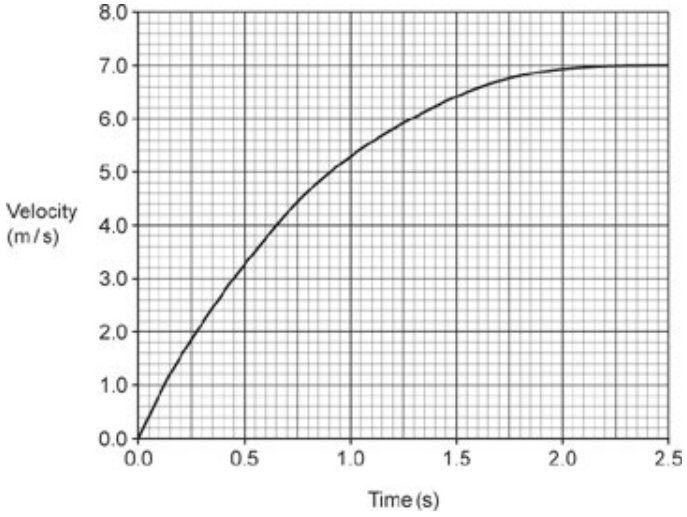
1(a). A badminton player investigates how the velocity of a shuttlecock varies as it falls vertically to the ground.

The player drops the shuttlecock and records the velocity of the shuttlecock as it falls.

The graph shows their results.



The gradient of a tangent drawn to the curved line of the graph gives the acceleration of the shuttlecock at that time.

Draw a tangent to the curved line at 1.0 s.

Use this tangent to find the acceleration of the shuttlecock at 1.0 s.

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

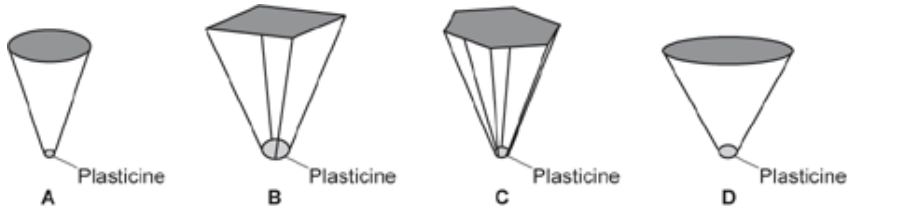
(b). Use the graph to find the approximate distance travelled by the shuttlecock during the 2.5 s of the experiment.

Distance = ... m **[3]**

2. A student investigates how the surface area of a parachute affects the time taken for the parachute to fall.

The student drops parachutes with different surface areas from a height of approximately 2 m and records the time taken to fall using a stopwatch.

The diagram shows the parachutes used by the student.



The table shows the data obtained from the experiment.

Parachute	Surface area of parachute (cm^2)	Time of fall (s)		
		Attempt 1	Attempt 2	Mean
A	10	0.84	1.04	0.94
B	15	1.02	1.18	1.1
C	20	1.09	1.11	1.1
D	30	1.2	1.3	1.25

Describe the trend shown in the student's results.

Explain how the experimental procedure could be improved.

[6]

3. A train accelerates from 20 m / s to 40 m / s in a distance of 1200 m.

What is the acceleration of the train?

Use the Equation Sheet

A 0.17 m / s^2
B 0.50 m / s^2
C 0.67 m / s^2
D 1.0 m / s^2

Your answer ☐ **[1]**

4(a). Fig. 22.1 shows a ray of red light from a laser entering a rectangular glass block from the air.

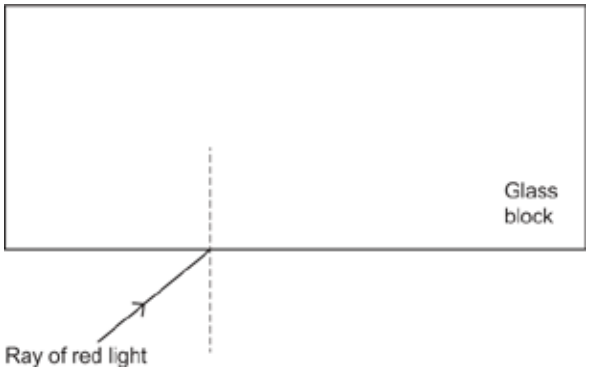


Fig. 22.1

When the red light enters the glass block from the air it will refract.

A student uses the red laser and glass block to investigate the relationship between the angle of incidence and angle of refraction for the glass.

The table shows the student's results.

Angle of incidence (°)	Angle of refraction (°)
22	14
34	22
48	30
55	33
62	36

i. Describe a method the student could have used to investigate this relationship.

