Wallace Hall Academy

Physics Department

Higher

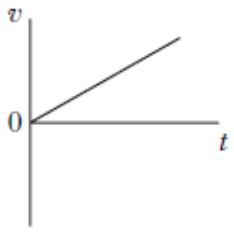
Our Dynamic Universe

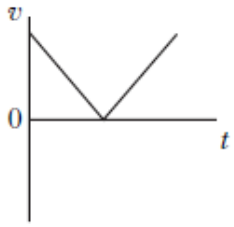
Homework

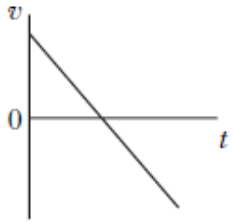
Exercise 1 - Scalar and Vector

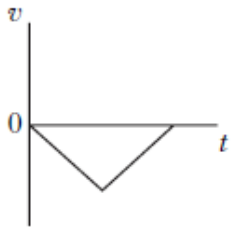
Past Paper Homework Questions

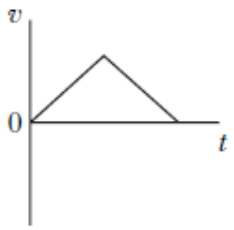
1. A ball is thrown vertically upwards and falls back to Earth. Neglecting air resistance, which velocity-time graph represents its motion?

A 

B 

C 

D 

E 

2. Which row shows both quantities classified correctly?

	Scalar	*Vector*
A	weight	force
B	force	mass
C	mass	distance
D	distance	momentum
E	momentum	time

3. Which of the following contains one scalar quantity and one vector quantity?

A acceleration; displacement

B kinetic energy; speed

C momentum; velocity

D potential energy; work

E power; weight

4. Acceleration is the change in

A distance per unit time

B displacement per unit time

C velocity per unit distance

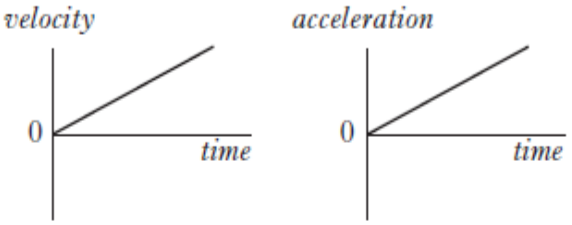
D speed per unit time

E velocity per unit time.

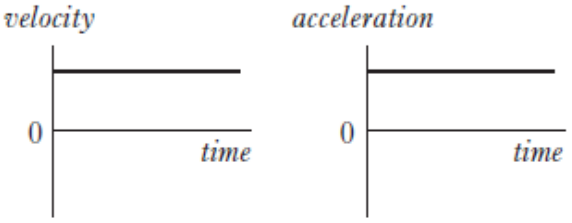
5. A vehicle is travelling in a straight line. Graphs of velocity and acceleration against time are shown.

Which pair of graphs could represent the motion of the vehicle?

A



B



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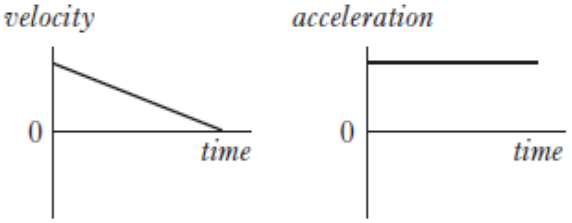
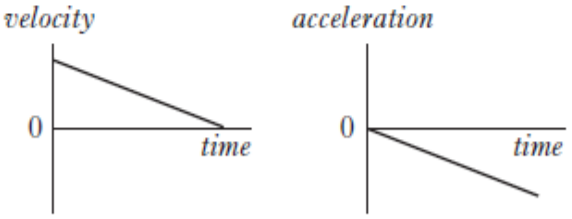
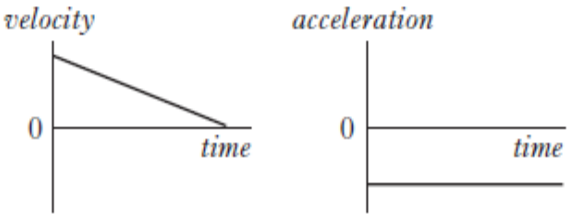


D

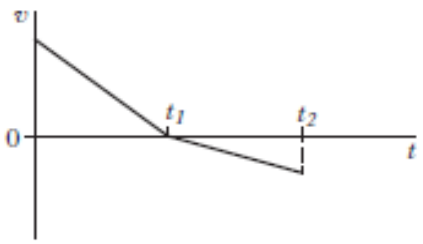


E



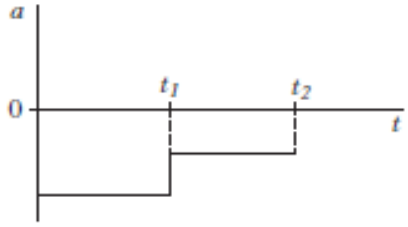
6. A trolley travels along a straight track.

The graph shows how the velocity v of the trolley varies with time t.



Which graph shows how the acceleration a of the trolley varies with time t?

A



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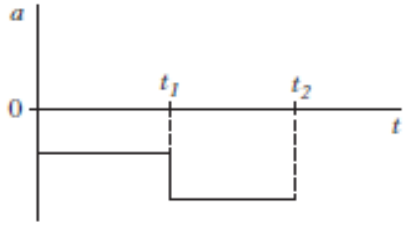

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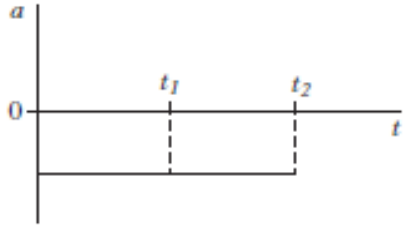

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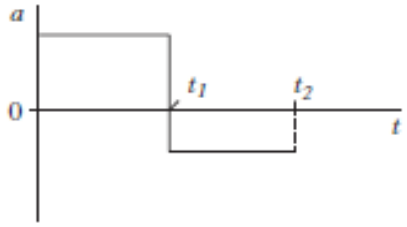

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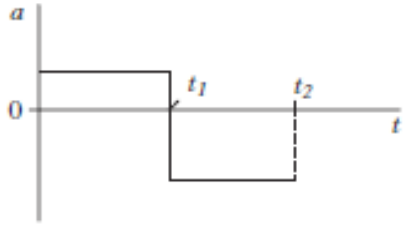


7. Which of the following is a vector quantity?

A distance

B time

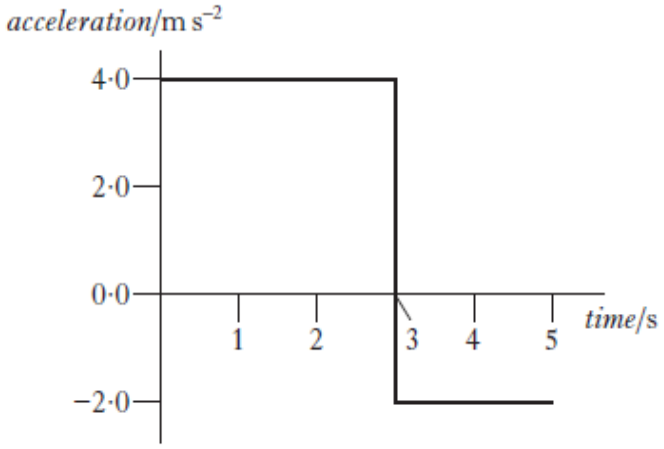
C speed

D energy

E weight

8. An object starts from rest and accelerates in a straight line.

The graph shows how the acceleration of the object varies with time.



The speed of the object at 5 seconds is

A $2\,m\,s^{-1}$

B $8\,m\,s^{-1}$

C $12\,m\,s^{-1}$

D $16\,m\,s^{-1}$

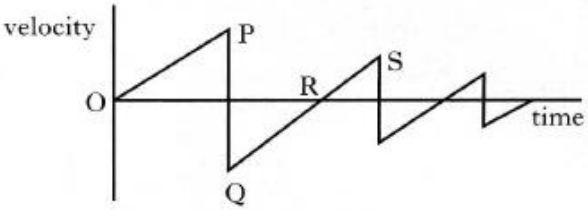
E $20\,m\,s^{-1}$.

9. A woman walks 12 km due North. She then turns round immediately and walks 4 km due South. The total journey takes 4 hours.

Which row in the following table gives the correct values for her average velocity and average speed?

	Average velocity	*Average speed*
A	4 km h^{-1} due N	4 km h^{-1}
B	4 km h^{-1} due N	2 km h^{-1}
C	3 km h^{-1} due N	4 km h^{-1}
D	2 km h^{-1} due N	4 km h^{-1}
E	2 km h^{-1} due N	3 km h^{-1}

10. The following velocity-time graph describes the motion of a ball, dropped from rest and bouncing several times.



Which of the following statements is/are true?

I The ball hits the ground at P.

II The ball is moving upwards between Q and R.

III The ball is moving upwards between R and S.

