Gleniffer High School

National 5

Dynamics and Space

Past Papers

Name: _____

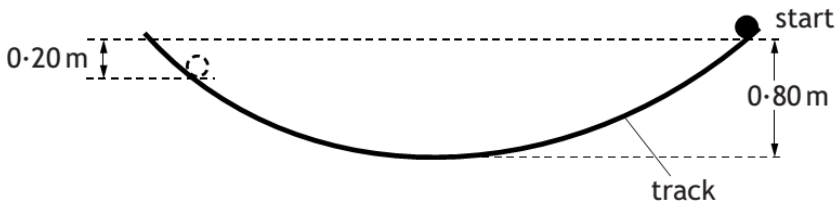
Mr Downie 2020

Contents

Section 1 - Questions

1.

A ball is released from rest and allowed to roll down a curved track as shown.



The mass of the ball is 0·50 kg.

The maximum height reached on the opposite side of the track is 0·20 m lower than the height of the starting point.

The amount of energy lost is

A 0·080 J

B 0·10 J

C 0·98 J

D 2·9 J

E 3·9 J.

2.

Which of the following contains two scalar quantities?

A Force and mass

B Weight and mass

C Displacement and speed

D Distance and speed

E Displacement and velocity

3.

An aircraft engine exerts a force on the air.

Which of the following completes the "Newton pair" of forces?

A The force of the air on the aircraft engine

B The force of friction between the aircraft engine and the air

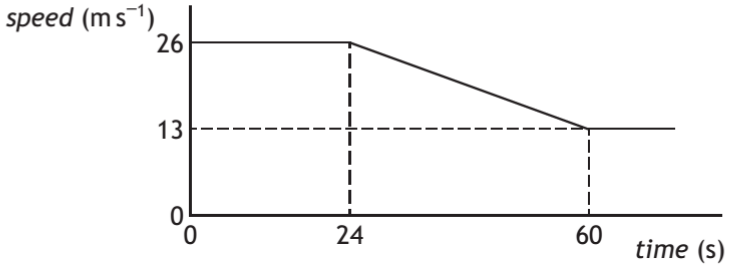
C The force of friction between the aircraft and the aircraft engine

D The force of the Earth on the aircraft engine

E The force of the aircraft engine on the Earth

4.

As a car approaches a village the driver applies the brakes. The speed-time graph of the car's motion is shown.



The brakes are applied for

A 13 s
B 20 s
C 24 s
D 36 s
E 60 s.

5.

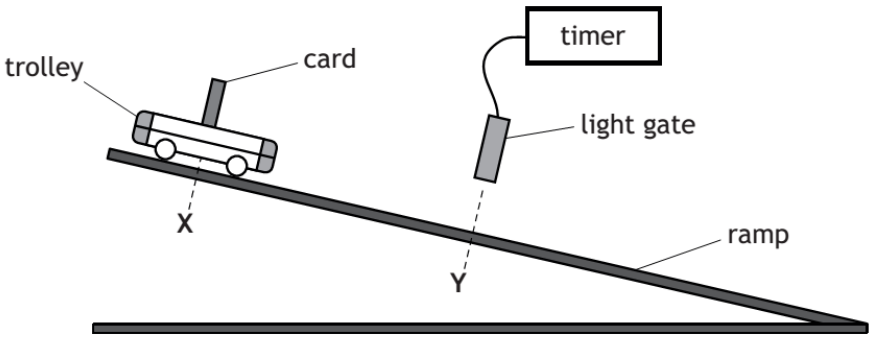
The Mars Curiosity Rover has a mass of 900 kg.

Which row of the table gives the mass and weight of the Rover on Mars?

	Mass (kg)	*Weight* (N)
A	243	243
B	243	900
C	900	900
D	900	3330
E	900	8820

6.

A student sets up the apparatus as shown.



The trolley is released from X and moves down the ramp.
The following measurements are recorded.

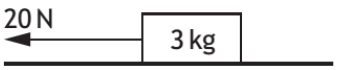
time for card to pass through light gate = 0·08 s
distance from X to Y = 0·5 m
length of card = 40 mm

The instantaneous speed of the trolley at Y is

A $0{\cdot}5\,m\,s^{-1}$
B $1{\cdot}6\,m\,s^{-1}$
C $2{\cdot}0\,m\,s^{-1}$
D $3{\cdot}2\,m\,s^{-1}$
E $6{\cdot}3\,m\,s^{-1}$.

7.

A block of mass 3 kg is pulled across a horizontal bench by a force of 20 N as shown below.



The block accelerates at $4\,m\,s^{-2}$.
The force of friction between the block and the bench is

A 0 N
B 8 N
C 12 N
D 20 N
E 32 N.

8.

A trolley of mass 0·50 kg has a kinetic energy of 0·36 J.

The speed of the trolley is

A $0{\cdot}60\ m\ s^{-1}$

B $0{\cdot}85\ m\ s^{-1}$

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

D $1{\cdot}44\ m\ s^{-1}$

E $1{\cdot}7\ m\ s^{-1}$.

9.

A student makes the following statements about the Universe.

I The Big Bang Theory is a theory about the origin of the Universe.

II The Universe is approximately 14 million years old.

III The Universe is expanding.

Which of these statements is/are correct?

