

# **NATIONAL 5 PHYSICS**

**Dynamics and Space**

**Exam Questions**

## Velocity and Displacement - Vectors and Scalars

2011 Int2 1 MC

1. During training an athlete sprints 30 m East and then 40 m West. Which row shows the distance travelled and the displacement from the starting point?

1

	<i>Distance travelled</i>	<i>Displacement</i>
A	10 m	10 m East
B	10 m	10 m West
C	10 m	70 m East
D	70 m	10 m West
E	70 m	10 m East

2013 Int2 1 MC

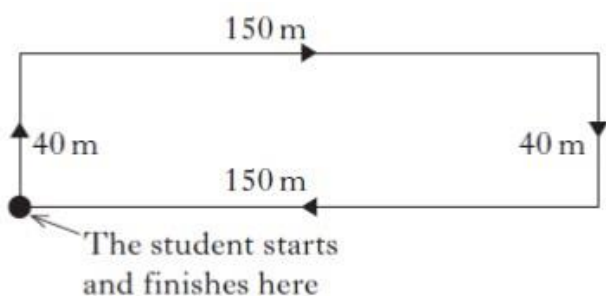
2. Which row contains two scalar quantities and one vector quantity?

- A Distance, momentum, velocity
- B Speed, mass, momentum
- C Distance, weight, momentum
- D Speed, weight, momentum
- E Velocity, force, mass

1

2013 Int2 2 MC

3. A student follows the route shown in the diagram and arrives back at the starting point.

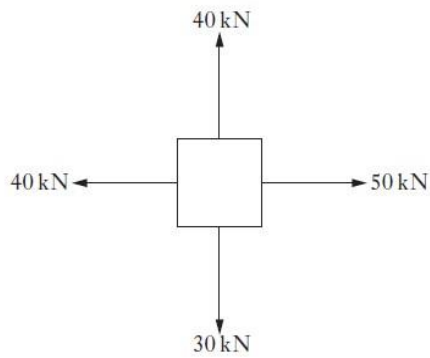


Which row in the table shows the total distance walked and the magnitude of the final displacement?

	Total distance (m)	Final displacement (m)
A	0	80
B	0	380
C	190	0
D	380	0
E	380	380

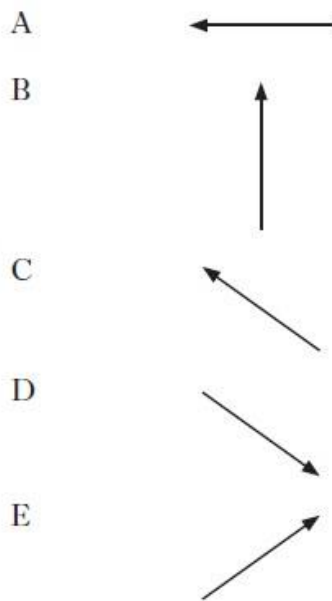
1

4. Four tugs apply forces to an oil-rig in the directions shown.



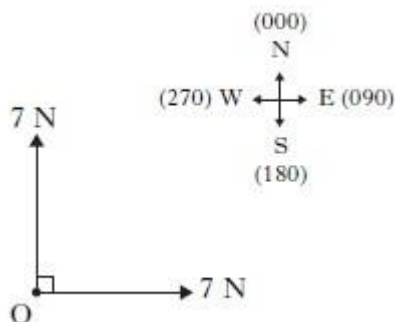
Which of the following could represent the direction of the resultant force?

1



2010 Int2 3 MC

5. Two forces, each of 7N, act on an object O. The forces act as shown.



The resultant of these two forces is

- A 7 N at a bearing of 135
- B 9.9 N at a bearing of 045
- C 9.9 N at a bearing of 135
- D 14 N at a bearing of 045
- E 14 N at a bearing of 135.

1

6. Which of the following is a scalar quantity?

- A Force
- B Acceleration
- C Momentum
- D Velocity
- E Energy

1

2007 Int2 1MC

7. In the following statements X, Y and Z represent physical quantities.

X is the displacement of an object in a given time.

Y is the change in velocity of an object in a given time.

Z is the distance travelled by an object in a given time.

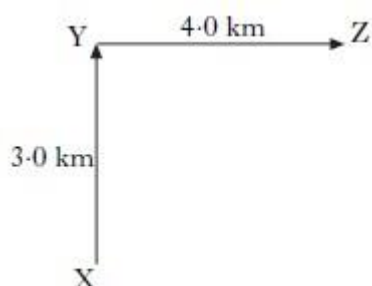
Which row in the table shows the quantities represented by X, Y and Z?

1

	X	Y	Z
A	speed	acceleration	velocity
B	velocity	speed	acceleration
C	acceleration	velocity	speed
D	acceleration	speed	velocity
E	velocity	acceleration	speed

2008 Int2 2 MC

8. A student walks from X to Y and then from Y to Z.

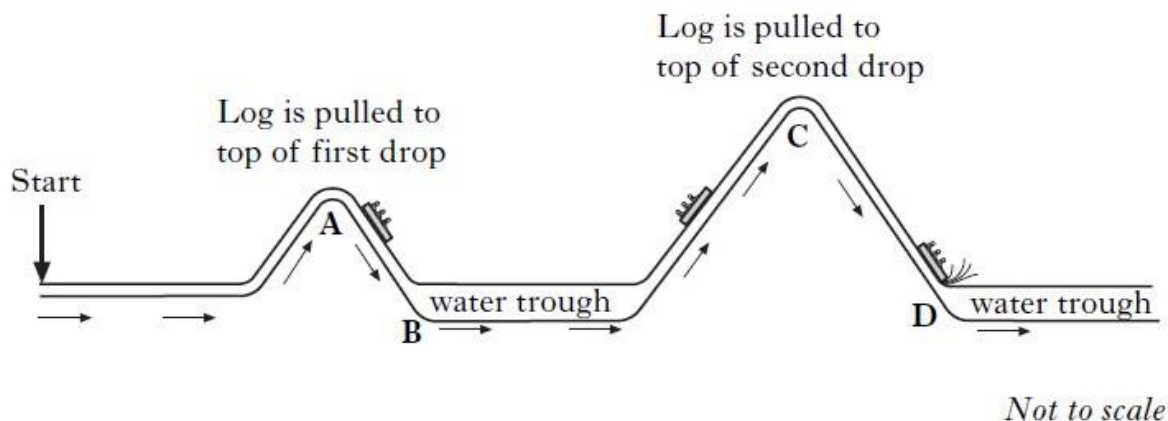


The complete walk takes 2 hours. Which row in the table shows the average speed and the average velocity for the complete walk?

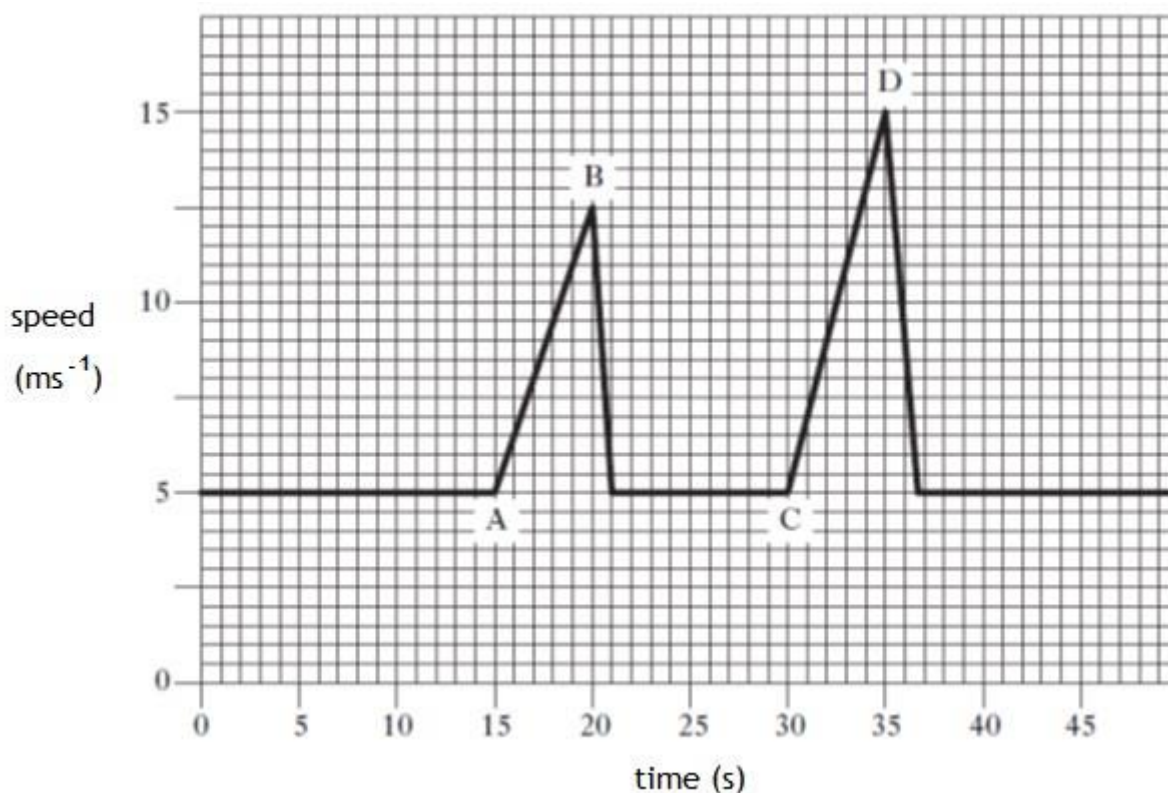
1

	Average speed	Average velocity
A	2.5 km h <sup>-1</sup>	2.5 km h <sup>-1</sup> at 053
B	2.5 km h <sup>-1</sup> at 053	2.5 km h <sup>-1</sup>
C	3.5 km h <sup>-1</sup>	2.5 km h <sup>-1</sup> at 053
D	3.5 km h <sup>-1</sup> at 053	3.5 km h <sup>-1</sup>
E	3.5 km h <sup>-1</sup>	3.5 km h <sup>-1</sup> at 053

1. On a visit to a theme park, four students ride the log flume.

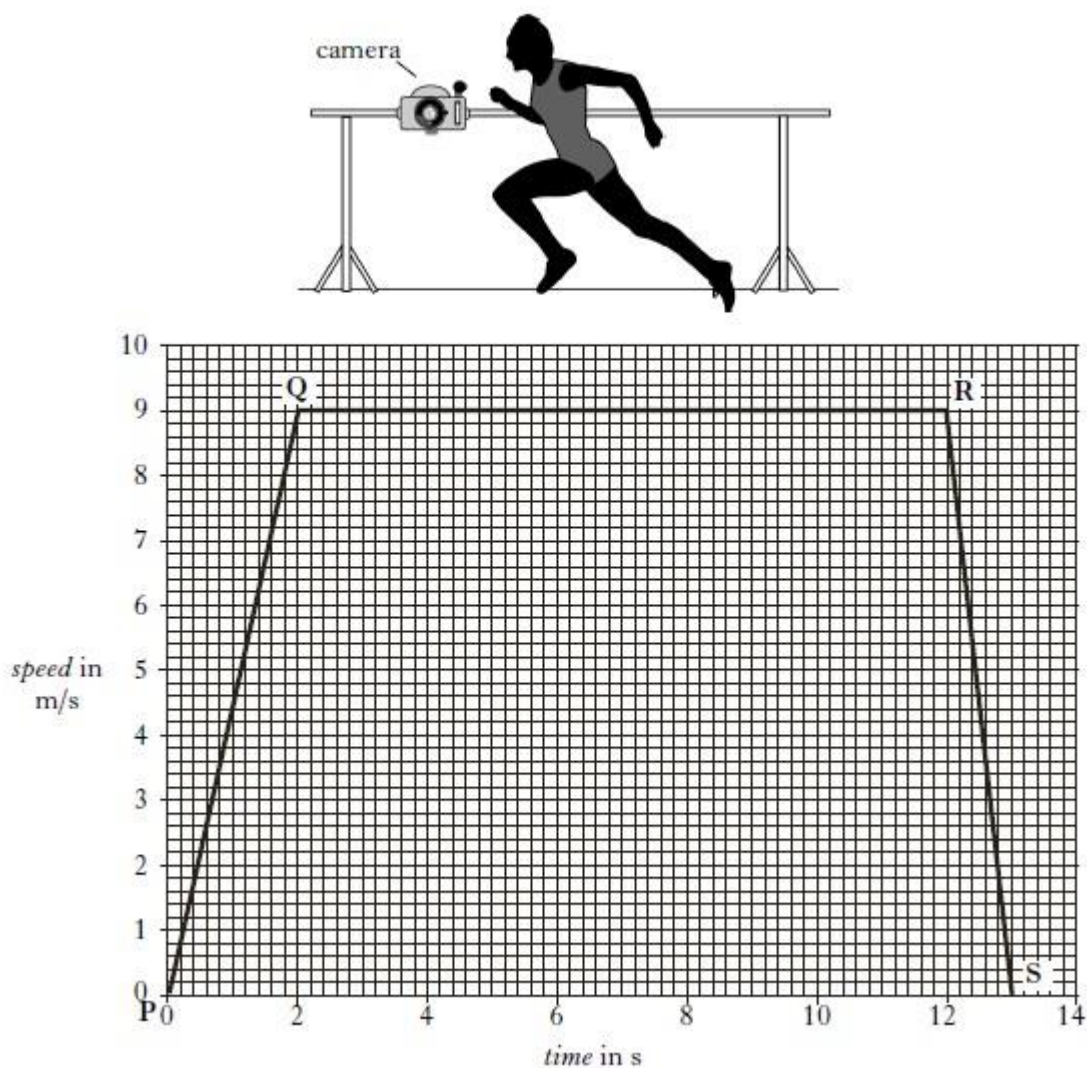


The graph shows how the speed of the log varies during the ride.