A I only

B II only

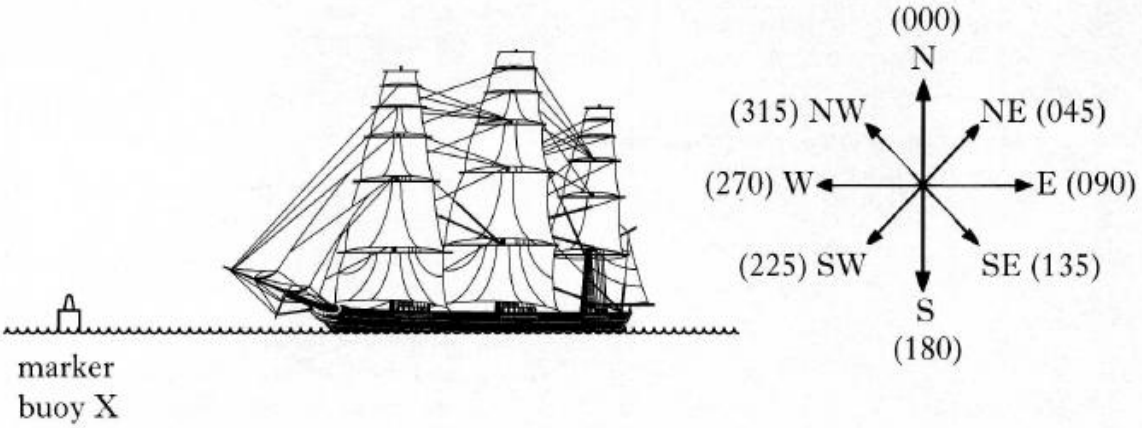
C III only

D I and II only

E I and III only

11. (*a*) State the difference between speed and velocity. **1**

(*b*) During a tall ships race, a ship called the Mir passes a marker buoy X and sails due West (270). It sails on this course for 30 minutes at a speed of $10{\cdot}0\,\text{km}\,\text{h}^{-1}$, then changes course to 20° West of North (340). The Mir continues on this new course for 1½ hours at a speed of $8{\cdot}0\,\text{km}\,\text{h}^{-1}$ until it passes marker buoy Y.



(i) Show that the Mir travels a total distance of 17 km between marker buoys X and Y.

(ii) By scale drawing or otherwise, find the displacement from marker buoy X to marker buoy Y.

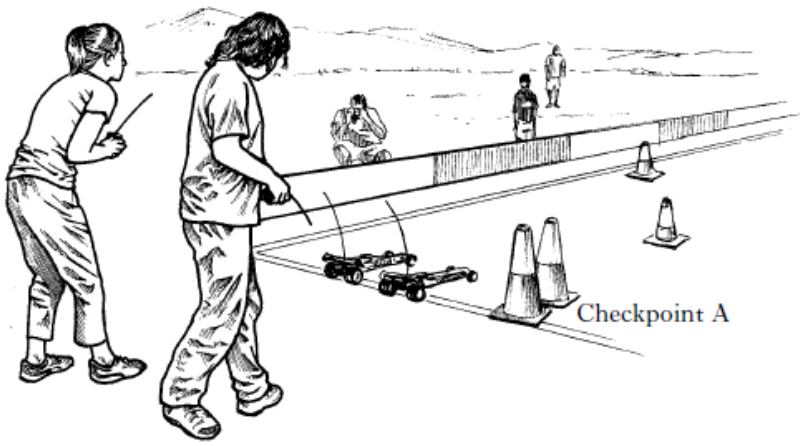
(iii) Calculate the average velocity, in $\text{km}\,\text{h}^{-1}$, of the Mir between marker buoys X and Y. **6**

(*c*) A second ship, the Leeuvin, passes marker buoy X 15 minutes after the Mir and sails directly for marker buoy Y at a speed of $7{\cdot}5\,\text{km}\,\text{h}^{-1}$.

Show by calculation which ship first passes marker buoy Y. **2**

(9)

12. Competitors are racing remote control cars. The cars have to be driven over a precise route between checkpoints.



Each car is to travel from checkpoint A to checkpoint B by following these instructions.

"Drive 150 m due North, then drive 250 m on a bearing of 60° East of North (060)."

Car X takes 1 minute 6 seconds to follow these instructions exactly.

(*a*) By scale drawing or otherwise, find the displacement of checkpoint B from checkpoint A. **2**

(*b*) Calculate the average velocity of car X from checkpoint A to checkpoint B. **2**

(*c*) Car Y leaves A at the same time as car X.

Car Y follows exactly the same route at an average speed of $6{\cdot}5\ \text{m s}^{-1}$.

Which car arrives first at checkpoint B?

Justify your answer with a calculation. **2**

(*d*) State the displacement of checkpoint A from checkpoint B. **1**

(7)

13. A helicopter is flying at a constant height above the ground. The helicopter is carrying a crate suspended from a cable as shown.

(*a*) The helicopter flies 20 km on a bearing of 180 (due South). It then turns on to a bearing of 140 (50° South of East) and travels a further 30 km.

The helicopter takes 15 minutes to travel the 50 km.

(i) By scale drawing (or otherwise) find the resultant displacement of the helicopter. **2**

(ii) Calculate the average velocity of the helicopter during the 15 minutes. **2**

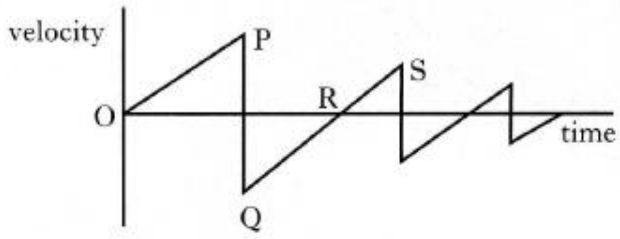
(4)

30 marks

Exercise 2 - Equations of Motion

Past paper Homework Questions

1. The following velocity-time graph describes the motion of a ball, dropped from rest and bouncing several times.



Which of the following statements is/are true?

I The ball hits the ground at P.

II The ball is moving upwards between Q and R.

III The ball is moving upwards between R and S.

A I only

B II only

C III only

D I and II only

E I and III only

2. A helicopter is **descending** vertically at a constant speed of $3{\cdot}0\,\text{m}\,\text{s}^{-1}$. A sandbag is released from the helicopter. The sandbag hits the ground 5·0 s later.

What was the height of the helicopter above the ground at the time the sandbag was released?

A 15·0 m

B 49·0 m

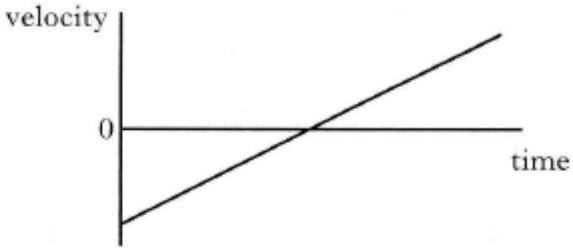
C 107·5 m

D 122·5 m

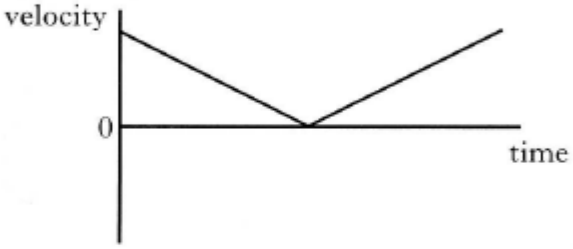
E 137·5 m

3. Which of the following velocity-time graphs best describes a ball being thrown vertically into the air and returning to the thrower's hand?

A



B



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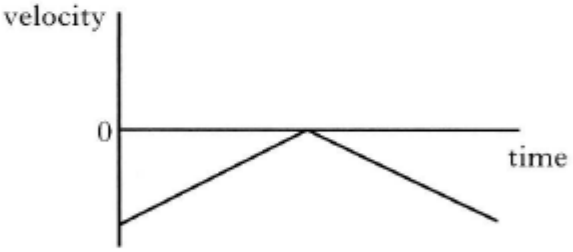

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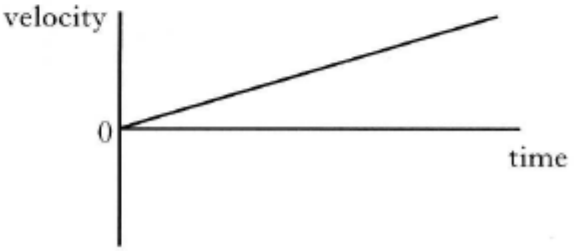
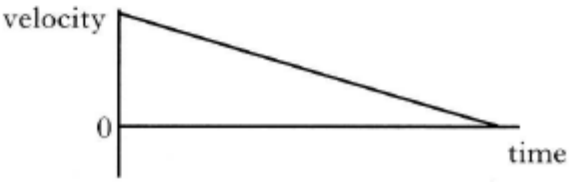
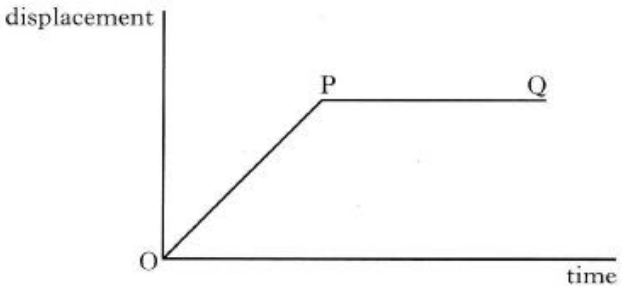


E



4. The following graph shows how the displacement of an object varies with time.

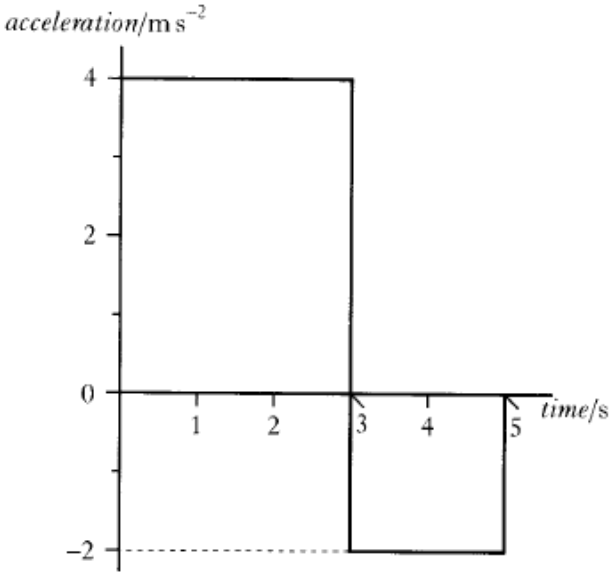


Which row of the table below best describes the motion of this object?