You can draw on **Fig. 22.1** to help explain your answer.

[4]

ii. The student concludes that the angle of incidence is directly proportional to the angle of refraction.

Show that the student is **incorrect**.

Use data from the table.

[2]

(b). The student replaces the red laser with a **green** laser and repeats the experiment for the same angles of incidence.

The student notices that the angles of refraction for the green light are all different from the angles of refraction for the red light.

Explain why the angles of refraction are different when light of a different colour is used.

[2]

(c). The student replaces the glass block with a glass lens and directs both the red and green lasers into the lens at the same time as shown in **Fig. 22.2**.

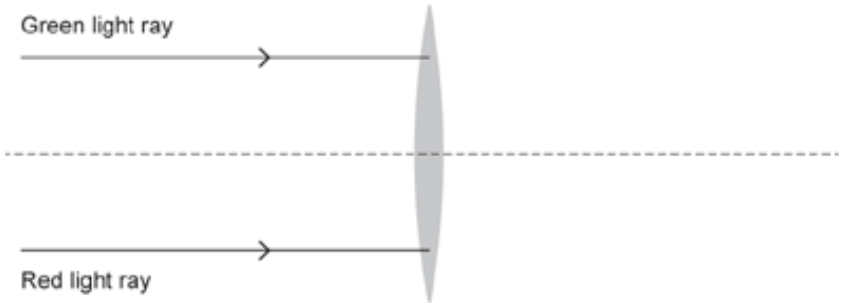


Fig. 22.2

Complete **Fig. 22.2** by continuing the paths of the red and green light rays.

[2]

5. Visible light and infrared radiation are transverse waves.

i. Describe the difference between visible light and infrared radiation using the words **frequency** and **wavelength**.

[2]

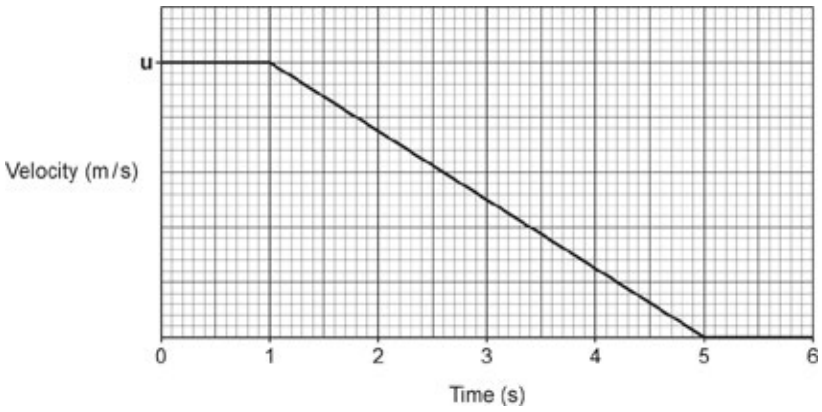
ii. Water waves are also transverse waves.

A scientist standing near the sea observes water waves moving past them.

Explain how the scientist can measure the **frequency** of the water waves.

[2]

6(a). The graph shows how the velocity of car **A** changes when the driver sees a hazard in the road at time = 0 seconds.



The braking distance is 30 m.

Calculate the initial velocity **u** of car **A**.

Use the graph.

Initial velocity **u** = ... m / s **[3]**

(b). A Car brakes and comes to a stop.

i. The deceleration of the car is 6 m/s^2.

The initial speed of the car is 18 m/s.

Calculate the braking distance of the car.

Use the Equation Sheet June 2024, J249-01-02-03-04

Braking distance = ... m **[3]**

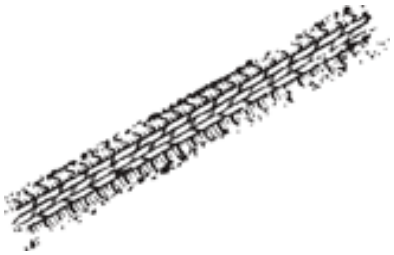
ii. Estimate the force acting on the car when it decelerates at 6 m/s^2.

Use the equation: force = mass × acceleration

For the mass in the equation, use an estimate of the mass of the car.

Force = ... N **[3]**

iii. The diagram shows a skid mark that the car's tyre makes on the road when the car brakes.



The length of the skid mark is 25 m.

Suggest **two** reasons why the braking distance and the length of the skid mark are **not** the same.