- (a) Describe the motion of the log during AB on the graph. 1
- (b) Calculate the distance travelled by the log from the start of the ride to the bottom of the first drop. 3
- (c) Calculate the log's acceleration as it goes down the second drop. 3

2. Athletes in a race are recorded by a TV camera which runs on rails beside the track.



The graph shows the speed of the camera during the race.

How far does the camera travel in the 13 s?

3

2007 Int2 22bii and iii

3. A cyclist approaches traffic lights at a speed of 8 m/s. He sees the traffic lights turn red and 3s later he applies the brakes. He comes to rest in a further 2.5 s.

- (a) Sketch a speed time graph showing the motion of the cyclist from the moment the lights turn red until he stops at the traffic lights.

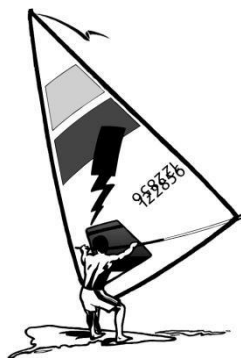
Numerical values must be included.

3

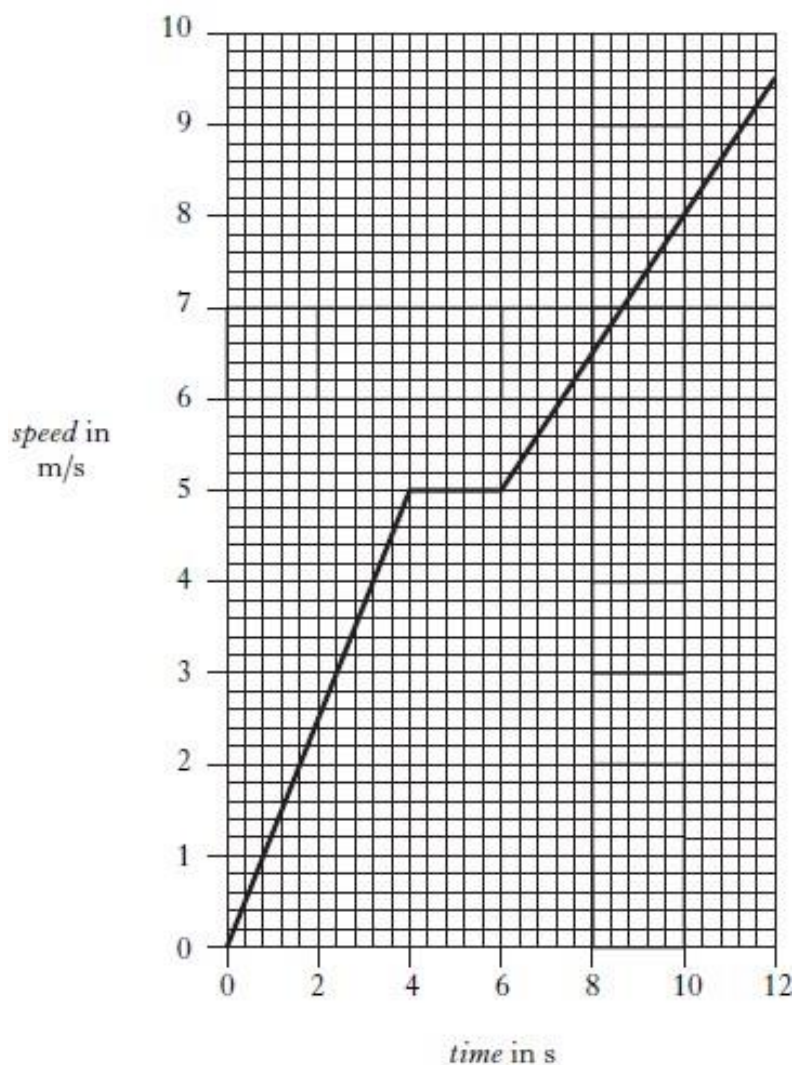
- (b) Use the graph to calculate the total distance the cyclist travels from the moment the lights turn red until he stops at the traffic lights.

3

4. A windsurfer takes part in a race.



The graph shows how the speed of the windsurfer and board changes with time during part of the race.

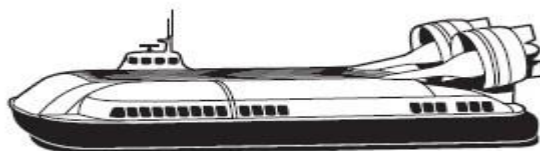


Calculate the total distance travelled by the windsurfer during the 12 s time interval shown on the graph.

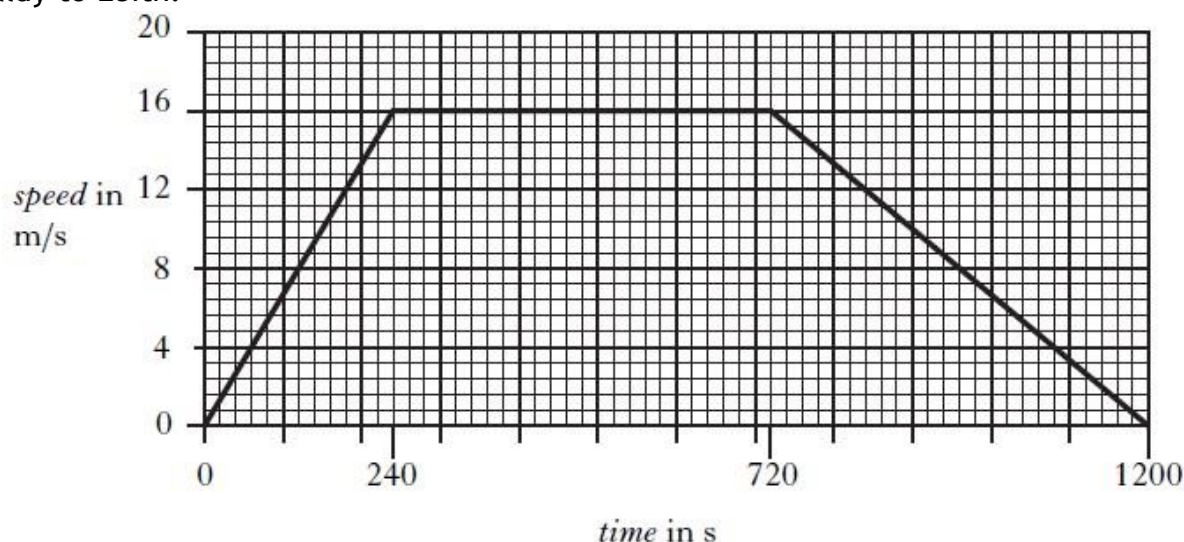
3



5. A hovercraft service was trialled on the Firth of Forth from Kirkcaldy to Leith.



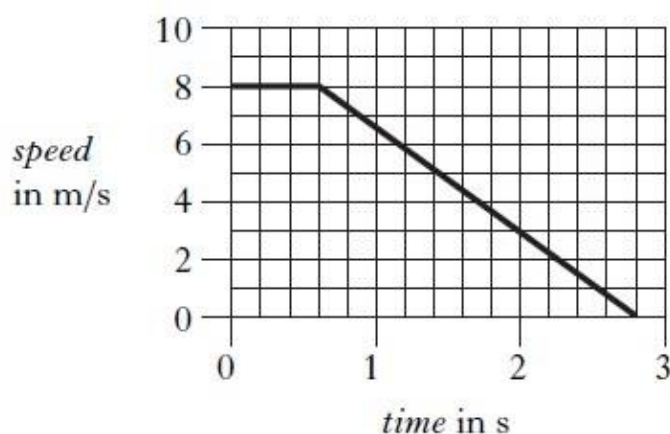
The graph shows how the speed of the hovercraft varies with time for one journey from Kirkcaldy to Leith.



- (a) Calculate the total distance travelled during the journey. 3
- (b) Calculate the average speed for the whole journey. 3

2010 C 10a

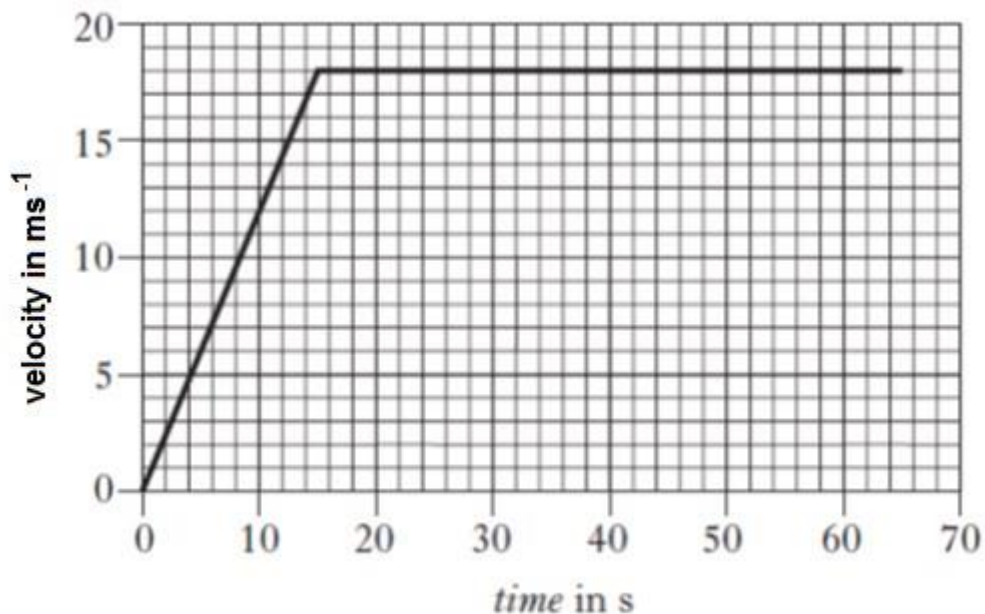
6. A cyclist is approaching traffic lights at a constant speed. The cyclist sees the lights change to red. The graph shows how the speed of the cyclist varies with time from the instant the cyclist sees the lights change to red.