	From O to P	*From P to Q*
A	constant acceleration	constant velocity
B	zero velocity	constant deceleration
C	constant velocity	zero velocity
D	zero velocity	constant velocity
E	constant velocity	constant deceleration

5. An object starts from rest and accelerates in a straight line.

The graph shows how the acceleration of the object varies with time.



The object's speed at 5 seconds is

A 2 m s^{-1}

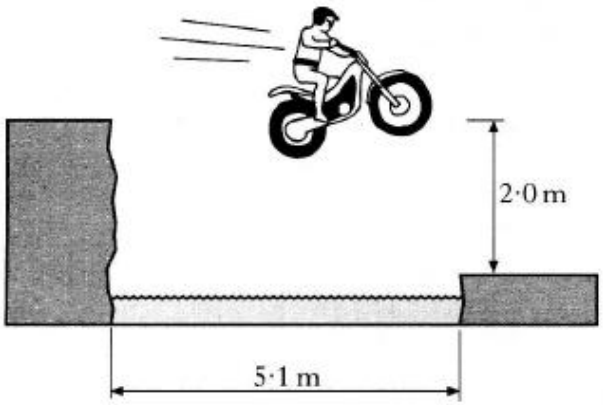
B 8 m s^{-1}

C 12 m s^{-1}

D 16 m s^{-1}

E 20 m s^{-1}.

6. A stuntman on a motorcycle jumps a river which is 5·1 m wide. He lands on the edge of the far bank, which is 2·0 m lower than the bank from which he takes off.



His minimum horizontal speed at take off is

A 2·0 m s^{-1}

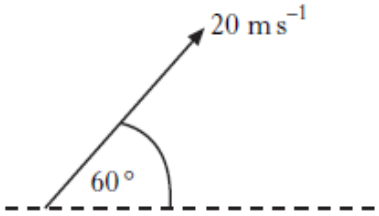
B 3·2 m s^{-1}

C 5·5 m s^{-1}

D 8·0 m s^{-1}

E 9·8 m s^{-1}.

7. A javelin is thrown at 60° to the horizontal with a speed of 20 m s^{-1}.



The javelin is in flight for 3·5 s.
Air resistance is negligible.
The horizontal distance the javelin travels is

A 35·0 m

B 60·6 m

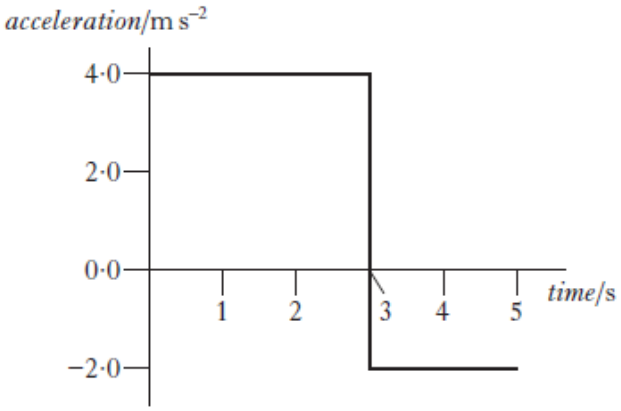
C 70·0 m

D 121 m

E 140 m.

8. An object starts from rest and accelerates in a straight line.

The graph shows how the acceleration of the object varies with time.



The speed of the object at 5 seconds is

A 2 m s^{-1}

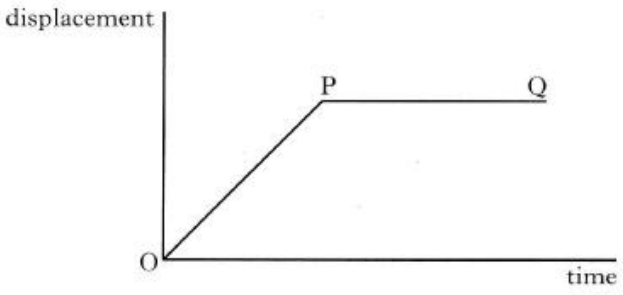
B 8 m s^{-1}

C 12 m s^{-1}

D 16 m s^{-1}

E 20 m s^{-1}.

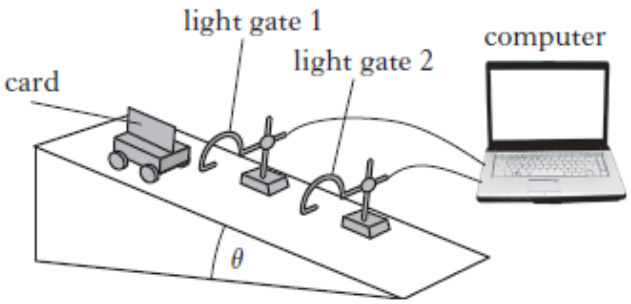
9. The following graph shows how the displacement of an object varies with time.



Which row of the table below best describes the motion of this object?

	From O to P	*From P to Q*
A	constant acceleration	constant velocity
B	zero velocity	constant deceleration
C	constant velocity	zero velocity
D	zero velocity	constant velocity
E	constant velocity	constant deceleration

10. A vehicle runs down a slope as shown.



The following results are obtained.

angle of slope,
$\theta = 15{\cdot}0 \pm 0{\cdot}5°$

length of card on top of vehicle,
$d = 0{\cdot}020 \pm 0{\cdot}001$ m

time for card to pass light gate 1,
$t_1 = 0{\cdot}40 \pm 0{\cdot}01$ s

time for card to pass light gate 2,
$t_2 = 0{\cdot}25 \pm 0{\cdot}01$ s

time for vehicle to travel between the light gates,
$t_3 = 0{\cdot}50 \pm 0{\cdot}01$ s

Which quantity has the largest percentage uncertainty?

A θ

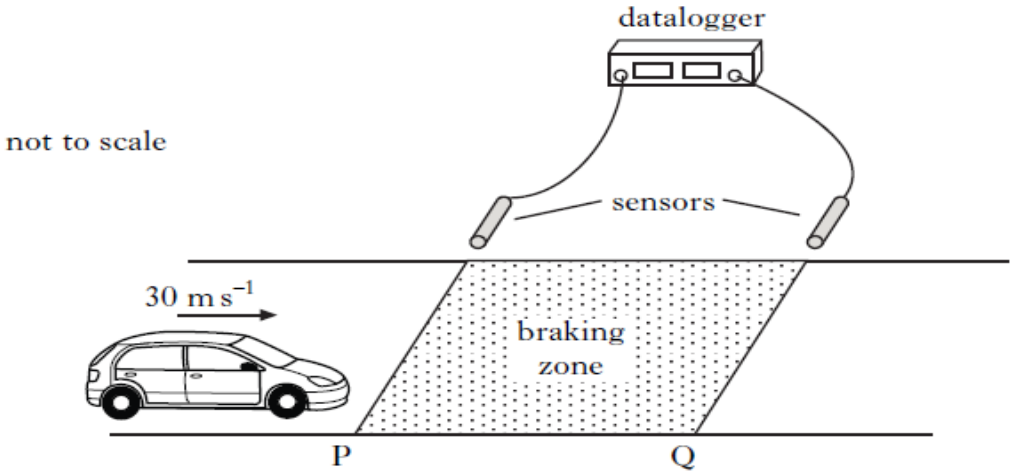
B d

C t_1

D t_2

E t_3

11. To test the braking system of cars, a test track is set up as shown.



The sensors are connected to a datalogger which records the speed of a car at both P and Q.

A car is driven at a constant speed of 30 m s^{-1} until it reaches the start of the braking zone at P. The brakes are then applied.

(*a*) In one test, the datalogger records the speed at P as 30 m s^{-1} and the speed at Q as 12 m s^{-1}. The car slows down at a constant rate of 9·0 m s^{-2} between P and Q.

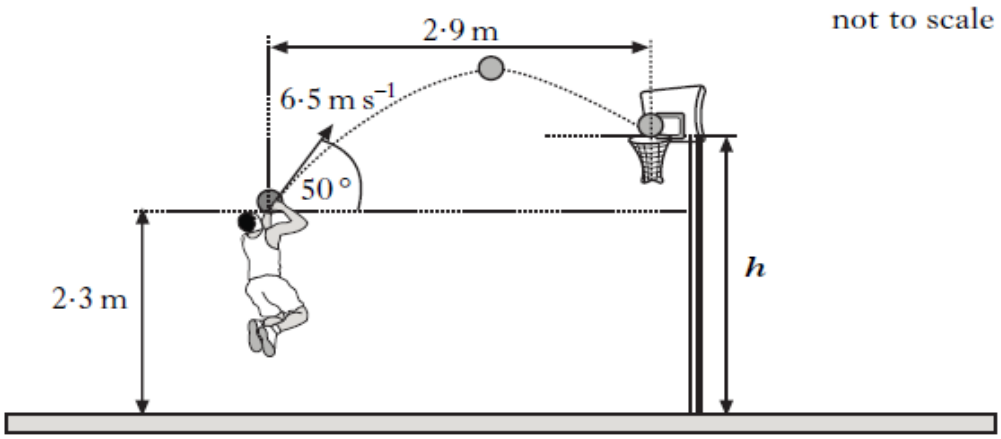
Calculate the length of the braking zone. **2**

(*b*) The test is repeated. The same car is used but now with passengers in the car. The speed at P is again recorded as 30 m s^{-1}.

The same braking force is applied to the car as in part (*a*).

How does the speed of the car at Q compare with its speed at Q in part (*a*)? Justify your answer. **2**

12. A basketball player throws a ball with an initial velocity of $6{\cdot}5\ \text{m s}^{-1}$ at an angle of $50\,°$ to the horizontal. The ball is 2·3 m above the ground when released.



The ball travels a horizontal distance of 2·9 m to reach the top of the basket.

The effects of air resistance can be ignored.

(*a*) Calculate:

(i) the horizontal component of the initial velocity of the ball; **1**

(ii) the vertical component of the initial velocity of the ball. **1**

(*b*) Show that the time taken for the ball to reach the basket is 0·69 s. **1**

(*c*) Calculate the height ***h*** of the top of the basket. **2**

(*d*) A student observing the player makes the following statement.