1 _____

_____

2 _____

[2]

7. The Earth orbits the Sun.

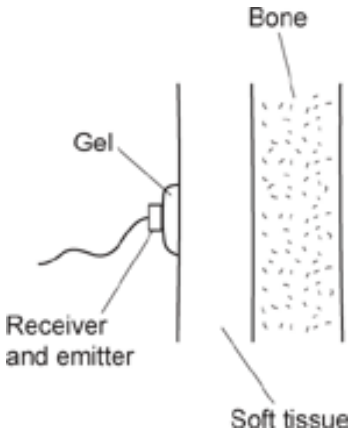
Which statement is correct?

Tick (✓) **one** box.

- The direction of the velocity of the Earth is towards the Sun. ☐
- The Earth is accelerating. ☐
- The Earth's velocity is the same as its speed. ☐
- The velocity of the Earth stays constant. ☐

[1]

8. The diagram shows a patient having an ultrasound scan.



The speed of ultrasound in soft tissue is 1500 m / s.

The echo from the boundary between the soft tissue and the bone is received 2.0×10^{-5} s after the ultrasound is emitted.

What is the thickness of the soft tissue?

Ignore the thickness of the gel.

Use the equation: distance travelled = speed × time

A 0.015 m
B 0.030 m
C 0.060 m
D 0.075 m

Your answer ☐ **[1]**

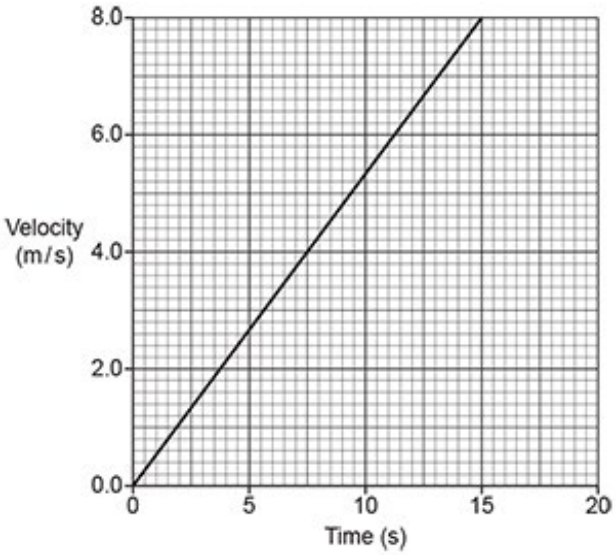
9. Which answer shows 800 km / h converted into m / s?

A 0.22 m / s
B 13.3 m / s
C 222 m / s
D 13 333 m / s

Your answer ☐ **[1]**

10. A scientist draws a velocity–time graph for an object.

What is the distance travelled by the object in 15 s?



A 0.53 m
B 1.9 m
C 60 m
D 120 m

Your answer ☐ **[1]**

11. Four athletes run a race in different times.

Athlete	Time taken (s)
1	21.5
2	21.6
3	
4	21.5
Mean	21.4

What is the time taken by athlete 3?

A 21.0 s
B 21.1 s
C 21.4 s
D 21.5 s

Your answer ☐ **[1]**

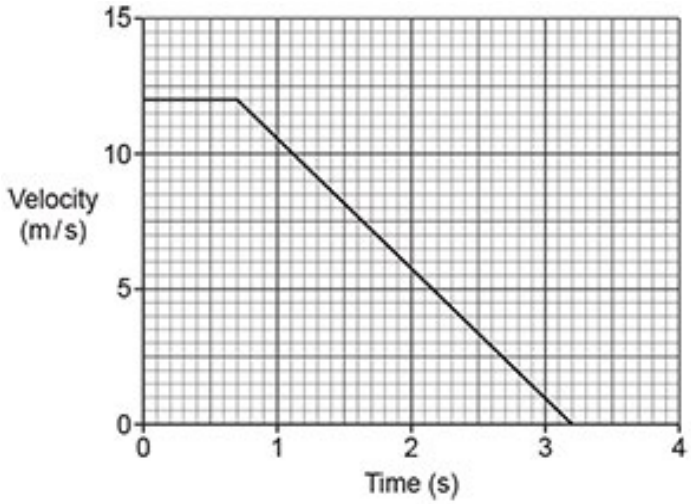
12. One mile is equal to 1609 metres.

How many miles are there in 5000 metres?

A 0.3218 miles
B 0.6782 miles
C 2.108 miles
D 3.108 miles

Your answer ☐ **[1]**

13. The velocity–time graph shows how the velocity of a car changes after the driver sees a hazard in the road.

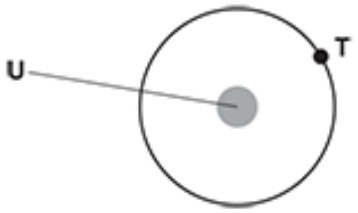


What is the braking distance of the car?