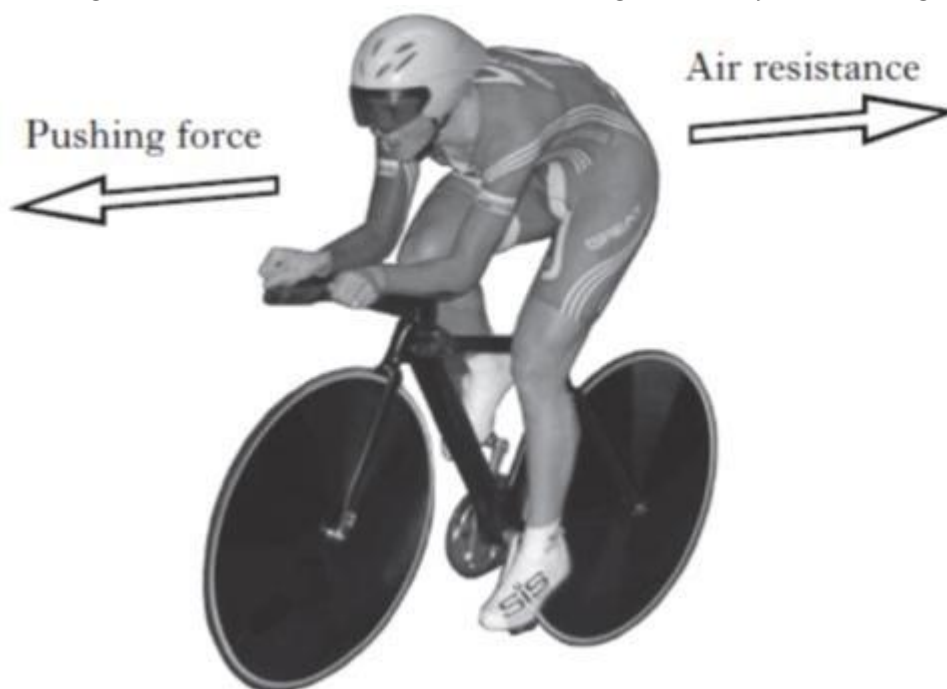
- (a) How long did it take for the cyclist to react before applying the brakes? 1
- (b) Calculate the distance travelled from the instant the cyclist sees the traffic lights change to red until stationary. 3



1. A competitor takes part in a cycling event along a straight road.  
The cyclist takes 65 s to complete the race.  
The graph below shows how the cyclist's velocity changes with time during the race.

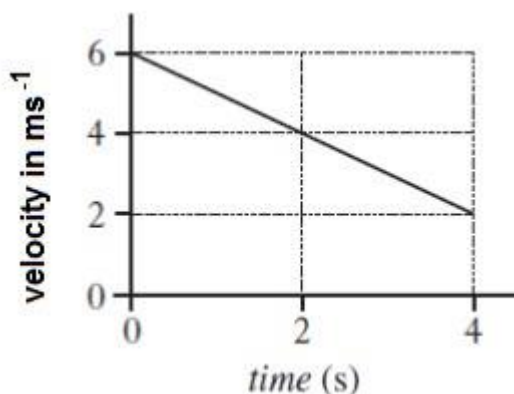


- (a) Calculate the acceleration of the cyclist during the first 15 s of the race. 3
- (b) Calculate the displacement of the cyclist during the race. 3
- (c) The diagram shows some of the forces acting on the cyclist during the race.



- (i) Suggest one way in which the cyclist reduces air resistance. 1
- (ii) Suggest one place where the cyclist requires friction. 1

2. The graph shows how the velocity of a ball changes with time.



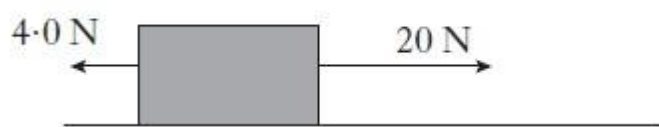
The acceleration of the ball is:

- A  $-8 \text{ ms}^{-2}$
- B  $-1 \text{ ms}^{-2}$
- C  $1 \text{ ms}^{-2}$
- D  $8 \text{ ms}^{-2}$
- E  $24 \text{ ms}^{-2}$

1

2012 Int2 4 MC

3. The diagram shows the horizontal forces acting on a box.



The box accelerates at  $1.6 \text{ m s}^{-2}$ . The mass of the box is

- A 0.10 kg
- B 10.0 kg
- C 15.0 kg
- D 25.6 kg
- E 38.4 kg

1

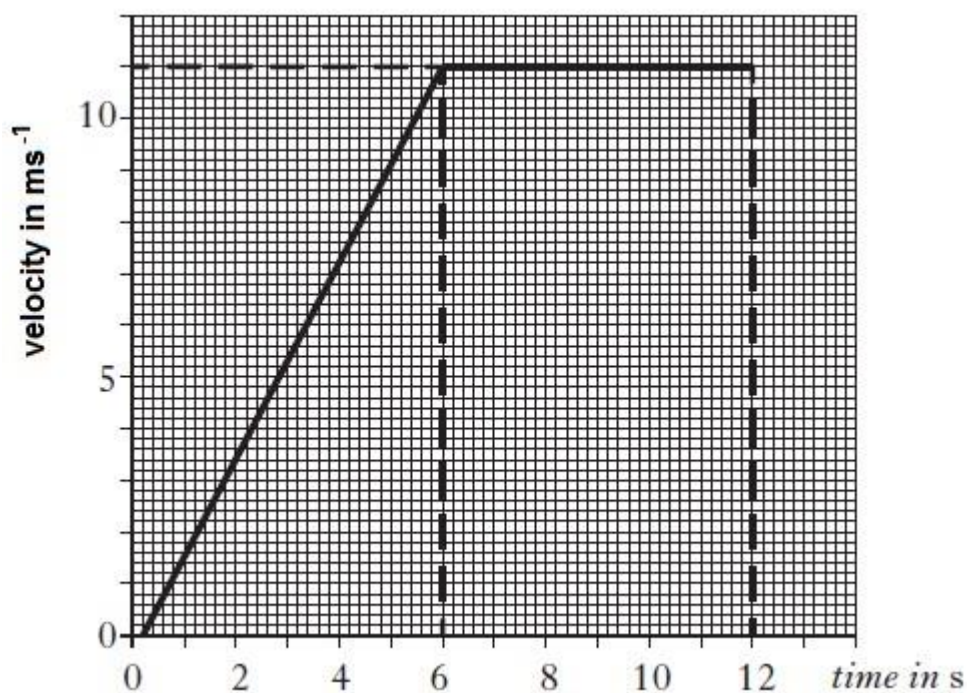
2007 Int2 22bi

4. A cyclist approaches traffic lights at a speed of  $8 \text{ m/s}$ . He sees the traffic lights turn red and he applies the brakes. He comes to rest in  $2.5 \text{ s}$ .

Calculate the acceleration of the cyclist whilst braking.

3

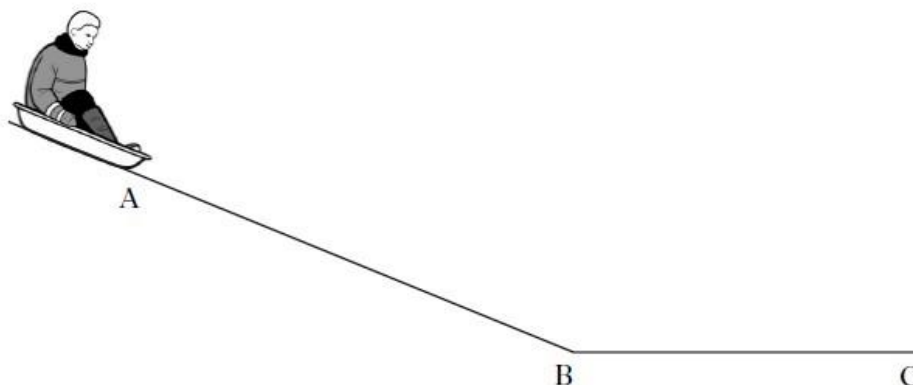
5. The graph shows the motion of a runner in the first 12 s of a race.



- (a) Calculate the acceleration of the runner. 3
- (b) Calculate the displacement of the runner in the first 12 s. 3

2009 Int2 22ac

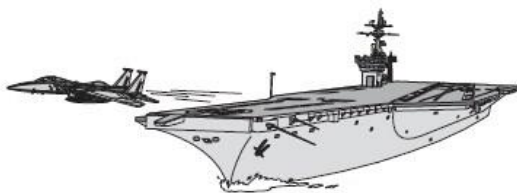
6. A child sledges down a hill.



The sledge and child are released from rest at point A. They reach a speed of  $3 \text{ ms}^{-1}$  at point B.

- (a) The sledge and child take 5 s to reach point B.  
Calculate the acceleration. 3
- (b) After the sledge and child pass point B, they slow down, coming to a halt at point C.  
Explain this motion in terms of forces. 2

7. An aeroplane on an aircraft carrier must reach a minimum speed of  $70 \text{ ms}^{-1}$  to safely take off.



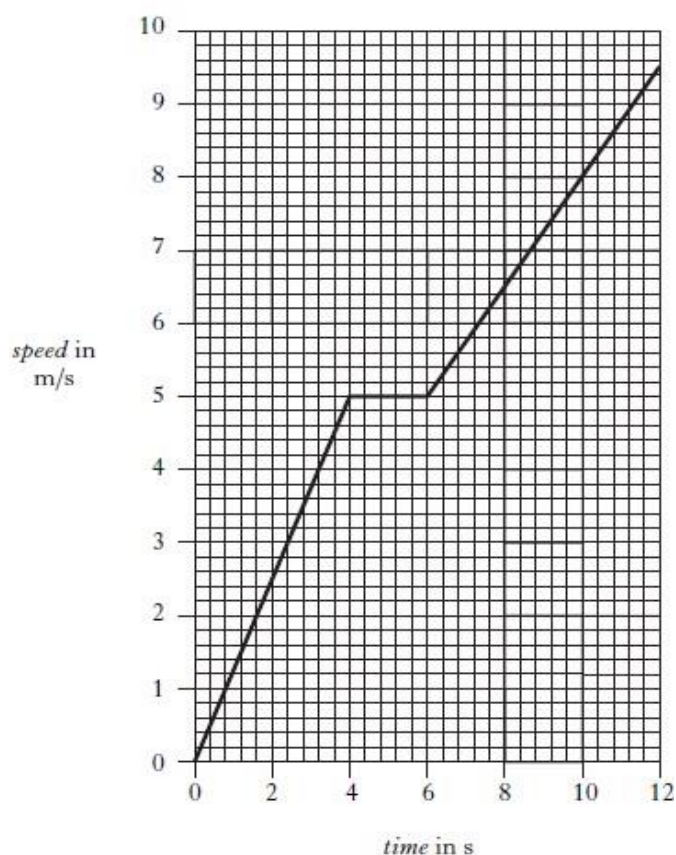
The aeroplane accelerates from rest to its minimum take off speed in 2 s.  
Calculate the acceleration of the aeroplane.

3

8. A windsurfer takes part in a race.



The graph shows how the speed of the windsurfer and board changes with time during part of the race.



Calculate the acceleration of the windsurfer and board during the first 4 s of the race. 3

1.

The first manned space flights took place 50 years ago. Spacecraft were launched into space using powerful rockets.



- (a) The operation of a rocket engine can be explained using Newton's Third Law of Motion.

(i) State Newton's Third Law of Motion.

1

(ii) Explain, in terms of Newton's Third Law, how the rocket engines propel the rocket upwards.

1

- (b) At lift-off, one rocket has a total mass of  $2.05 \times 10^6$  kg. The resultant force acting upwards on the rocket is  $8.2 \times 10^6$  N.

Calculate the acceleration of the rocket at lift-off.

3

**2011 Int2 4 MC**

2. An engine applies a force of 2000 N to move a lorry at a constant speed. The lorry travels 100 m in 16 s. The power developed by the engine is

A 0.8 W  
B 12.5 W  
C 320 W  
D 12500 W  
E 3200000 W

1

3. Near the Earth's surface, a mass of 6 kg is falling with a constant velocity. The air resistance and the unbalanced force acting on the mass are:

	Air resistance	Unbalanced force
A	60 N upwards	0N
B	10 N upwards	10 N downwards
C	10 N downwards	70 N downwards
D	10 N upwards	0 N
E	60 N upwards	60 N downwards

1

4. In 2014 the European Space Agency will fly a manned mission to the International Space Station (ISS).



A spacecraft with booster rockets attached will be launched.