"The player should throw the ball with a higher speed at the same angle. The ball would then land in the basket as before but it would take a shorter time to travel the 2·9 metres."

Explain why the student's statement is incorrect. **2**

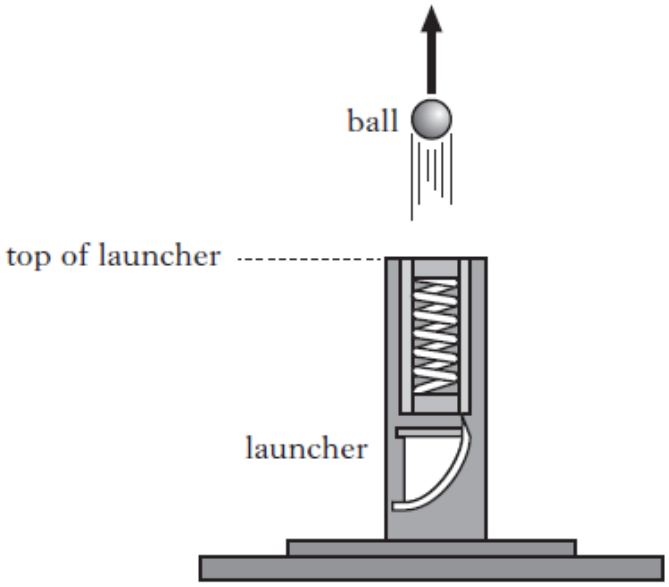
(7)

13. A student investigates the motion of a ball projected from a launcher.

The launcher is placed on the ground and a ball is fired vertically upwards.

The vertical speed of the ball as it leaves the top of the launcher is $7{\cdot}0\,\text{m s}^{-1}$.

The effects of air resistance can be ignored.

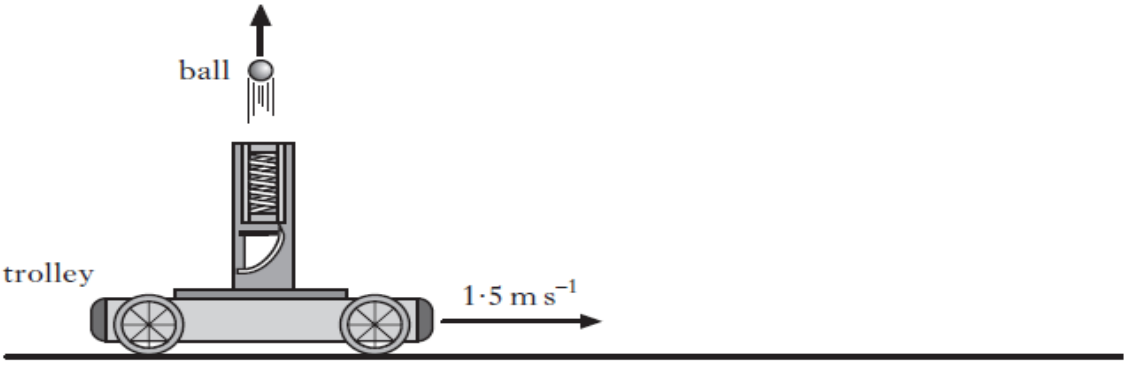


(*a*) (i) Calculate the maximum height above the top of the launcher reached by the ball. **2**

(ii) Show that the time taken for the ball to reach its maximum height is 0·71s. **1**

(*b*) The student now fixes the launcher to a trolley. The trolley travels horizontally at a constant speed of $1{\cdot}5\ \text{m s}^{-1}$ to the right.

The launcher again fires the ball vertically upwards with a speed of $7{\cdot}0\ \text{m s}^{-1}$.



(i) Determine the velocity of the ball after 0·71 s. **1**

(ii) The student asks some friends to predict where the ball will land relative to the moving launcher. They make the following statements.

Statement X: *The ball will land behind the launcher.*

Statement Y: *The ball will land in front of the launcher.*

Statement Z: *The ball will land on top of the launcher.*

Which of the statements is correct?

You must justify your answer. **2**

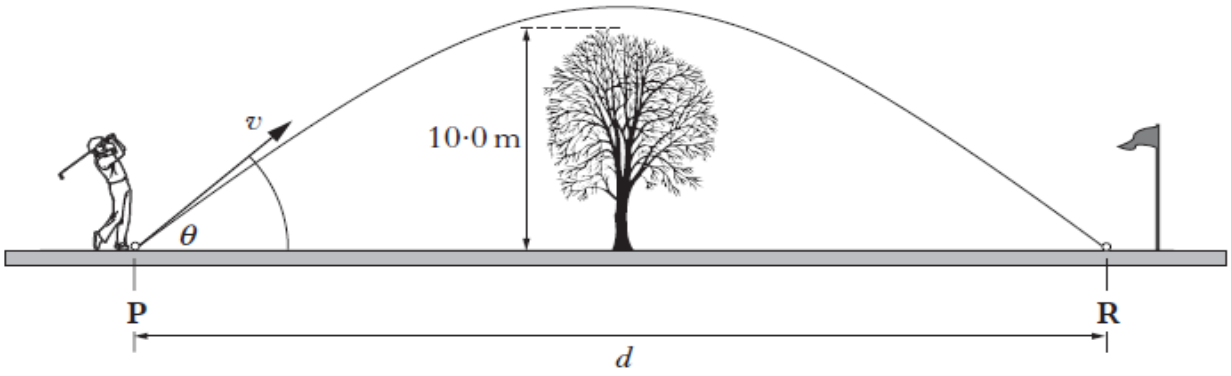
(6)

14. A golfer hits a ball from point **P**. The ball leaves the club with a velocity v at an angle of θ to the horizontal.

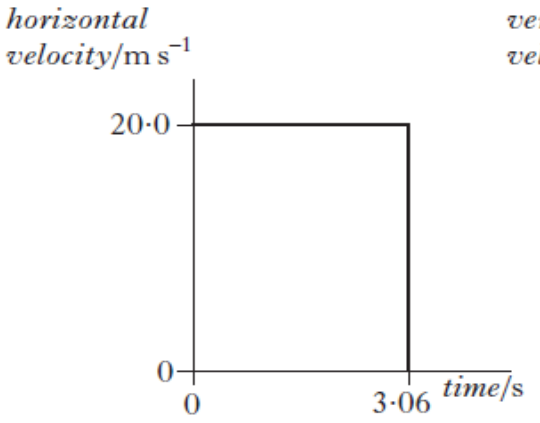
The ball travels through the air and lands at point **R**.

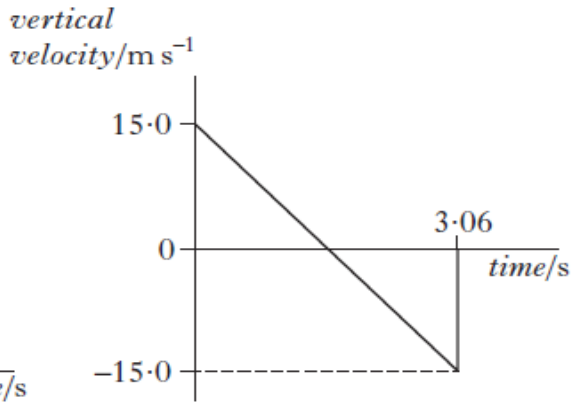
Midway between **P** and **R** there is a tree of height 10·0 m.

not to scale



(*a*) The horizontal and vertical components of the ball's velocity during its flight are shown.





The effects of air resistance can be ignored.

Calculate:

(i) the horizontal distance d; **1**

(ii) the maximum height of the ball above the ground. **2**

(3)

(30 marks)

Exercise 3 – Forces and Energy

Past paper Homework Questions

1. A person stands on bathroom scales in a lift. The scales show a reading greater than the person's weight.

The lift is moving

A upwards at constant velocity

B downwards at constant velocity

C downwards and accelerating

D downwards and decelerating

E upwards and decelerating.

2. A person stands on a weighing machine in a lift. When the lift is at rest, the reading on the machine is 700 N. The lift now descends and its speed increases at a constant rate. The reading on the machine

A is a constant value higher than 700 N

B is a constant value lower than 700 N

C continually increases from 700 N

D continually decreases from 700 N

E remains constant at 700 N.

3. The total mass of a motorcycle and rider is 250 kg. During braking, they are brought to rest from a speed of $16{\cdot}0\,m\,s^{-1}$ in a time of 10·0 s.

The maximum energy which could be converted to heat in the brakes is

A 2000 J

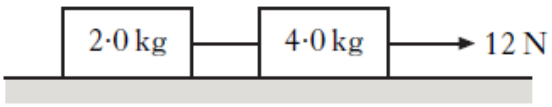
B 4000 J

C 32 000 J

D 40 000 J

E 64 000 J.

4. Two boxes on a frictionless horizontal surface are joined together by a string. A constant horizontal force of 12 N is applied as shown.



The tension in the string joining the two boxes is

A 2·0 N

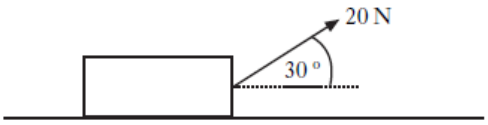
B 4·0 N

C 6·0 N

D 8·0 N

E 12 N.

5. A box of weight 120 N is placed on a smooth horizontal surface.
A force of 20 N is applied to the box as shown.



The box is pulled a distance of 50 m along the surface.

The work done in pulling the box is

A 500 J

B 866 J

C 1000 J

D 6000 J

E 6866 J.

6. A skydiver of total mass 85 kg is falling vertically.

At one point during the fall, the air resistance on the skydiver is 135 N.