A 8.4 m
B 15.0 m
C 17.5 m
D 23.4 m

Your answer ☐ **[1]**

14. Object **T** moves at a constant speed in a circular orbit around object **U**.



Why does the velocity of **T** change?

A The force of gravity is at right angles to the velocity of **T**.
B The forces acting on **T** are balanced.
C The force of **U** on **T** equals the force of **T** on **U**.
D The forces acting on **U** are balanced.

Your answer ☐ **[1]**

15. A vehicle is travelling at 30 m / s.

The vehicle travels 75 m while decelerating to a stop.

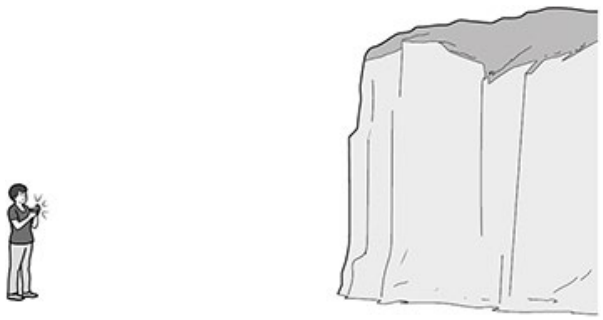
What is the deceleration of the vehicle?

Use the Equation Sheet June 23 J249-01-02-03-04.

A 2.5 m / s^2
B 6.0 m / s^2
C 12 m / s^2
D 24 m / s^2

Your answer ☐ **[1]**

16. A student is trying to calculate how far away they are from a large cliff.



The student claps loudly once.

After a short time, they hear a second clap. The second clap is quieter.

i. Explain why they hear the second clap **and** why the second clap is quieter.

[2]

ii. The student measures the time between the first clap and the second clap.

The time taken is 1.40 s.
The speed of sound in air is 330 m / s.

Calculate the distance from the student to the cliff.
Use the Data Sheet.

Distance = ... m **[4]**

iii. The student measures the time between the first and second clap with a stopwatch.

Suggest **two** reasons why the distance calculated in **(a)(ii)** is **not** accurate.

1

2

[2]

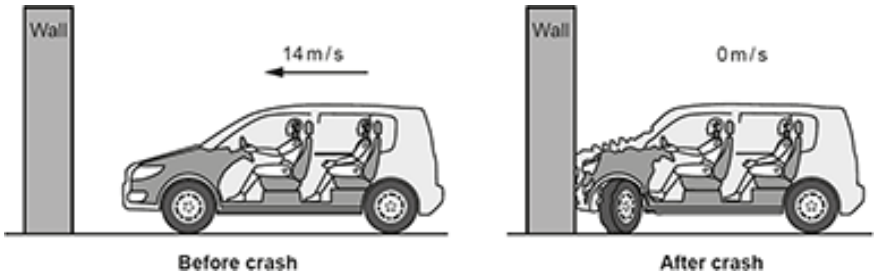
iv. Suggest how the experiment could be improved.

[1]

17. * A car manufacturer tests two different cars of the same length, car **A** and car **B**.

Each car is pulled along at 14 m / s and crashes into a wall.

The diagrams show car **A** before and after the crash.



Before crash After crash

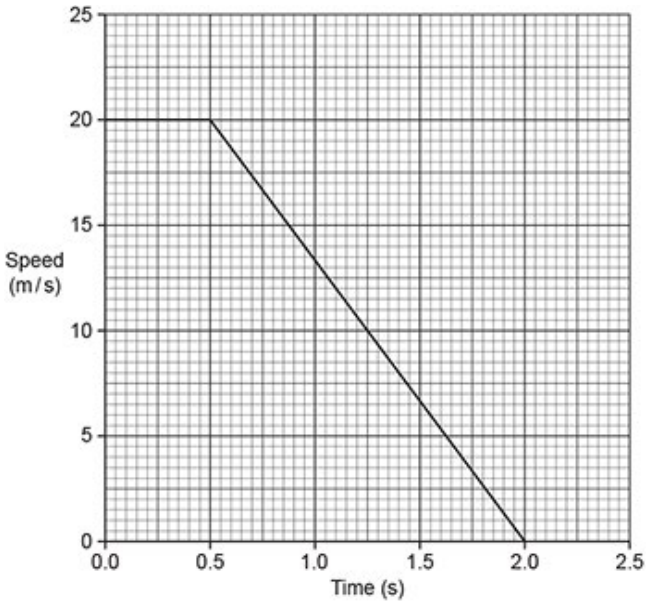
After hitting the wall, the rear wheel of car **A** takes **twice** the distance to stop compared to the rear wheel of car **B**.