- (a) On the diagram above draw and label the two forces acting on the spacecraft at lift off. 1
- (b) The combined mass of the spacecraft and booster rockets is  $3.08 \times 10^5$  kg and the initial thrust on the rocket at lift off is 3352 kN. The frictional forces acting on the rocket at lift off are negligible.
- (i) Calculate the weight of the spacecraft and booster rockets at lift off. 3
- (ii) Calculate the acceleration of the spacecraft and booster rockets at lift off. 4
- (c) The ISS orbits at a height of approximately 360 km above the Earth. Explain why the ISS stays in orbit around the Earth. 2
- (d) An astronaut on board the ISS takes part in a video link-up with a group of students. The students see the astronaut floating.
- (i) Explain why the astronaut appears to float. 1
- (ii) The astronaut then pushes against a wall and moves off. Explain in terms of Newton's Third Law why the astronaut moves. 1

5. A space probe has a mass of 60 kg. The weight of the space probe at the surface of a planet in our solar system is 660 N.
- The planet is
- A Venus
  - B Mars
  - C Jupiter
  - D Saturn
  - E Neptune

1

6. A block is pulled across a horizontal surface as shown.



The mass of the block is 5 kg. The block is travelling at a constant speed. The force of friction acting on the block is

- A 0 N
- B 4 N
- C 15 N
- D 20 N
- E 25 N

1

7. A crate of mass 200 kg is pushed a distance of 20 m across a level floor. The crate is pushed with a force of 150N. The force of friction acting on the crate is 50N. The work done in pushing the crate across the floor is
- A 1000 J
  - B 2000 J
  - C 3000 J
  - D 4000 J
  - E 20 000 J

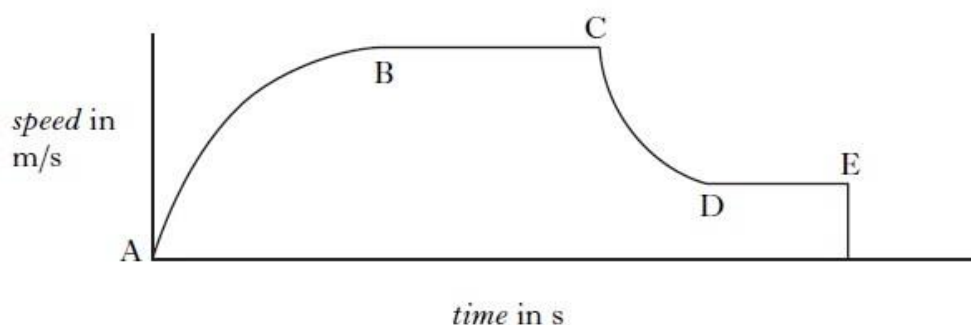
1



8. A parachutist jumps out of an aircraft. Sometime later, the parachute is opened.



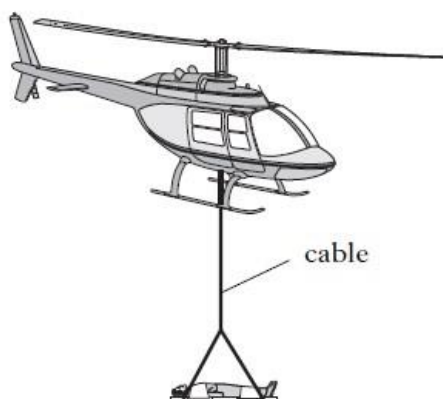
The graph shows the motion of the parachutist from leaving the aircraft until landing.



- (a) Which parts of the graph show when the forces acting on the parachutist are balanced?

1

- (b) The parachutist lands badly and is airlifted to hospital by helicopter. The stretcher and parachutist have a total mass of  $90.0 \text{ kg}$ .

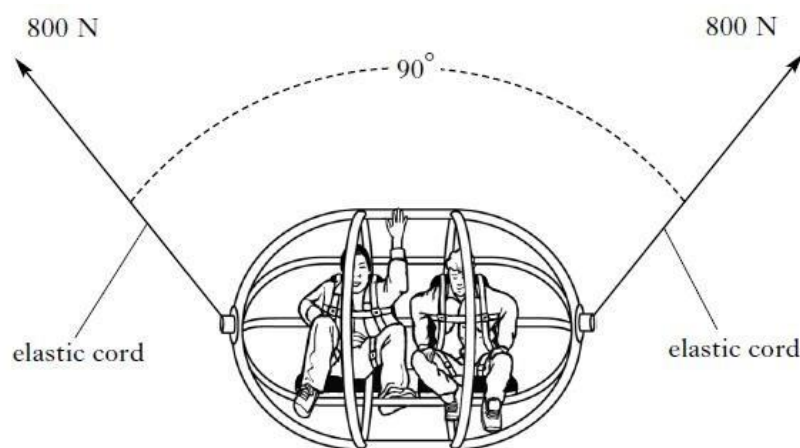


- (i) Calculate the weight of the stretcher and parachutist.
- (ii) The helicopter cable provides an upward force of  $958.5 \text{ N}$  to lift the stretcher and parachutist. Calculate the acceleration of the stretcher and parachutist.

3

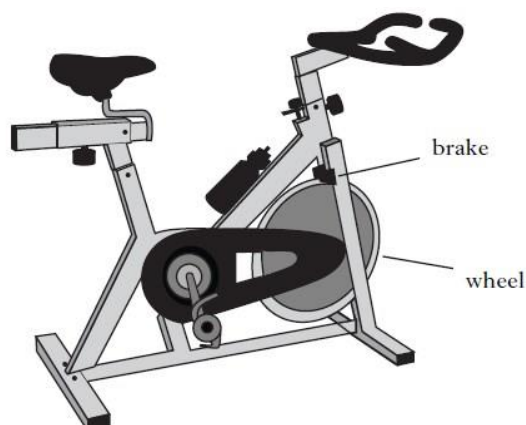
5

9. A fairground ride uses a giant catapult to launch people upwards using elastic cords.



- (a) Each cord applies a force of 800N and the cords are at  $90^\circ$  as shown. Using a scale diagram, or otherwise, find the size of the resultant of these two forces. 2
- (b) The cage is now pulled further down before release. The cords provide an upward resultant force of 2700N. The cage and its occupants have a total mass of 180 kg.
- (i) Calculate the weight of the cage and occupants. 3
- (ii) Calculate the acceleration of the cage and occupants when released. 3

10. One type of exercise machine is shown below.



- (a) A person using this machine pedals against friction forces applied to the wheel by the brake. A friction force of 300N is applied at the edge of the wheel, which has a circumference of 1.5m.
- (i) How much work is done by friction in one turn of the wheel?

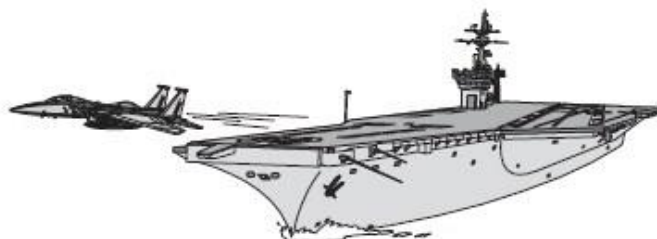
11.

A cyclist is waiting at a red traffic light. She sees the traffic lights change to green and accelerates away from the lights. The combined mass of the cycle and cyclist is 75 kg. An unbalanced force of 150 N acts on this combined mass. Calculate the acceleration.

3

2007 C 11a

12. An aeroplane on an aircraft carrier must reach a minimum speed of  $70 \text{ ms}^{-1}$  to safely take off. The mass of the aeroplane is 28 000 kg.

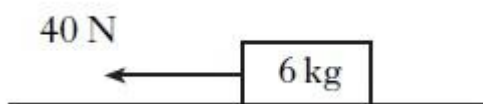


The aeroplane accelerates from rest to its minimum take off speed in 2 s.

- (a) Calculate the acceleration of the aeroplane. 3
- (b) Calculate the force required to produce this acceleration. 3
- (c) The aeroplane's engines provide a total thrust of 240 kN. An additional force is supplied by a catapult to produce the acceleration required. Calculate the force supplied by the catapult. 2

2007 Int2 6 MC

13. A block of mass 6 kg is pulled across a horizontal bench by a force of 40 N as shown below.



The block accelerates at  $4 \text{ ms}^{-2}$ .

The force of friction between the block and the bench is

- A zero  
B 16N  
C 24N  
D 40N  
E 64N.

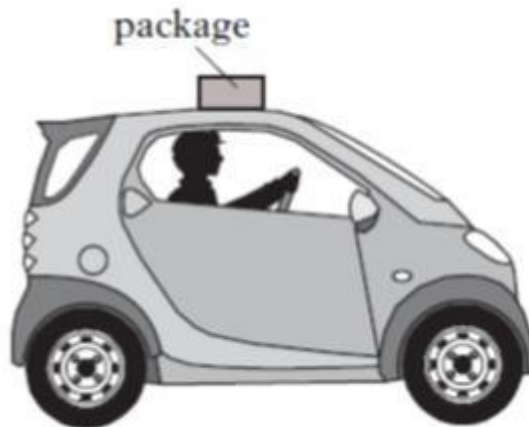
2007 Int2 27b

14. As a raindrop falls it reaches a steady speed. Using Newton's laws of motion, explain why it falls at a steady speed. 2

## Projectile Motion

2011 C 13

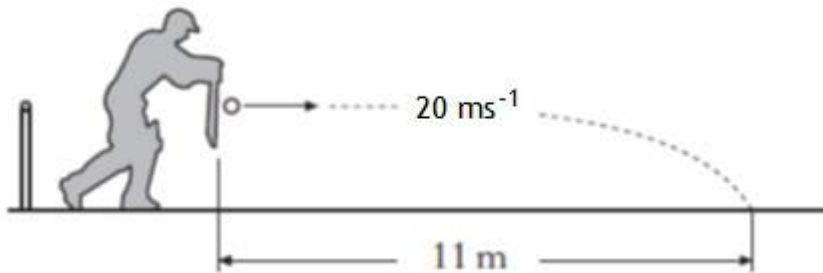
1. A car driver exits a car park having accidentally left a package resting on the roof of the car. The car is travelling at a constant velocity of  $15 \text{ m s}^{-1}$  when the driver brakes suddenly and the car stops. The package continues to move forward.



- (a) (i) On the above diagram sketch the path taken by the package. 1
- (ii) Explain why the package follows this path. 2
- (b) The package takes  $0.55 \text{ s}$  to fall to the ground. Calculate its vertical velocity as it reaches the ground. 4

2011 Int2 21

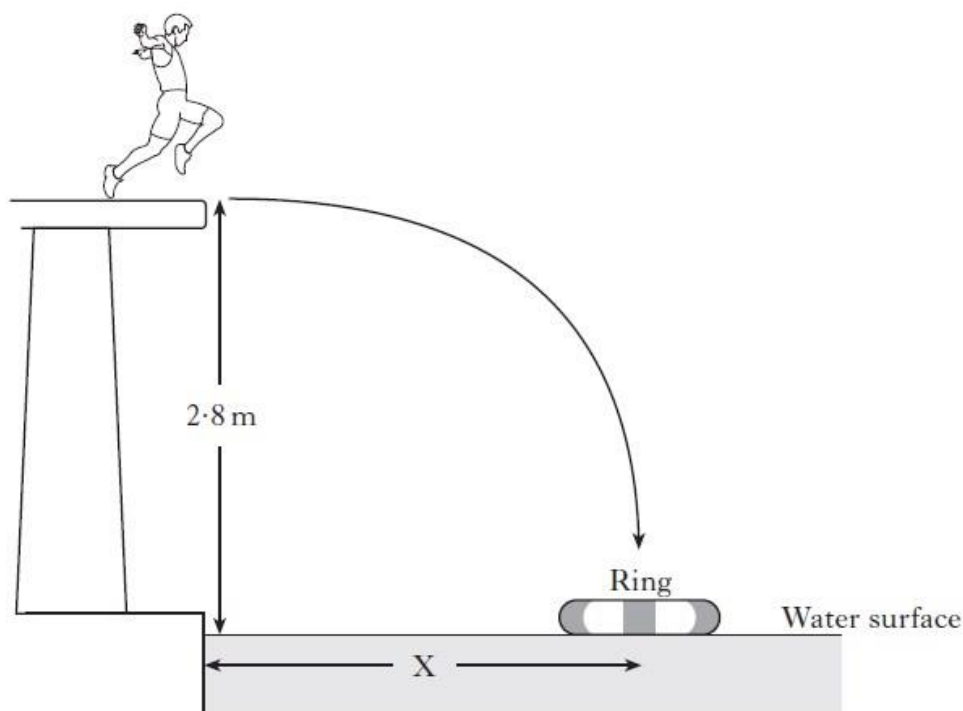
2. A cricketer strikes a ball. The ball leaves the bat horizontally at  $20 \text{ m s}^{-1}$ . It hits the ground at a horizontal displacement of  $11 \text{ m}$  from the point where it was struck.