The acceleration of the skydiver at this point is

A $0{\cdot}6\,m\,s^{-2}$

B $1{\cdot}6\,m\,s^{-2}$

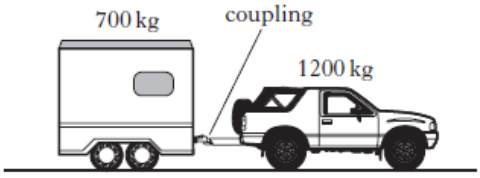
C $6{\cdot}2\,m\,s^{-2}$

D $8{\cdot}2\,m\,s^{-2}$

E $13{\cdot}8\,m\,s^{-2}$.

7. A car of mass 1200 kg pulls a horsebox of mass 700 kg along a straight, horizontal road.

They have an acceleration of $2{\cdot}0\,m\,s^{-2}$.



Assuming that the frictional forces are negligible, the tension in the coupling between the car and the horsebox is

A 500 N

B 700 N

C 1400 N

D 2400 N

E 3800 N.

8. A car of mass 1000 kg is travelling at a speed of $40\,m\,s^{-1}$ along a race track. The brakes are applied and the speed of the car decreases to $10\,m\,s^{-1}$.

How much kinetic energy is lost by the car?

A 15 kJ

B 50 kJ

C 450 kJ

D 750 kJ

E 800 kJ

9. A rocket of mass 200 kg accelerates vertically upwards from the surface of a planet at $2{\cdot}0\,m\,s^{-2}$.

The gravitational field strength on the planet is $4{\cdot}0\,N\,kg^{-1}$.

What is the size of the force being exerted by the rocket's engines?

A 400 N

B 800 N

C 1200 N

D 2000 N

E 2400 N

10. Two blocks are linked by a newton balance of negligible mass.

The blocks are placed on a level, frictionless surface. A force of 18·0 N is applied to the blocks as shown.

The reading on the newton balance is

A 7·2 N

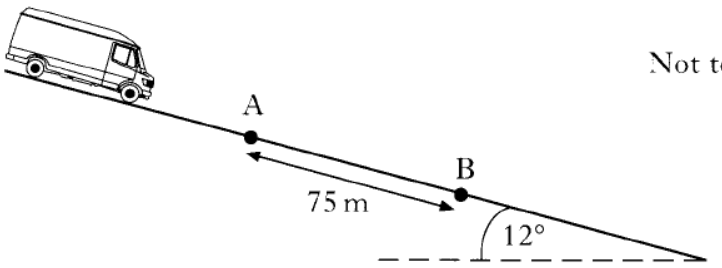
B 9·0 N

C 10·8 N

D 18·0 N

E 40·0 N.

11. A van of mass 2600 kg moves down a slope which is inclined at 12° to the horizontal as shown.



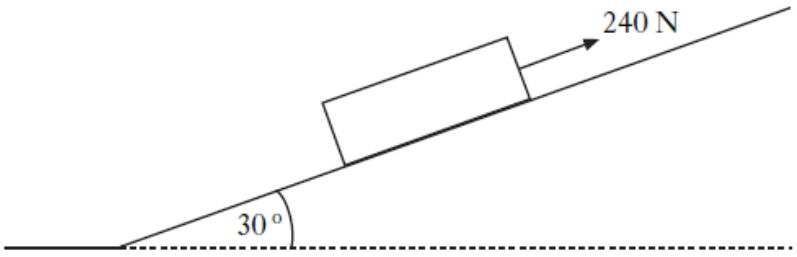
(*a*) Calculate the component of the van's weight parallel to the slope. **2**

(*b*) A constant frictional force of 1400 N acts on the van as it moves down the slope.

Calculate the acceleration of the van. **2**

(4)

12. A crate of mass 40·0 kg is pulled up a slope using a rope.
The slope is at an angle of 30° to the horizontal.



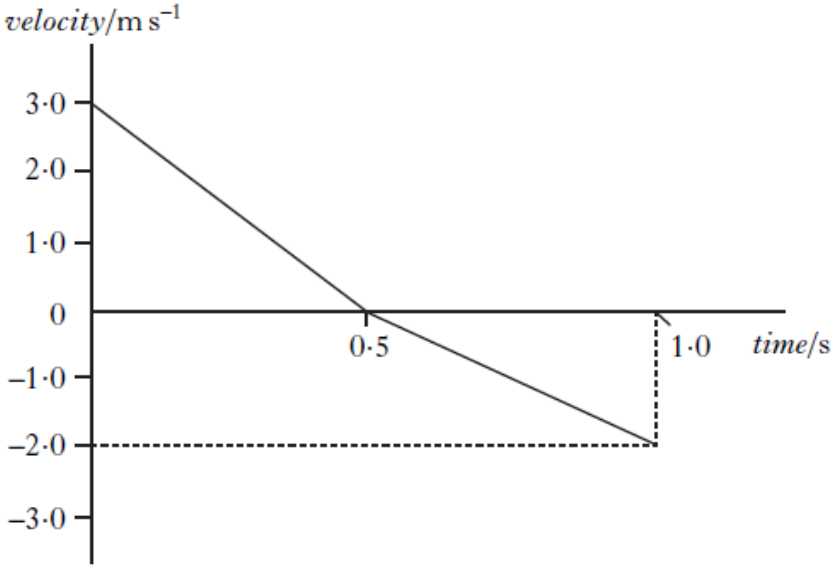
A force of 240 N is applied to the crate parallel to the slope.
The crate moves at a constant speed of 3·0 m s^{-1}.

(*a*) (i) Calculate the component of the weight of the crate acting parallel to the slope. **2**

(ii) Calculate the frictional force acting on the crate. **2**

(*b*) As the crate is moving up the slope, the rope snaps.

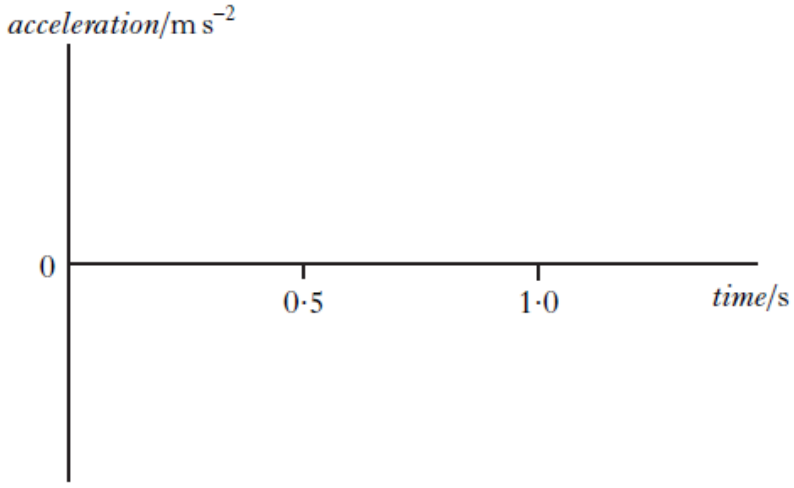
The graph shows how the velocity of the crate changes from the moment the rope snaps.



(i) Describe the motion of the crate during the first 0·5 s after the rope snaps. **1**

(ii) Copy the axes shown below and sketch the graph to show the acceleration of the crate between 0 and 1·0 s.

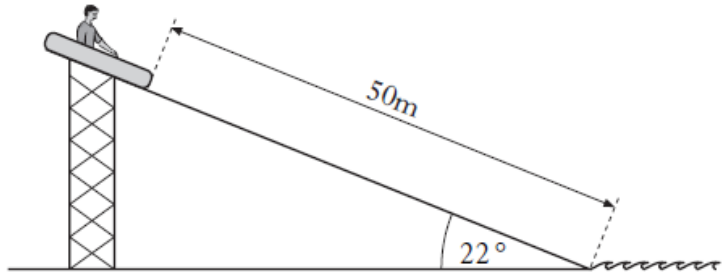
Appropriate numerical values are also required on the acceleration axis. **2**



(iii) Explain, in terms of the forces acting on the crate, why the magnitude of the acceleration changes at 0·5 s. **2**

(9)

13. A fairground ride consists of rafts which slide down a slope into water.



The slope is at an angle of 22 ° to the horizontal. Each raft has a mass of 8·0 kg. The length of the slope is 50 m.

A child of mass 52 kg sits in a raft at the top of the slope. The raft is released from rest. The child and raft slide together down the slope into the water. The force of friction between the raft and slope remains constant at 180 N.

(*a*) Calculate the component of weight, in newtons, of the child and raft down the slope. **1**

(*b*) Show by calculation that the acceleration of the child and raft down the slope is 0·67 m s^{-2}. **2**

(*c*) Calculate the speed of the child and raft at the bottom of the slope. **2**

(*d*) A second child of smaller mass is released from rest in an identical raft at the same starting point. The force of friction is the same as before.

How does the speed of this child and raft at the bottom of the slope compare with the answer to part (*c*)?

Justify your answer. **2**

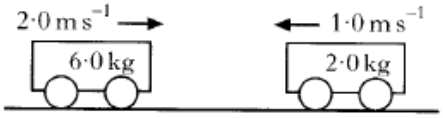
(7)

30 marks

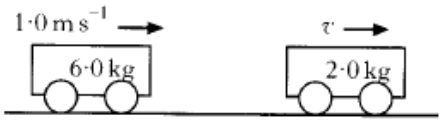
Exercise 4 – Momentum and Impulse

Past paper Homework Questions

1. Two trolleys travel towards each other in a straight line as shown.



The trolleys collide. After the collision the trolleys move as shown below.



What is the speed v of the 2·0 kg trolley after the collision?