Explain why car **A** is safer than car **B**.

In your answer, estimate the deceleration of car **A** during the crash.
Use the Data sheet_J249 01/02/03/04, June 2022.

[6]

18. The graph shows how the speed of a car varies with time.



At time = 0.0 s, the driver sees an obstruction in the road.
At time = 0.5 s, the driver presses the brakes.
At time = 2.0 s, the car stops.

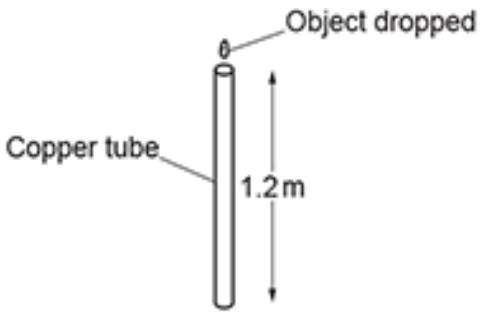
What is the thinking distance of this car?
Use the graph.

A 10 m
B 15 m
C 25 m
D 40 m

Your answer ☐ **[1]**

19(a). A student drops a piece of metal and a small magnet through a vertical copper tube. They record the time taken for each object to pass through the tube.

The diagram shows how they set up the experiment.



The student records their results in a table.

	Time taken to fall through the copper tube (s)					
	1	**2**	**3**	**4**	**5**	**Mean**
Magnet	1.13	1.11	1.12	1.11	1.13	
Metal	0.44	0.45	0.46	0.44	0.43	0.4444

i. Calculate the mean time that the magnet takes to pass through the copper tube.

[1]

ii. The student has made a mistake when recording their results in the table.

Identify the mistake and suggest a correction.

Mistake: _____

Correction: _____

[2]

iii. The student claims that their data shows that their experiment is reproducible.
Explain if the student is correct.

_____

[1]

iv. Why did the student repeat their experiment 5 times and calculate a mean?

_____

[1]

(b).

i. Calculate how many times longer it took the magnet to fall compared to the piece of metal.

Number of times longer: ..... **[1]**

ii. Calculate the mean speed of the metal through the copper tube.

Write your answer to **2** significant figures.

Use the equation: distance travelled = speed × time

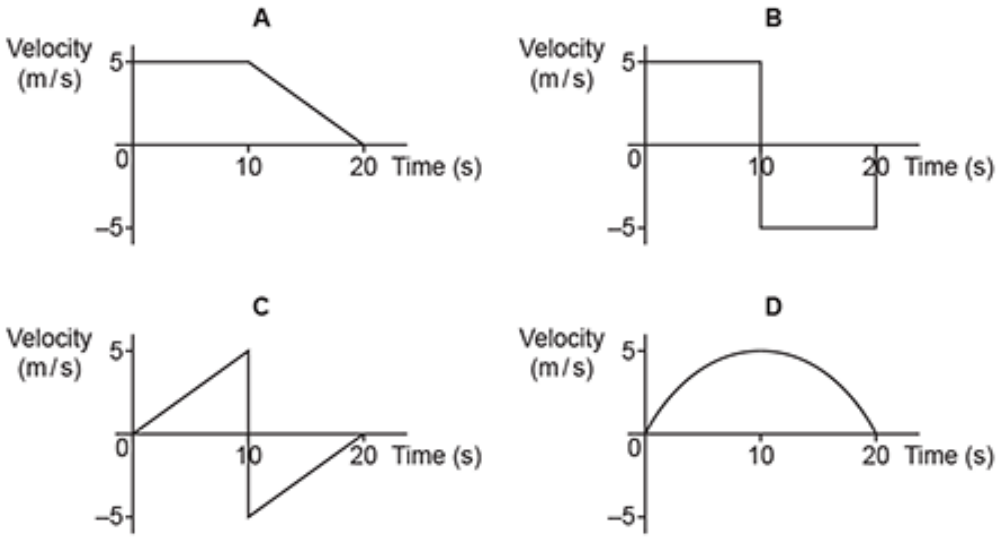
Mean speed = ... m / s **[4]**

(c). Explain why the magnet took longer to fall than the piece of metal.

Include ideas about electromagnetic induction in your answer.

[3]

20. Velocity-time graphs are drawn for four different objects.



Which object has the largest displacement?

Your answer ☐ **[1]**

21. There are 1609 m in a mile.
Which of these is approximately the same speed as 56 miles per hour?

A 25 m/s
B 29 m/s
C 52 m/s
D 90 m/s

Your answer ☐ **[1]**

END OF QUESTION PAPER