Assume that air resistance is negligible.

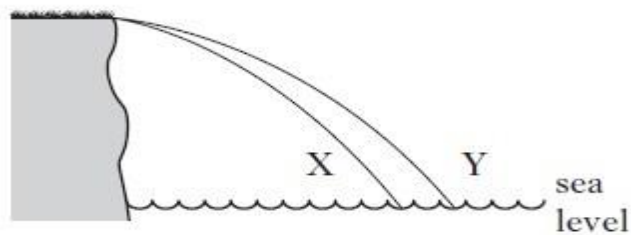
- (a) Calculate the time of flight of the ball. 3
- (b) Calculate the vertical velocity of the ball as it reaches the ground. 3
- (c) Sketch a graph of vertical velocity against time for the ball. Numerical values are required on both axes. 2
- (d) Calculate the vertical displacement of the ball during its flight. 3

3. In a TV game show contestants are challenged to run off a horizontal platform and land in a rubber ring floating in a swimming pool. The platform is 2.8 m above the water surface.



- (a) A contestant has a mass of 60 kg.  
He runs off the platform with a horizontal velocity of  $2 \text{ m s}^{-1}$ .  
He takes  $0.76 \text{ s}$  to reach the water surface in the centre of the ring.
- (i) Calculate the horizontal displacement  $X$  from the poolside to the centre of the ring. 3
- (ii) Calculate the vertical velocity of the contestant as he reaches the water surface. 3
- (b) Another contestant has a mass of 80 kg.
- (i) State if she will need to run faster, slower or at the same horizontal velocity as the first contestant to land in the ring. 1
- (ii) You must explain your answer to (b) (i). 1

4. Two identical balls X and Y are projected horizontally from the edge of a cliff. The path taken by each ball is shown.



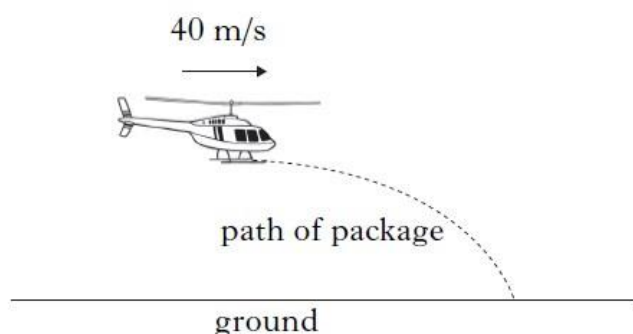
A student makes the following statements about the motion of the two balls.

- I They take the same time to reach sea level.
- II They have the same vertical acceleration.
- III They have the same horizontal velocity.

Which of these statements is/are correct?

- A I only
- B II only
- C I and II only
- D I and III only
- E II and III only

5. A package is released from a helicopter flying horizontally at a constant speed of  $40 \text{ ms}^{-1}$ .



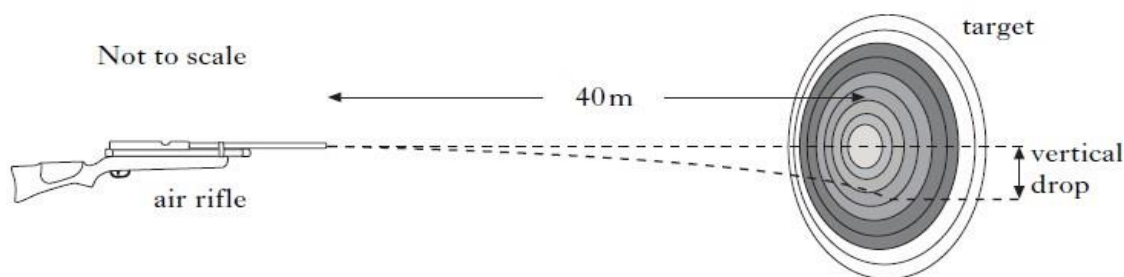
The package takes  $3.0 \text{ s}$  to reach the ground.

The effects of air resistance can be ignored.

Which row in the table shows the horizontal speed and vertical speed of the package just before it hits the ground?

	Horizontal speed ( $\text{ms}^{-1}$ )	Vertical speed ( $\text{ms}^{-1}$ )
A	0	30
B	30	30
C	30	40
D	40	30
E	40	40

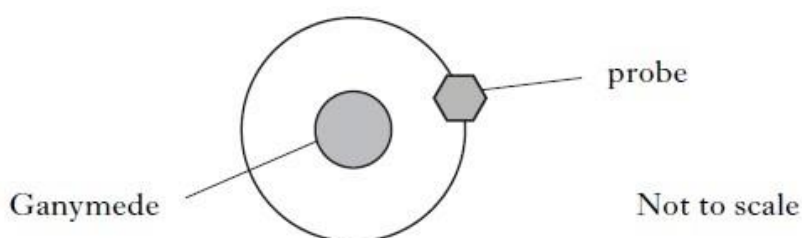
6. At a firing range a pellet is fired horizontally at a target 40 m away. It takes 0.20 s to reach the target.



Calculate the **vertical** velocity of the pellet on reaching the target.

3

7. A space probe is in orbit around Ganymede, a moon of Jupiter.

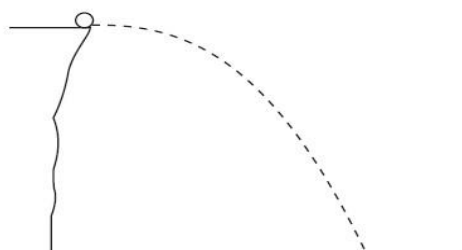


- (a) Explain why the probe follows a circular path while in orbit.
- (b) The probe has gas thrusters that fire to slow it down in order to land on Ganymede. In terms of Newton's laws, explain how these thrusters achieve this task.

2

2

8. A ball is thrown horizontally from a cliff as shown.



The effect of air resistance is negligible.

A student makes the following statements about the ball.

- I The vertical speed of the ball increases as it falls.
- II The vertical acceleration of the ball increases as it falls.
- III The vertical force on the ball increases as it falls.

Which of the statements is/are correct?

- A I only
- B II only
- C I and II only
- D II and III only
- E I, II and III

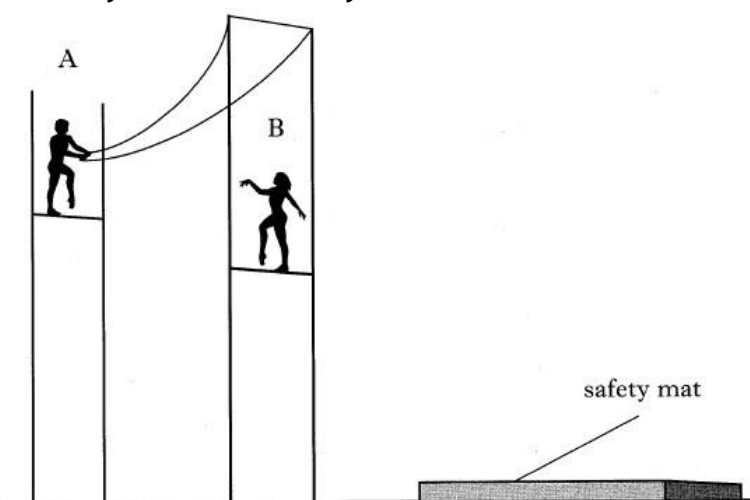
1



9. In June 2005, a space vehicle called Mars Lander was sent to the planet Mars. The Mars Lander released a rover exploration vehicle on to the surface of Mars. To collect data from the bottom of a large crater, the rover launched a probe horizontally at  $30 \text{ ms}^{-1}$ . The probe took 6 s to reach the bottom of the crater. (The gravitational field strength on the surface of Mars is  $4 \text{ N kg}^{-1}$ .)

- (a) Calculate the horizontal distance travelled by the probe. 3
- (b) Calculate the vertical speed of the probe as it reached the bottom of the crater. 3

10. In a circus trapeze act, gymnast A swings down on the trapeze and collides with gymnast B. At the point of the collision, gymnast A lets go of the trapeze and the two gymnasts move off together with a horizontal velocity of  $4.8 \text{ ms}^{-1}$ . They fall together for 0.65 s until they land on a safety mat.



- (a) Calculate the horizontal distance they travel until they reach the mat. 3
- (b) Calculate the vertical speed with which they strike the mat. 3

11. A seagull, flying horizontally at  $8 \text{ ms}^{-1}$  drops a piece of food. What will be the horizontal and vertical speeds of the food when it hits the ground 2.5 s later. Air resistance should be ignored.

1

	Horizontal speed ( $\text{ms}^{-1}$ )	Vertical speed ( $\text{ms}^{-1}$ )
A	0	8
B	8	20
C	8	25
D	25	25
E	33	50

## Space Exploration

2001 G 16b

1. A telescope consists of two lenses, X and Y, in a light tube.



Complete the following statements about the lenses in this telescope, using the words or phrases from the list.

**eyepiece   objective   magnify   collect light**

- (a) Lens X is called the ..... lens. Its purpose is to ..... 1

- (b) Lens Y is called the ..... lens. Its purpose is to ..... and produce an image of the object. 1

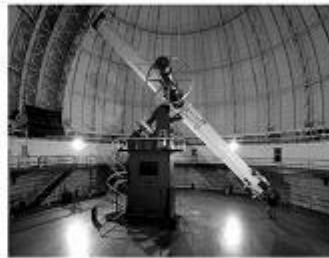
## Cosmology

2012 C 14

1. The Mills Observatory in Dundee and the Yerkes Observatory in Wisconsin, USA both have refracting telescopes.



Mills Observatory Telescope

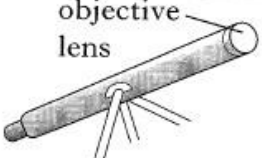
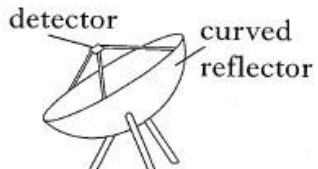
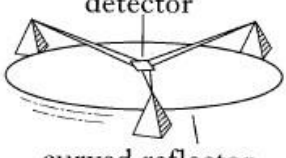


Yerkes Observatory Telescope

Astronomers in both observatories are studying the Andromeda galaxy which is approximately 2.2 million light years away.

- (a) A light year is defined as “the distance that light travels in one year”.  
Show by calculation that 1 light year =  $9.4608 \times 10^{15}$  m. 3
- (b) Not all telescopes detect visible light.  
Why are different kinds of telescope used to detect signals from space? 1

2. The table below has information about three telescopes used to detect radiation from space.

	Refracting telescope in Edinburgh, with a 150 mm diameter objective lens.
	Radio telescope at Jodrell Bank, with a curved reflector of diameter 76 m.
	Radio telescope at Arecibo, Puerto Rico, with a curved reflector of diameter 300 m.