A $1{\cdot}25\,\text{m s}^{-1}$

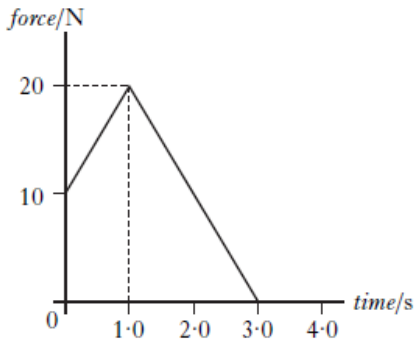
B $1{\cdot}75\,\text{m s}^{-1}$

C $2{\cdot}0\,\text{m s}^{-1}$

D $4{\cdot}0\,\text{m s}^{-1}$

E $5{\cdot}0\,\text{m s}^{-1}$

2. The graph shows the force acting on an object of mass 5·0 kg.



The change in the object's momentum is

A $7{\cdot}0\,\text{kg m s}^{-1}$

B $30\,\text{kg m s}^{-1}$

C $35\,\text{kg m s}^{-1}$

D $60\,\text{kg m s}^{-1}$

E $175\,\text{kg m s}^{-1}$.

3. Momentum can be measured in

A N kg^{-1}

B N m

C N m s^{-1}

D kg m s^{-1}

E kg m s^{-2}.

4. A cannon of mass 2000 kg fires a cannonball of mass 5·00 kg.

The cannonball leaves the cannon with a speed of $50{\cdot}0\,\text{m s}^{-1}$.

The speed of the cannon immediately after firing is

A $0{\cdot}125\,\text{m s}^{-1}$

B $8{\cdot}00\,\text{m s}^{-1}$

C $39{\cdot}9\,\text{m s}^{-1}$

D $40{\cdot}1\,\text{m s}^{-1}$

E $200\,\text{m s}^{-1}$.

5. A shell of mass 5·0 kg is travelling horizontally with a speed of $200\,\text{m s}^{-1}$. It explodes into two parts. One part of mass 3·0 kg continues in the original direction with a speed of $100\,\text{m s}^{-1}$.

The other part also continues in this same direction. Its speed is

A $150\,\text{m s}^{-1}$

B $200\,\text{m s}^{-1}$

C $300\,\text{m s}^{-1}$

D $350\,\text{m s}^{-1}$

E $700\,\text{m s}^{-1}$.

6. A 2·0 kg trolley travels in a straight line towards a stationary 5·0 kg trolley as shown.

The trolleys collide. After the collision the trolleys move as shown below.

What is the speed v of the 5·0 kg trolley after the collision?

A 0·4 m s^{-1}

B 1·2 m s^{-1}

C 2·0 m s^{-1}

D 2·2 m s^{-1}

E 3·0 m s^{-1}

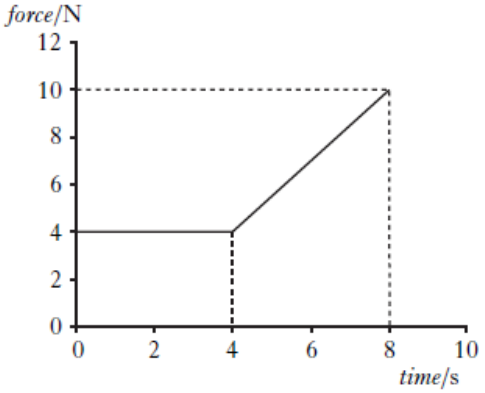
7. Two trolleys travel towards each other in a straight line along a frictionless surface.

The trolleys collide. After the collision the trolleys move as shown below.

Which row in the table gives the total momentum and the total kinetic energy **after** the collision?

	Total momentum/ kg m s^{-1}	*Total kinetic energy/* J
A	10	7·0
B	10	13
C	10	20
D	14	13
E	14	7·0

8. The graph shows the force which acts on an object over a time interval of 8 seconds.



The momentum gained by the object during this 8 seconds is

A 12 kg m s^{-1}

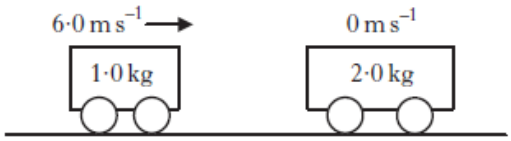
B 32 kg m s^{-1}

C 44 kg m s^{-1}

D 52 kg m s^{-1}

E 72 kg m s^{-1}.

9. The diagram shows the masses and velocities of two trolleys just before they collide on a level bench.



After the collision, the trolleys move along the bench joined together.

How much kinetic energy is lost in this collision?

A 0 J

B 6·0 J

C 12 J

D 18 J

E 24 J

10. The momentum of a rock of mass 4 kg is 12 kg m s^{-1}.

The kinetic energy of the rock is

A 6 J

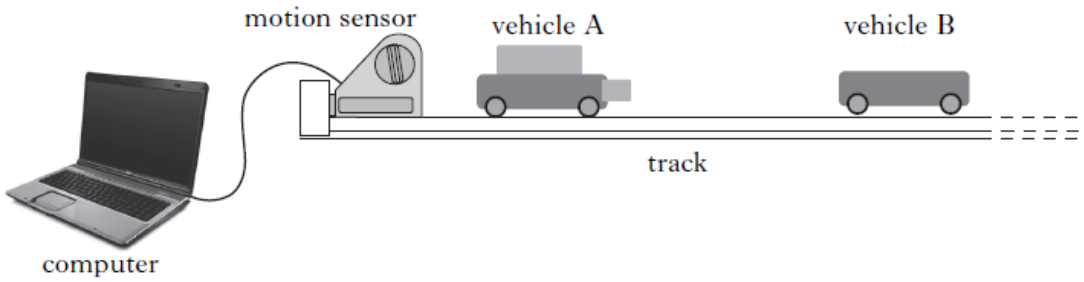
B 18 J

C 36 J

D 144 J

E 288 J.

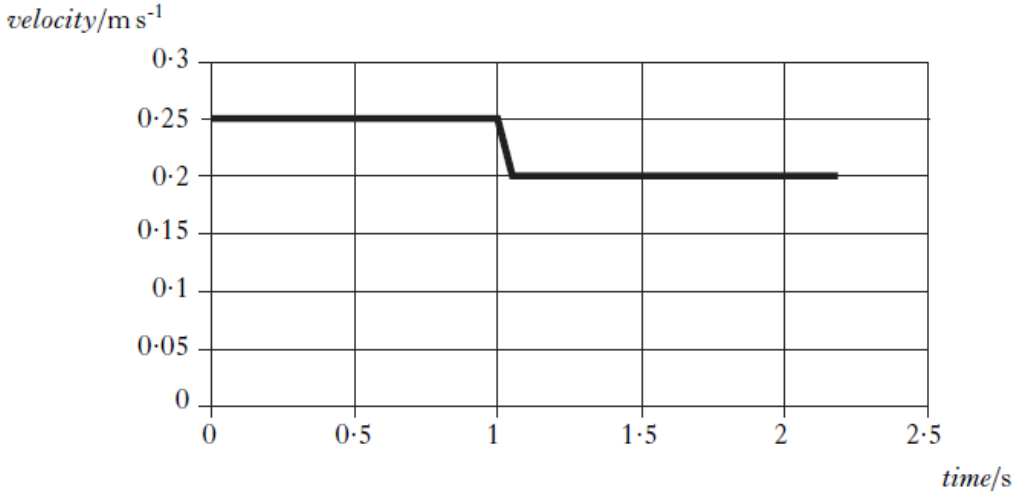
11. The apparatus shown is set up to investigate collisions between two vehicles on a track.



The mass of vehicle A is 0·22 kg and the mass of vehicle B is 0·16 kg.

The effects of friction are negligible.

(*a*) During one experiment the vehicles collide and stick together. The computer connected to the motion sensor displays the velocity-time graph for vehicle A.



(i) State the law of conservation of momentum. **1**

(ii) Calculate the velocity of vehicle B before the collision. **2**

(*b*) The same apparatus is used to carry out a second experiment.

In this experiment, vehicle B is stationary before the collision.

Vehicle A has the same velocity before the collision as in the first experiment.

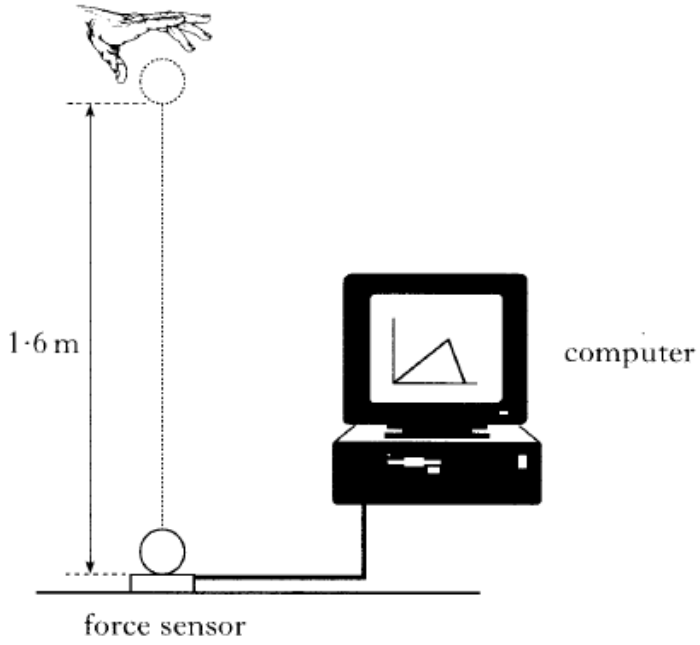
After the collision, the two vehicles stick together.

Is their combined velocity less than, equal to, or greater than that in the first collision?

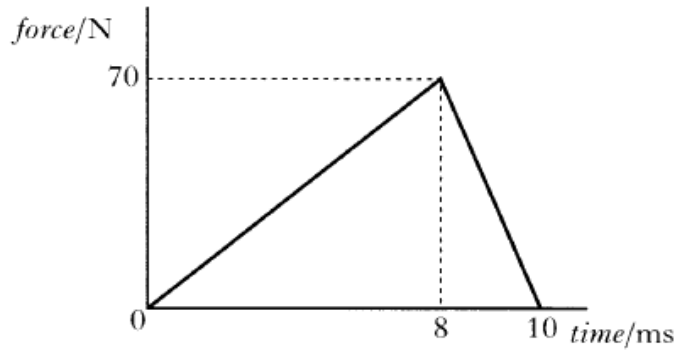
Justify your answer. **2**

(5)

12. A force sensor is used to investigate the impact of a ball as it bounces on a flat horizontal surface. The ball has a mass of 0·050 kg and is dropped vertically, from rest, through a height of 1·6 m as shown.