- (a) What type of radiation is detected by a refracting telescope? 1
- (b) Why are different types of telescope used to detect radiation from space? 1
- (c) In a radio telescope, where is the detector placed in relation to the curved reflector? 1
- (d) Explain which of the three telescopes above is best for detecting very weak radio signals from deep space. 2

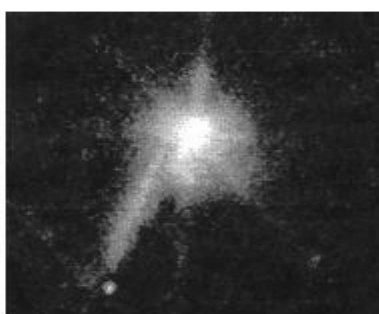
2008 C 14ab

3. A team of astronomers observes a star 200 light-years away.

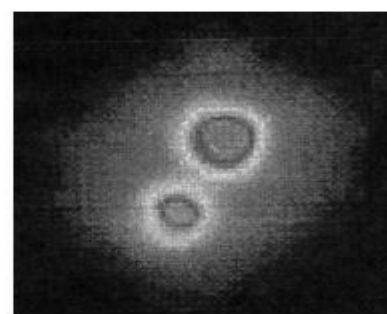
- (a) State what is meant by the term “light-year”. 1
- (b) Images of the star are taken with three different types of telescope as shown.



Telescope A  
visible light



Telescope B  
infrared



Telescope C  
X-ray

- (i) Explain why different types of telescope are used to detect signals from space. 2
- (ii) Place the telescopes in order of the increasing wavelength of the radiation which they detect. 1
- (iii) State a detector that could be used in telescope C. 1

4. Radio waves emitted by galaxies are detected and used to provide images of the galaxies.
- (a) How does the wavelength of radio waves compare with the wavelength of light? 1
- (b) Name a detector for radio waves. 1
- (c) Why are different kinds of telescope used to detect signals from space? 1

5. Some spectral lines of radiation from a distant star are shown below.



Spectral lines of radiation from distant star

The spectral lines of a number of elements are also shown.

Cadmium



Calcium



Krypton



Mercury

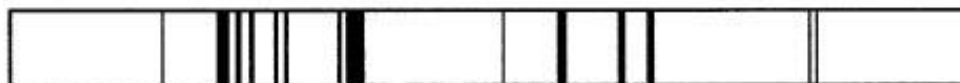


Use the spectral lines of the elements shown above to identify which of these elements are present in the distant star.

2

6. Early in 2005, a probe was released from a spacecraft which was orbiting Titan, a moon of Saturn.

The probe carried equipment to analyse the spectral lines of radiation from gases in the atmosphere of Titan. These lines are shown below.



Spectral lines from gases in Titan's atmosphere

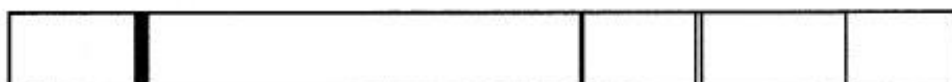
The spectral lines of a number of elements are also shown.



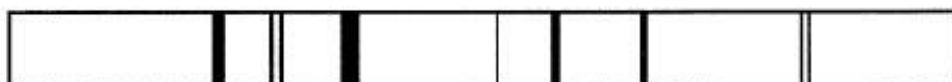
Helium



Hydrogen



Mercury



Nitrogen

Use the spectral lines of the elements to identify which elements are present in the atmosphere of Titan.

1

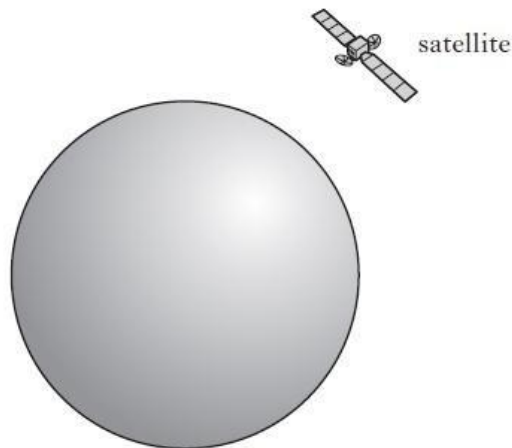
7. Light from a star produces a line spectrum.  
What information is obtained about the star from this spectrum?

1

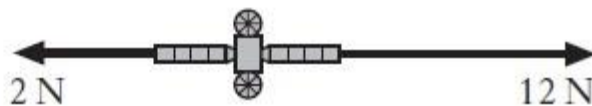
**Various**

**2011 Int2 22**

1. A satellite moves in a circular orbit around a planet. The satellite travels at a constant speed whilst accelerating.



- (a) (i) State the meaning of the term acceleration. 1
- (ii) Explain how the satellite can be accelerating when it is travelling at a constant speed. 1
- (b) At one particular point in its orbit the satellite fires two rockets. The forces exerted on the satellite by these rockets are shown on the diagram.

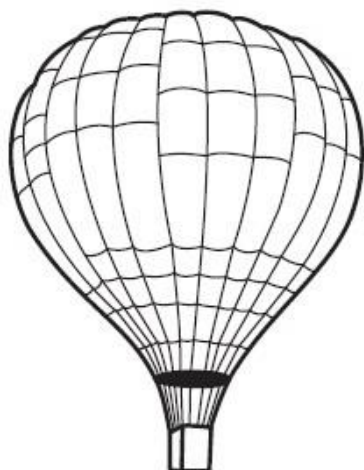


The satellite has a mass of 50 kg.

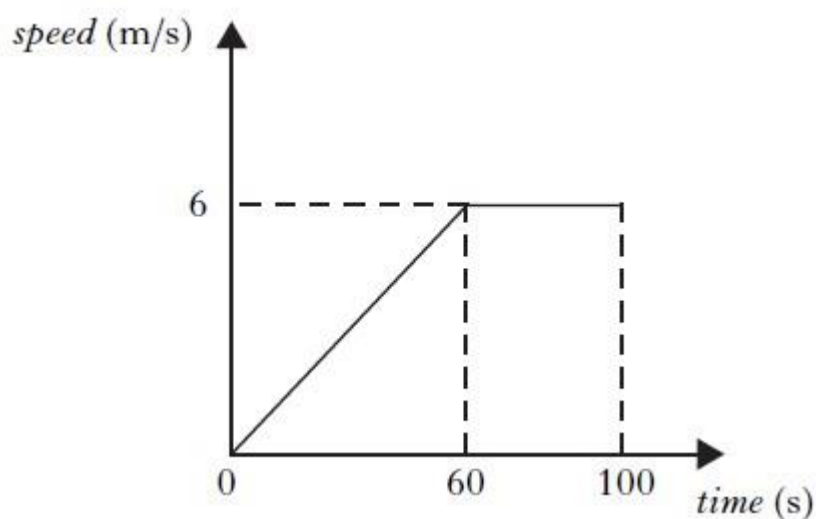
Calculate the resultant acceleration due to these forces.

4

2. A balloon of mass 400kg rises vertically from the ground.



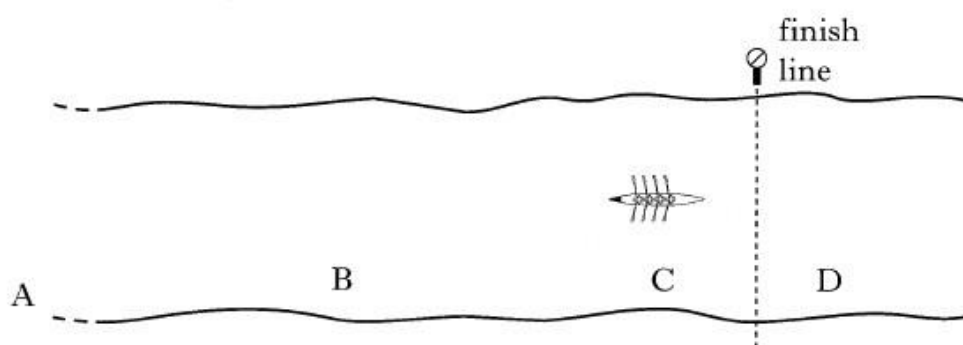
The graph shows how the vertical speed of the balloon changes during the first 100 s of its upward flight.



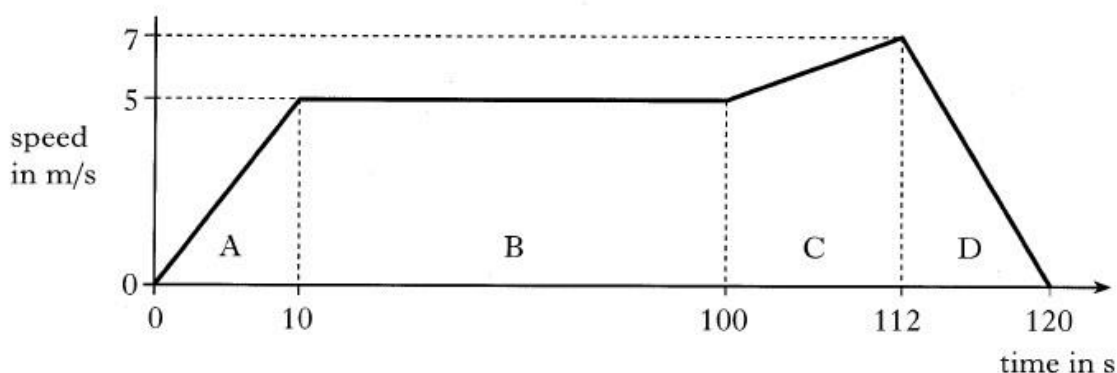
- |   |   |
|---|---|
| (a) Calculate the acceleration of the balloon during the first 60 s.                            | 3 |
| (b) Calculate the distance travelled by the balloon in 100 s.                                   | 3 |
| (c) Calculate the average speed of the balloon during the first 100 s.                          | 3 |
| (d) Calculate the weight of the balloon.  | 3 |
| (e) Calculate the total upward force acting on the balloon during the first 60 s of its flight. | 4 |



3. A rowing team is taking part in a race on calm water.



The following graph shows how it is predicted that the speed of the boat will vary with time during the stages A, B, C and D of the race.

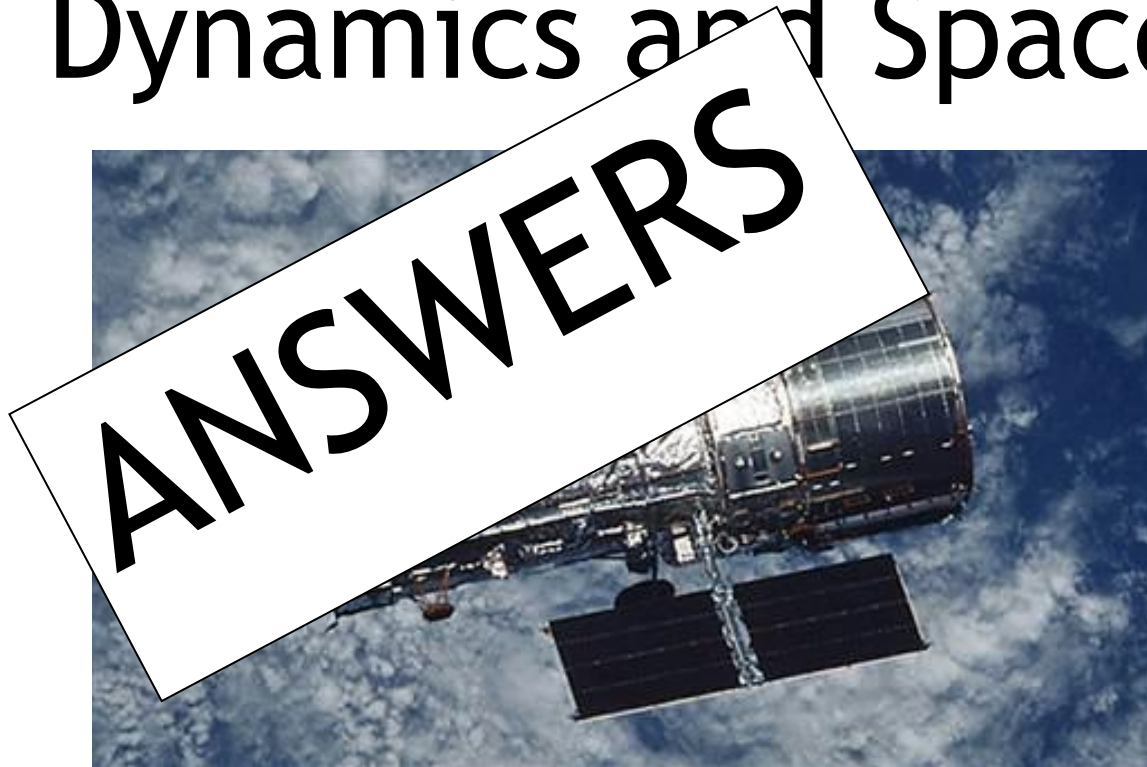


The prediction assumes that the frictional force on the team's boat remains constant at 800 N during the race.