(*a*) The graph shows how the force on the ball varies with time during the impact.



(i) Show by calculation that the magnitude of the impulse on the ball is 0·35 N s. **1**

(ii) What is the magnitude and direction of the change in momentum of the ball? **1**

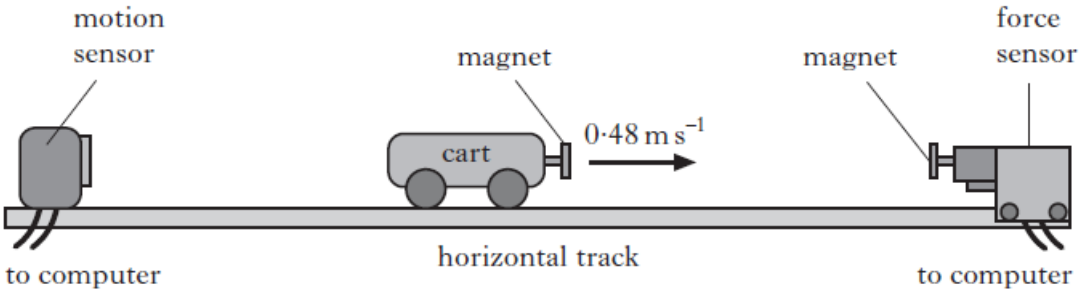
(iii) The ball is travelling at 5·6 m s^{-1} just before it hits the force sensor. Calculate the speed of the ball just as it leaves the force sensor. **2**

(*b*) Another ball of identical size and mass, but made of a harder material, is dropped from rest and from the same height onto the same force sensor. Sketch the force-time graph shown above and, on the same axes, sketch another graph to show how the force on the harder ball varies with time.

Numerical values are not required but you must label the graphs clearly. **2**

(6)

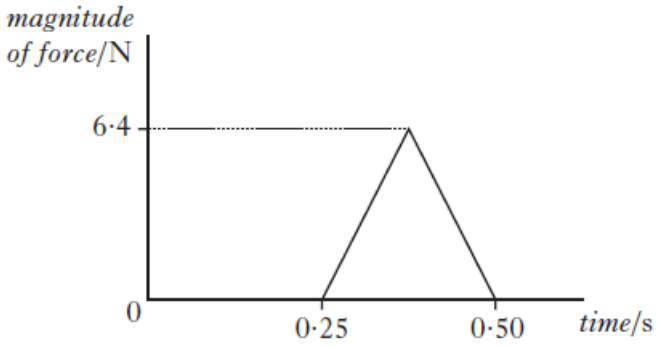
13. An experiment is set up to investigate the motion of a cart as it collides with a force sensor.



The cart moves along the horizontal track at 0·48 m s^{-1} to the right.

As the cart approaches the force sensor, the magnets repel each other and exert a force on the cart.

The computer attached to the force sensor displays the following force-time graph for this collision.

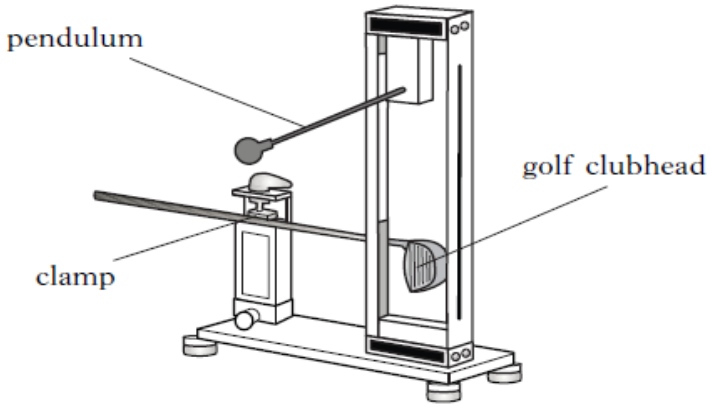


(*a*) (i) Calculate the magnitude of the impulse on the cart during the collision. **2**

(2)

14. Golf clubs are tested to ensure they meet certain standards.

(*a*) In one test, a securely held clubhead is hit by a small steel pendulum. The time of contact between the clubhead and the pendulum is recorded.



The experiment is repeated several times.

The results are shown.

248 µs 259 µs 251 µs 263 µs 254 µs

(i) Calculate:

(A) the mean contact time between the clubhead and the pendulum; **1**

(B) the approximate absolute random uncertainty in this value. **1**

(ii) In this test, the standard required is that the maximum value of the mean contact time must not be greater than 257 µs.

Does the club meet this standard?

You must justify your answer. **1**

(*b*) In another test, a machine uses a club to hit a stationary golf ball.

The mass of the ball is $4{\cdot}5 \times 10^{-2}$ kg. The ball leaves the club with a speed of $50{\cdot}0\ m\ s^{-1}$. The time of contact between the club and ball is 450 µs.

(i) Calculate the average force exerted on the ball by the club. **2**

(ii) The test is repeated using a different club and an identical ball. The machine applies the same average force on the ball but with a longer contact time.

What effect, if any, does this have on the speed of the ball as it leaves the club?

Justify your answer. **2**

(7)

30 marks

Exercise 5 – Gravitation and Special Relativity

Past paper Homework Questions

1. A satellite orbits a planet at a distance of $5{\cdot}0 \times 10^7$ m from the centre of the planet.

The mass of the satellite is $2{\cdot}5 \times 10^4$ kg.

The mass of the planet is $4{\cdot}0 \times 10^{24}$ kg.

The gravitational force acting on the satellite due to the planet is

A $1{\cdot}7 \times 10^{-6}$ N

B $2{\cdot}7 \times 10^{3}$ N

C $1{\cdot}3 \times 10^{11}$ N

D $2{\cdot}7 \times 10^{14}$ N

E $2{\cdot}7 \times 10^{32}$ N.

2. The length of a spaceship at rest is L.

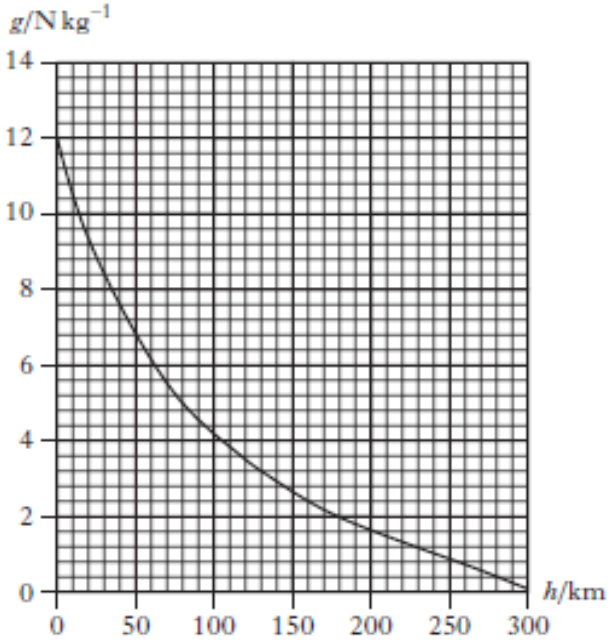
This spaceship passes a planet at a speed of $0{\cdot}95c$.

Which row in the table gives the measured lengths of the spaceship according to an observer on the spaceship and an observer on the planet?

	Length measured by observer on spaceship	*Length measured by observer on planet*
A	L	L
B	L	less than L
C	less than L	L
D	less than L	less than L
E	greater than L	less than L

3. A rock of mass 0·80 kg falls towards the surface of a planet.

The graph shows how the gravitational field strength, g, of the planet varies with height, h, above the surface of the planet.



At one point during its fall the weight of the rock is 4·0 N. The height of this point above the surface of the planet is

A 15 km

B 80 km

C 105 km

D 130 km

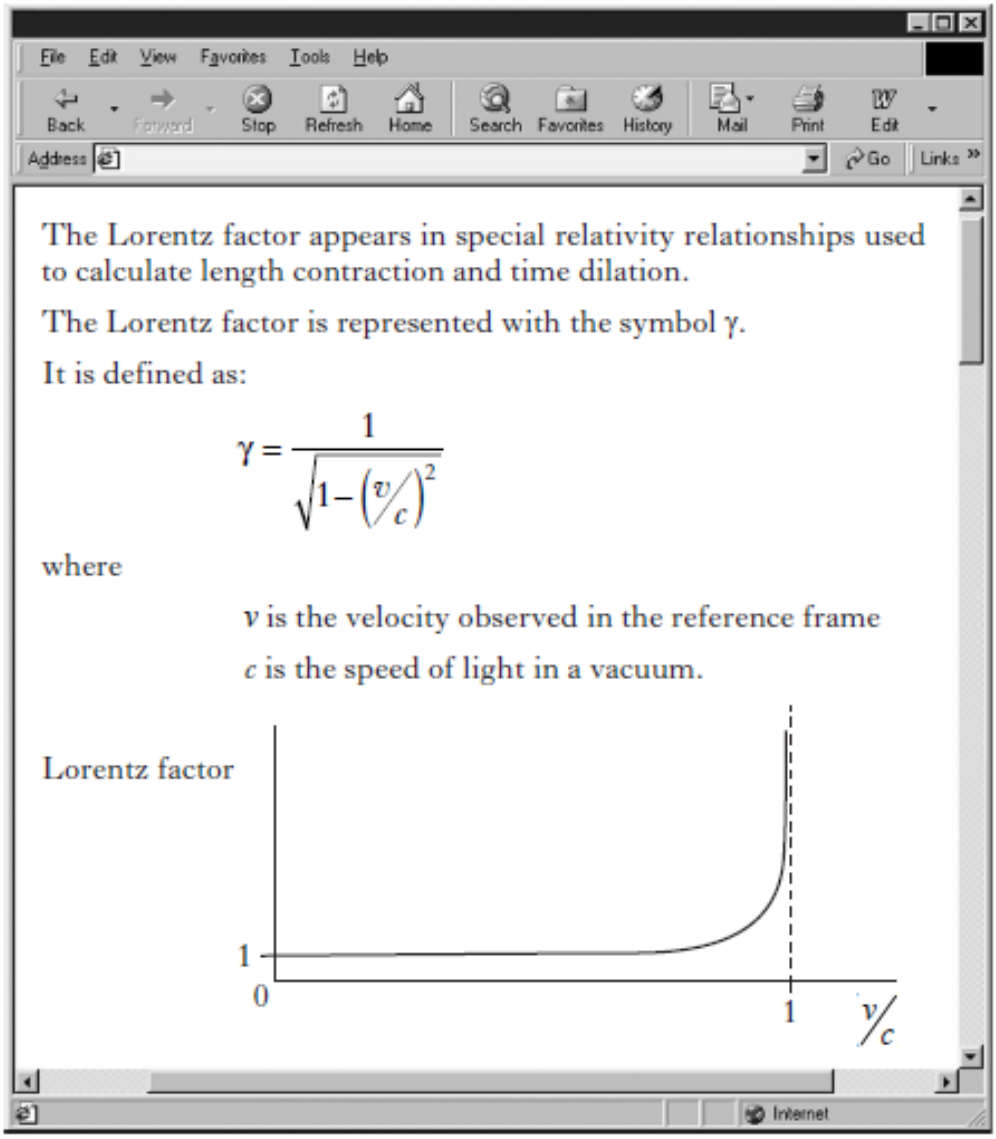
E 255 km.