- (a) (i) State the size of the forward force applied by the oars during stage B. 1
- (ii) Calculate the acceleration of the boat during stage C. 3
- (iii) The total mass of the boat and its crew is 400kg.  
Calculate the size of the forward force applied by the oars during stage C. 5
- (iv) The boat crosses the finishing line after 112 seconds.  
Calculate the distance the boat travels **from the instant it crosses the line until it comes to rest.** 3
- (b) The frictional force acting on the boat during stage D actually becomes smaller as the speed decreases. as
- (i) What will be the effect of this smaller frictional force on the time taken for the boat to come to rest? 1
- (ii) Sketch a graph of speed against time for stage D, assuming that the frictional force becomes smaller as the speed decreases. 1

# NATIONAL 5 PHYSICS

## Unit 3 Dynamics and Space



## Exam Questions

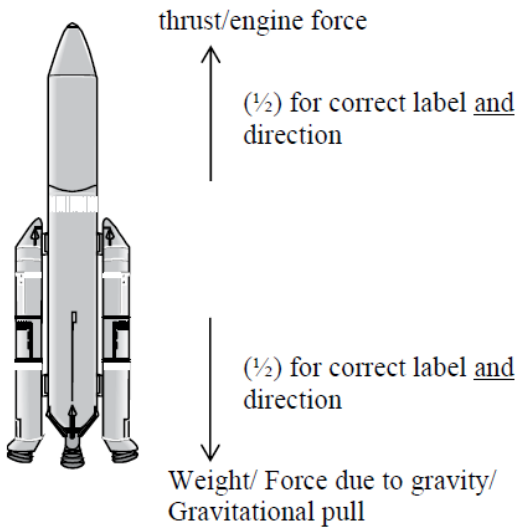
VELOCITY AND DISPLACEMENT				
1		D	1	
2		B	1	
3		D	1	
4		E	1	
5		B	1	
6		E	1	
7		E	1	
8		C	1	
VELOCITY TIME GRAPHS				
1	(a)	It is accelerating OR Speeding up (NOT 'going down the flume')	1	DO NOT accept "goes faster"
	(b)	distance = area under graph (1) = $(\frac{1}{2} \times 7.5 \times 5) + (20 \times 5)$ (1) = $18.75 + 100$ = $118.75 \text{ m}$ (1)	3	(0) marks for $d = vt$ Can award (1) for implied relationship if addition of areas is attempted No significant figure penalty (exact answer)
	(c)	$a = (v-u)/t$ (1) $a = 10/5$ (1) $a = 2.0 \text{ ms}^{-2}$ (1)	3	
2		$d = \text{area under graph}$ (1) $d = (0.5 \times 9 \times 2) + (10 \times 9) + (0.5 \times 9 \times 1)$ (1) $d = 9 + 90 + 4.5$ $d = 103.5 \text{ m}$ (1)	3	
3	(a)	(b) <p>axes (1) shape (1) values (1)</p>	3	
	(b)	distance = area under graph (1) = $(8 \times 3) + (\frac{1}{2} \times 2.5 \times 8)$ (1) = $34 \text{ m}$ (1)	3	
4		distance = area under graph (1) = $(\frac{1}{2} \times 4 \times 5) + (8 \times 5) + (\frac{1}{2} \times 6 \times 4.5)$ (1) = $63.5 \text{ m}$ (1)	3	
5	(a)	distance = area under graph (1) = $(\frac{1}{2} \times 240 \times 16) + (480 \times 16) + (\frac{1}{2} \times 480 \times 16)$ (1) = $13440 \text{ m}$ (1)	3	
	(b)	$v = d/t$ (1) = $13440/1200$ (1) = $11.2 \text{ ms}^{-1}$ (1)	3	

<b>6</b>	(a)	0.6 s	1	
	(b)	distance = area under graph (1) = (8 x 0.6) + ( $\frac{1}{2} \times 8 \times 2.2$ ) (1) = 13.6 m (1)	3	

ACCELERATION				
1	(a)	$a = (v-u)/t$ (1) $= (18-0)/15$ (1) $= 1.2 \text{ m s}^{-2}$ (1)	3	If wrong values extracted from graph then (1) MAX for equation deduct (1) for wrong/missing unit Do not accept $a = v/t$ as wrong equation- stop marking and award (0) marks
	(b)	$s = \text{area under graph}$ (1) $= (1/2 \times 15 \times 18) + (50 \times 18)$ (1) $= 1035 \text{ m}$ (1)	3	If wrong substitution then (1) MAX Deduct (1) for wrong/missing unit.
	(c) (i)	<ul style="list-style-type: none"> <li>• (wear) tight fitting clothes</li> <li>• Crouch</li> <li>• (wear) streamlined helmet</li> <li>• Streamlined shoes</li> <li>• Solid wheels</li> </ul>	1	Question refers to the cyclist in picture so answer should refer to this Not: 'Pushes forward'
	(ii)	<ul style="list-style-type: none"> <li>• Tyres</li> <li>• (handle) grips</li> <li>• Brakes</li> <li>• Shoes on pedals</li> <li>• Saddle</li> </ul>	1	Not: Wheels
2		B	1	
3		B	1	
4		$a = \frac{v-u}{t}$ (1)		
5	(a)	<del><math>a = \frac{v-u}{t}</math></del> (1) <del><math>= \frac{18-0}{2.5}</math></del> <del><math>= 113.20 \text{ m s}^{-2}</math></del> (1)	3	If wrong values extracted from graph then (1) MAX for equation.
		<del>5.8</del> $= 1.9 \text{ m s}^{-2}$ (1)	3	If $t = 6$ then wrong substitution award (1) mark max Deduct (1) for wrong/missing unit. Do not accept $a = v/t$ as this is the wrong equation - stop marking and award (0) sig. fig. range 1–4 1.9, 1.90, 1.897, 2
	(b)	displacement = area under graph (1) $= \frac{1}{2} \times (11 \times 5.8) + (11 \times 6)$ (1) $= 31.9 + 66$ $= 97.9 \text{ m}$ (1)	3	Any attempt to use $s = vt$ applied to the graph is wrong physics (0) marks. If first time $\neq 5.8$ then (1) mark max for implied equation. sig. fig. range 1–3 97.9, 98, 100

<b>6</b>	(a)	$a = \frac{v - u}{t} \quad (1)$ $= \frac{3 - 0}{5} \quad (1)$ $= 0.6 \text{ m s}^{-2} \quad (1)$	3	
	(b)	There is an unbalanced force/friction, (1) this acts against the motion. (1) (must have some mention of opposing the motion) Ignore mention of component of weight	2	
<b>7</b>		$a = \frac{v - u}{t} \quad (1)$ $= \frac{70 - 0}{2} \quad (1)$ $= 35 \text{ m s}^{-2} \quad (1)$	3	
<b>8</b>		$a = \frac{v - u}{t} \quad (1)$ $= \frac{5 - 0}{4} \quad (1)$ $= 1.25 \text{ m s}^{-2} \quad (1)$	3	

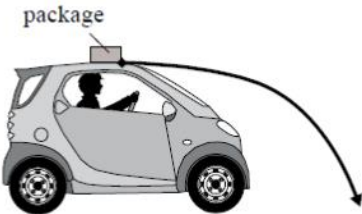
# NEWTON'S LAWS

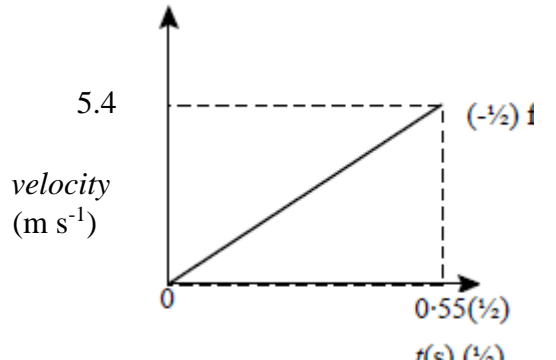
1	(a)	(i) If A exerts a force on B, B exerts an equal but opposite force on A. Or To every action (force) there is an equal and opposite reaction (force)	1	Must show a good attempt at stating Law
		(ii) Engine/exhaust gases pushed down(A on B); gases push rocket up (B on A)	1	Must refer to engine/exhaust gases
	(b)	$F_{UN} = ma \quad (1)$ $8200000 = 2.05 \times 10^6 \times a \quad (1)$ $a = 4 \text{ ms}^{-2} \quad (1)$	3	
2		D	1	
3		A	1	
4	(a)		1	<p>Must have correct label <u>and</u> direction. Accept:</p> <ul style="list-style-type: none"> <li>• Upthrust</li> <li>• Upward thrust</li> <li>• Upwards force</li> <li>• Force of gravity on the rocket</li> <li>• Force of gravity</li> </ul> <p>Do not accept:</p> <ul style="list-style-type: none"> <li>• Gravity alone,</li> </ul>
	(b)	$W = mg$		
	(i)	$= 3.08 \times 10^5 \times 9.8 \quad (1)$ $= 3.02 \times 10^6 \text{ N} \quad (1)$	3	

	(ii)	$F_{un} = 3352\,000 - 3020\,000 = 332\,000\text{ (N)}$ (1) $F = ma$ ( $\frac{1}{2}$ ) (1) $332\,000 = 3.08 \times 10^5 \times a$ (1) $a = 1.08\text{ m s}^{-2}$ (1)	4	<p>or consistent with answer in 13(b)(i)</p> <p>If arithmetic error can be seen in subtraction to get <math>F_{un}</math> then deduct (1) mark. Candidate can still get next (3) marks.</p> <p><b>If no subtraction is attempted</b> and 3352000 or answer from 13(b)(i) is used in calculation for acceleration then (1) MAX for equation.</p> <p>sig. fig. range 2–5 1.1, 1.08, 1.078, 1.0779</p>
	(c)	It moves with constant speed in the horizontal direction (1) while accelerating due to the force of gravity in the vertical direction (1)	2	<p>Answer should be based on the following two points:</p> <ul style="list-style-type: none"> <li>statement relating to horizontal motion:</li> </ul> <p>eg ‘ISS moves forward’ OR curvature of the earth, OR ‘surface curves away’. (1)</p> <ul style="list-style-type: none"> <li>statement relating to vertical motion eg ‘falling (towards the Earth)’, or force of gravity (1)</li> </ul> <p>Accept:</p> <ul style="list-style-type: none"> <li>pull of gravity</li> </ul> <p>NOT ‘gravity’ alone</p>
	(d) (i)	<p>The astronaut is falling (towards Earth) at the same rate as the ISS</p> <p>OR</p> <p>The astronaut is in freefall</p>	1	<p>Answer must refer to the astronaut.</p> <p>Do not accept:</p> <p>a straight statement of Newton III</p>
	(ii)	The astronaut exerts a force against the wall and the wall exerts an equal and opposite force against the astronaut (causing him to move)	1	<p>Answer must refer to the astronaut.</p> <p>Do not accept:</p> <p>a straight statement of Newton III</p>
5		E	1	
6		D	1	
7		C	1	
8	(a)	BC and DE	1	Both parts needed



				Do not accept single letters e.g. B and D <b>NOT</b> 'where graph is flat/horizontal' <b>NOT</b> 'where speed is constant'
	(b) (i)	$W = m \times g$ (1) $= 90.0 \times 10$ (1) $= 900 \text{ N}$ (1)	3	Accept $g = 9.81$ : $W = 883 \text{ N}$ 2 – 5 sig fig {880, 883, 882.9, 882.90} Accept $g = 9.8$ : $W = 882 \text{ N}$ 1 – 4 sig fig {900, 880, 882, 882.0}
	(b) (ii)	$F_{\text{res}} = F_u - F_d$ (1) $= 958.5 - 900$ $= 58.5 \text{ N}$ (1)  $a = F_{\text{res}}/m$ (1) $= 58.5/90.0$ (1) $= 0.65 \text{ ms}^{-2}$ (1)	5	Accept answer for weight from b(i)  for $W = 880$ $a = 0.87 \text{ ms}^{-2}$ for $W = 882$ $a = 0.85 \text{ ms}^{-2}$ for $W = 882.9$ $a = 0.84 \text{ ms}^{-2}$ for $W = 883$ $a = 0.839 \text{ ms}^{-2}$
9	(a)	Scale diagram (1) 1131N (1) <b>OR</b> Resultant = $\sqrt{(800^2 + 800^2)}$ (1) $= 1131\text{N}$ (1)	2	
	(b) (i)	$W = mg$ (1) $= 180 \times 10$ (1) $= 1800 \text{ N}$ (1)	3	
	(b) (ii)	resultant = $2700 - 1800 = 900 \text{ N}$ (1) $a = F/m$ (1) $= 900/180$ (1) $= 5 \text{ ms}^{-2}$ (1)	4	
10		$E_w = F \times d$ (1) $E_w = 300 \times 1.5$ (1) $E_w = 450 \text{ J}$ (1)	3	
11		$a = F/m$ (1) $= 150/75$ (1) $= 2 \text{ ms}^{-2}$ (1)	3	
12	(a)	$a = (v-u)/2$ (1) $= (70 - 0)/2$ (1) $= 35 \text{ ms}^{-2}$ (1)	3	
	(b)	$F = ma$ (1) $= 28\,000 \times 35$ (1) $= 980\,000\text{N}$ (1)	3	
	(c)	additional force required = total force – aircraft thrust(1) $= 980\,000 - 240\,000$ $= 740\,000\text{N}$ (1)	2	
13		B	1	
14		two forces: air resistance and weight (1) balanced (1)	2	

PROJECTILE MOTION				
1	(a)		1	<p>(1) mark or zero.</p> <p>Sketch should show a reasonable <b>curve</b> from the package (to ground level).</p> <p>Straight line – zero marks.</p>
		<p>It moves with constant velocity in the horizontal direction (1)</p> <p>while accelerating due to the force of gravity in the vertical direction (1)</p>	2	<p>Answer should be based on the following two points:</p> <ul style="list-style-type: none"> <li>Statement relating to horizontal motion, eg ‘package moves forward’, or ‘package continues at a constant velocity’ (1)</li> <li>Statement relating to vertical motion eg ‘package falls towards the road/Earth’, or ‘force of gravity acts/pulls downwards’ (1)</li> </ul> <p><b>Not</b> an answer referring to ‘gravity’ alone.</p>
	(b)	<p><math>g = 9.8 \text{ (m s}^{-2}\text{)}</math> (1) data</p> <p><math>a = \frac{v - u}{t}</math> (1)</p> <p><math>9.8 = \frac{v - 0}{0.55}</math> (1)</p> <p><math>v = 5.4 \text{ m s}^{-1}</math> (1)</p> <p>If incorrect relationship stated (eg <math>a = v/t</math>, <math>v = at</math> or <math>v = gt</math>) stop marking and award (0) marks but can still get (1) for data.</p> <p>Candidates who start with <math>v = 0.55 \times 9.8</math> have not shown an incorrect relationship so should not be penalised</p> <p>eg <math>v = 0.55 \times 9.8</math> (1) for implied formula, (2) for substitution &amp; data mark</p> <p><math>v = 5.4 \text{ m s}^{-1}</math> (1)</p>	4	<p>(1) data mark for correct selection of <b>g</b> from table.</p> <p>Accept 5.39</p>

2	(a)	$s = vt$ (1) $11 = 20 \times t$ (1) $= 0.55 \text{ s}$ Accept 0.6 s (1)	3	
	(b)	$a = \frac{v - u}{t}$ (1) $9.8 = \frac{v - 0}{0.55}$ (1) $v = 5.4 \text{ m s}^{-1}$ (1)	3	
	(c)		2	Figures on axis must be consistent with parts (a) and (b) above s vs t → No marks
	(d)	$s = \text{area under graph}$ or $s = \bar{v}t$ (1) $s = \frac{1}{2} \times 0.55 \times 5.4$ s = (5.4) x 0.55 (1) $s = 1.5 \text{ m}$ s = 1.5 m (1)	3	Must be $s = \bar{v}t$  No other symbols
3	(a)	$s = vt$ (1)	3	
	(i)	$s = 2 \times 0.76$ (1) $s = 1.52 \text{ m}$ (1)		
	(ii)	$a = \frac{v - u}{t}$ (1) $9.8 = \frac{v - 0}{0.76}$ (1) $v = 7.45 \text{ m s}^{-1}$ (1)	3	

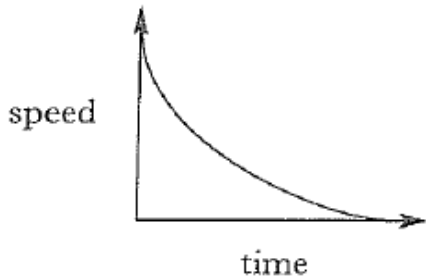
	(b)	Same	1	Must have explanation to get first mark
	(i)			
	(ii)	All objects fall with the same (vertical) acceleration.	1	Will take the same time to reach the water
4		C	1	
5		D	1	
6		$a = (v - u)/t$ (1) $10 = (v - 0)/0.2$ (1) $v = 2 \text{ ms}^{-1}$ (1)	3	
7	(a)	Answer should be based on the following two points: statement relating to vertical motion, eg 'falling (towards the moon)', or force (of gravity) (1) statement relating to horizontal motion, eg 'probe moves forward', or curvature of Ganymede, eg 'surface curves away' (1)	2	NOT 'gravity' alone <b>Satellite falls towards Ganymede due to gravity. Satellite also has a horizontal motion so it follows a curved path. The path curves at the same rate as the curvature of the surface of Ganymede.</b>
	(b)	Newton III: The thrusters force gas one way (1) So the gas exerts an equal and opposite force on the probe.(1)		Explanations in terms of Newton I and Newton II are also acceptable. Newton I: mention of balanced forces (1) would not slow down/indication of constant speed (1) Newton II: unbalanced force (1) in the opposite direction/opposing motion (1) Quoting NI, NII or NIII alone is insufficient, the answer must relate to the thrusters/probe
8		A	1	
9	(a)	$d = v \times t$ (1) $= 30 \times 6$ (1) $= 180\text{m}$ (1)	3	
	(b)	$a = \frac{v - u}{t}$ (1) $4 = \frac{v - (-0)}{6}$ (1) $v = 24\text{ms}^{-1}$ (1)	3	
10	(a)	$d = v \times t$ (1) $= 4.8 \times 0.65$ (1) $= 3.12 \text{ m}$ (1)	3	
	(b)	$a = \frac{v - u}{t}$ (1) $10 = \frac{v - 0}{0.65}$ (1) $v = 6.5 \text{ m/s}$ (1)	3	
11		C	1	
SPACE EXPLORATION				

<b>1</b>	(a)	Eyepiece    magnify    (1)	1	Both correct
	(b)	Objective    collect light    (1)	1	Both correct

# COSMOLOGY

<b>1</b>	(a)	$s = vt$ (1) $= 3 \times 10^8 \times (1 \times 365 \times 24 \times 60 \times 60)$ (1) + (1) $= 9.4608 \times 10^{15} \text{ m}$	3	<b>NOT a standard (3)marker</b> (1) for initial equation (1) for speed of light (1) for correct substitution of time <b>No</b> marks for final answer-given Unit not required but deduct (1) if wrong Accept the number 31536000s in place of $(1 \times 365 \times 24 \times 60 \times 60)$
	(b)	Different frequencies/ wavelengths /signals require different detectors/telescopes OR Certain detectors/telescopes cannot pick up certain frequencies/wavelengths/signals OR Different signals have different frequencies/ wavelengths	1	Accept: <ul style="list-style-type: none"> <li>Different telescopes detect different signals</li> </ul> Do not accept: <ul style="list-style-type: none"> <li>'Different types of signals' - <b>unless</b> mentioned along with different wavelengths/frequencies/telescopes/ detectors.</li> <li>"types of radiation" – ambiguous – could be <math>\alpha</math> or <math>\beta</math></li> <li>Any mention of sound "types of wave" or "wave" – too vague</li> </ul>
<b>2</b>	(a)	(visible) Light	1	
	(b)	Different types of radiation have different properties/wavelengths/frequencies	1	
	(c)	At the focus	1	Accept diagram with light rays shown
	(d)	Arecibo (1) Larger dish can detect more waves (1)	2	
<b>3</b>	(a)	distance travelled by light in one year	1	
	(b)	different detectors (1) are required for different radiations/ frequencies/wavelengths (1)	2	
	(b)	C A B (1) or (0)	1	
	(ii)	accept: X-ray Visible Infrared		
	(b)	G-M tube OR photographic film	1	
	(iii)	)		
<b>4</b>	(a)	(Radio waves are) longer/greater/bigger/larger OR light has a shorter wavelength	1	NOT 'wider'
	(b)	Aerial OR Radio telescope	1	NOT satellite dish NOT telescope (on its own)
	(c)	Different frequencies/wavelengths/signals require different detectors/telescopes OR Certain detectors/telescopes can't pick up certain frequencies/wavelengths/signals	1	eg different telescopes detect different signals NOT 'types of wave' or 'waves' – too vague NOT 'types of radiation' – ambiguous could be alpha or beta Any mention of sound – 0 marks
<b>5</b>		Cadmium and mercury	1	Both required
<b>6</b>		Helium and nitrogen	1	Both required

7		information about atoms (or elements) present OR age of star OR distance to star OR speed of star OR type of star OR temperature of star	1	Accept: gases (identified) OR chemicals (identified) OR 'what it is made of' Do not accept: position OR radiation
VARIOUS				
1	(a)	(i) Acceleration is the change of velocity (not speed) in unit time	1	Need to be indication of time requirement.
		(ii) Direction of satellite is (continually) changing <b>OR</b> Velocity of satellite is (continually) changing <b>OR</b> There is an unbalanced (not 'resultant') force on the satellite	1	
	(b)	$F = 12 - 2 = 10 \text{ N}$ (1) $F = ma$ (1) $10 = 50 \times a$ (1) $a = 0.2 \text{ m s}^{-2}$ direction is right (1)	4	No attempt to calculate F $\Rightarrow$ (1) for formula
2	(a)	$a = (v-u)/2$ (1) $a = (6-0)/60$ (1) $a = 0.1 \text{ ms}^{-2}$ (1)	3	
	(b)	$s = \text{area under graph}$ (1) $= (0.5 \times 60 \times 6) + (40 \times 6)$ (1) $= 420 \text{ m}$ (1)	3	
	(c)	$v = s/t$ (1) $= 420/100$ (1) $= 4.2 \text{ ms}^{-1}$ (1)	3	
	(d)	$W = mg$ (1) $= 400 \times 10$ (1) $= 4000 \text{ N}$ (1)	3	accept 9.8 and 9.81 for 'g' which give 3920 N and 3924 N
	(e)	$F = ma$ (1) $= 400 \times 0.1$ (1) $= 40 \text{ N}$ (1) Upward force $= 4000 + 40 = 4040 \text{ N}$ (1)	4	must be consistent with (a) and (d)
3	(a)	800N	1	
	(i)			
	(a)	$a = (v - u)/t$ (1)		Accept 0.2, 0.167
	(ii)	$= (7 - 5)/12$ (1) $= 0.17 \text{ ms}^{-2}$ (1)	3	
	(a)	$F = ma$ (1)		
	(iii)	$= 400 \times 0.17$ (1)		
	)	$= 67 \text{ (N)}$ (1)		
		Forward force $= 800 + 67$ (1) $= 867 \text{ N}$ (1)	5	
	(a)	Distance $= \text{area under graph}$ (1)		
	(iv)	$= \frac{1}{2} \times 8 \times 7$ (1)		
	)	$= 28 \text{ m}$ (1)	3	
	(b)	Time will be longer		
	(i)		1	

	(b) (ii)	 <p>speed</p> <p>time</p>	1	<p>Straight line NOT acceptable</p> <p>Ignore any values on graph</p> <p>No labels on axes acceptable but wrong labels is not</p>
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