4. A spaceship on a launch pad is measured to have a length L. This spaceship has a speed of $2{\cdot}5 \times 10^8\ \text{m s}^{-1}$ as it passes a planet.

Which row in the table describes the length of the spaceship as measured by the pilot in the spaceship and an observer on the planet?

	Length measured by pilot in the spaceship	*Length measured by observer on the planet*
A	L	less than L
B	L	greater than L
C	L	L
D	less than L	L
E	greater than L	L

5. A page from a website on special relativity is shown.



(*a*) Explain what is meant by the term *length contraction*. **1**

(*b*) Calculate the Lorentz factor when the ratio $v/c = 0{\cdot}80$. **1**

(*c*) Length contraction calculations use the relationship

$$l' = l\sqrt{1-\left(v/c\right)^2}$$

where the symbols have their usual meanings.

State this relationship in terms of l', l and γ. **1**

(*d*) Explain, in terms of the Lorentz factor, why an observer can ignore relativistic effects for an object which is moving with a velocity much less than *c*. **2**

(5)

6. Estimate the gravitational force of attraction between two students sitting beside each other.

Clearly show your working for the calculation and any estimates you have made. **(3)**

7. According to Newton's Universal Law of Gravitation, the force exerted by the Earth on an object is proportional to the mass of the object. A student suggests that this means that a heavy object will fall with a greater acceleration than a light object.

Use your knowledge of physics to explain why this is not true.

(3)

8 What is meant by the term "dark energy "and describe the evidence scientists used to conclude its existence. (2)

9 What is meant by the term "dark matter" and describe the evidence scientists used to conclude its existence. (2)

19 Marks

Exercise 6 – The Expanding Universe

Past Paper Homework Questions

1. The siren on an ambulance is emitting sound with a constant frequency of 900 Hz. The ambulance is travelling at a constant speed of 25 m s^{-1} as it approaches and passes a stationary observer. The speed of sound in air is 340 m s^{-1}.

Which row in the table shows the frequency of the sound heard by the observer as the ambulance approaches and as it moves away from the observer?

	Frequency as ambulance approaches/Hz	*Frequency as ambulance moves away*/Hz
A	900	900
B	971	838
C	838	900
D	971	900
E	838	971

2. Light from an element in a distant star is observed by an astronomer. Analysis of the line spectrum of this light shows it to be redshifted compared to the line spectrum of the same element on Earth.

Compared to the spectrum observed from this element on Earth

A the frequency of each line in the spectrum from the star is greater

B the wavelength of each line in the spectrum from the star is less

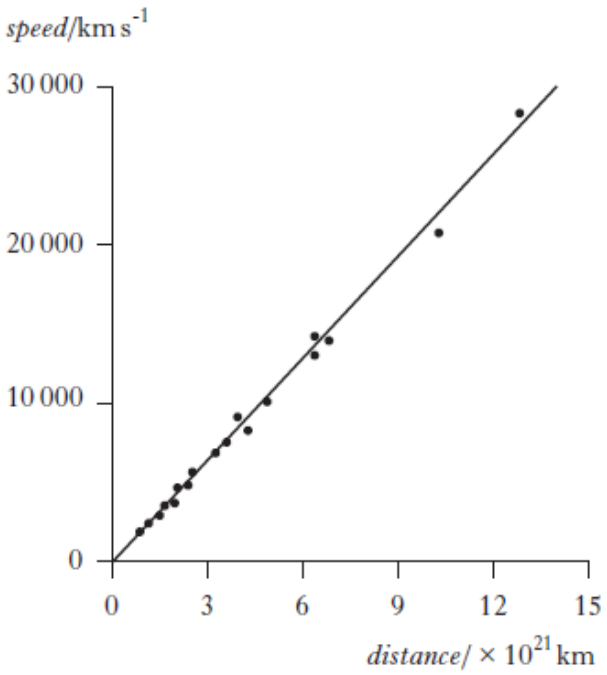
C the frequency of each line in the spectrum from the star is less

D the wavelength of each line in the spectrum from the star is the same

E the frequency of each line in the spectrum from the star is the same.

3. Galaxies at different distances from the Earth have been found to have different speeds.

The graph shows data for some distant galaxies.



A student studies this graph and makes the following statements.

I The speed of distant galaxies varies inversely with their distance from the Earth.

II The gradient of the line gives the value of Hubble's constant.

III The unit for Hubble's constant is s^{-1}.

Which of these statements is/are correct?

A I only

B II only

C III only

D I and II only

E II and III only

4. A galaxy is moving away from the Earth at a velocity of $1{\cdot}20 \times 10^{7}\,\text{m s}^{-1}$.

Light of wavelength 450 nm is emitted from this galaxy.

When detected and measured on Earth this light has a wavelength of

A 425 nm

B 432 nm

C 468 nm

D 475 nm

E 630 nm.

5. An astronomer observes the spectrum of light from a star. The spectrum contains the emission lines for hydrogen.

The astronomer compares this spectrum with the spectrum from a hydrogen lamp. The line which has a wavelength of 656 nm from the lamp is found to be shifted to 663 nm in the spectrum from the star.

The redshift of the light from this star is

A 0·011

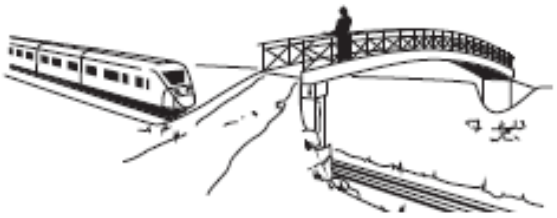
B 0·50

C 0·99

D 2·0

E 94.

6. A train is travelling at a constant speed of $16{\cdot}0\,\text{m s}^{-1}$ as it approaches a bridge.



A horn on the train emits sound of frequency 277 Hz.

The sound is heard by a person standing on the bridge.

The speed of sound in air is $340\,\text{m s}^{-1}$.

The frequency of the sound heard by the person on the bridge is

A 265 Hz

B 277 Hz

C 291 Hz

D 357 Hz

E 361 Hz.

7. By observing the spectrum of light received from galaxy M101, astronomers have determined that the galaxy is moving away from us with a velocity of $5{\cdot}5 \times 10^{5}\,\text{m s}^{-1}$.

(*a*) Calculate the distance of the galaxy from us. **3**

(*b*) The observation that galaxies are moving away from us is evidence for the expanding universe. As the universe expands it cools down.

What property of the Cosmic Microwave Background has been measured by astronomers to determine the present temperature of the universe? **1**

(4)

8. All stars emit radiation with a range of wavelengths. The peak wavelength of radiation, λ_{peak}, emitted from a star is related to the surface temperature, T, of the star.

The table gives the surface temperatures, in kelvin, of four different stars and the peak wavelength radiated from each star.

Surface temperature of star T/K	*Peak wavelength radiated* λ_{peak}/m
4200	$6{\cdot}90 \times 10^{-7}$
5800	$5{\cdot}00 \times 10^{-7}$
7900	$3{\cdot}65 \times 10^{-7}$
12 000	$2{\cdot}42 \times 10^{-7}$

(*a*) Use **all** the data in the table to show that the relationship between the surface temperature, T, of a star and the peak wavelength radiated, λ_{peak}, from the star is

$$T = \frac{2{\cdot}9 \times 10^{-3}}{\lambda_{peak}}$$

2

(*b*) The blue supergiant star Eta Carinae is one of the largest and most luminous stars in our galaxy. It emits radiation with a peak wavelength of 76 nm.

Calculate the surface temperature, in kelvin, of this star. **2**

(*c*) Radiation of peak wavelength 1·06 mm can be detected on Earth coming from all directions in space.

(i) What name is given to this radiation? **1**

(ii) Give a reason why the existence of this radiation supports the Big Bang Theory. **1**

(6)

9. (*a*) Experimental work at CERN has been described as "*recreating the conditions that occurred just after the Big Bang*".

Describe what scientists mean by the *Big Bang theory* and give **one** piece of evidence which supports this theory. **2**

(*b*) During a television programme the presenter states, "*Looking through a telescope at the night sky is like looking back in time*".

Use physics principles to comment on this statement. **3**

(5)

21 marks