A I only

B II only

C I and II only

D I and III only

E I, II and III

10.

Which of the following contains two vectors and one scalar quantity?

A Acceleration, mass, displacement

B Displacement, force, velocity

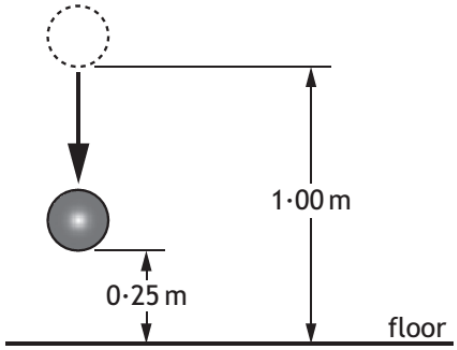
C Time, distance, force

D Displacement, velocity, acceleration

E Speed, velocity, distance

11.

A ball of mass 0·50 kg is released from a height of 1·00 m and falls towards the floor.



Which row in the table shows the gravitational potential energy and the kinetic energy of the ball when it is at a height of 0·25 m from the floor?

	Gravitational potential energy (J)	*Kinetic energy* (J)
A	0·12	0·12
B	1·2	1·2
C	1·2	3·7
D	3·7	1·2
E	4·9	1·2

12.

A spacecraft completes the last stage of its journey back to Earth by parachute, falling with constant speed into the sea.

The spacecraft falls with constant speed because

A the gravitational field strength of the Earth is constant near the Earth's surface

B it has come from space where the gravitational field strength is almost zero

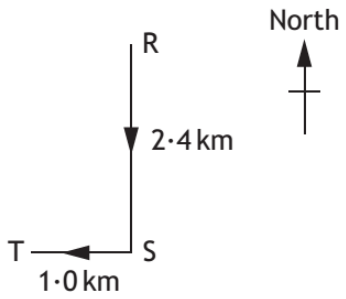
C the air resistance is greater than the weight of the spacecraft

D the weight of the spacecraft is greater than the air resistance

E the air resistance is equal to the weight of the spacecraft.

13.

A vehicle follows a course from R to T as shown.



The total journey takes 1 hour.

Which row in the table gives the average speed and the average velocity of the vehicle for the whole journey?

	Average speed	*Average velocity*
A	2·6 km h^{-1} (023)	3·4 km h^{-1}
B	2·6 km h^{-1}	3·4 km h^{-1} (203)
C	3·4 km h^{-1} (203)	2·6 km h^{-1}
D	3·4 km h^{-1}	2·6 km h^{-1} (023)
E	3·4 km h^{-1}	2·6 km h^{-1} (203)

14.

A force of 10 N acts on an object for 2 s.

During this time the object moves a distance of 3 m.

The work done on the object is

A 6·7 J

B 15 J

C 20 J

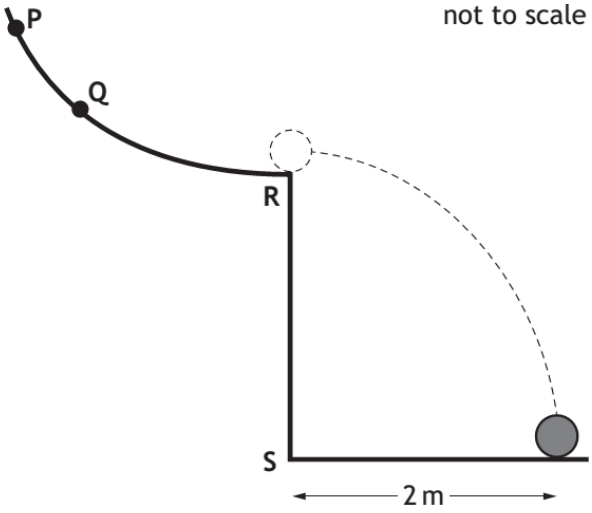
D 30 J

E 60 J.

15.

A ball is released from point **Q** on a curved rail, leaves the rail horizontally at R and lands 1 s later.

The ball is now released from point **P**.



Which row describes the motion of the ball after leaving the rail?

	Time to land after leaving rail	*Distance from S to landing point*
A	1 s	less than 2 m
B	less than 1 s	more than 2 m
C	1 s	more than 2 m
D	less than 1 s	2 m
E	more than 1 s	more than 2 m

16.

The distance from the Sun to Proxima Centauri is 4·3 light years.

This distance is equivalent to

A $1{\cdot}4 \times 10^{8}$ m

B $1{\cdot}6 \times 10^{14}$ m

C $6{\cdot}8 \times 10^{14}$ m

D $9{\cdot}5 \times 10^{15}$ m

E $4{\cdot}1 \times 10^{16}$ m.

17.

The table shows the velocities of three objects X, Y and Z over a period of 3 seconds. Each object is moving in a straight line.

Time (s)	0	1	2	3
Velocity of X ($m\,s^{-1}$)	2	4	6	8
Velocity of Y ($m\,s^{-1}$)	0	1	2	3
Velocity of Z ($m\,s^{-1}$)	0	2	5	9

Which of the following statements is/are correct?

I X moves with constant velocity.

II Y moves with constant acceleration.

III Z moves with constant acceleration.

A I only

B II only

C I and II only

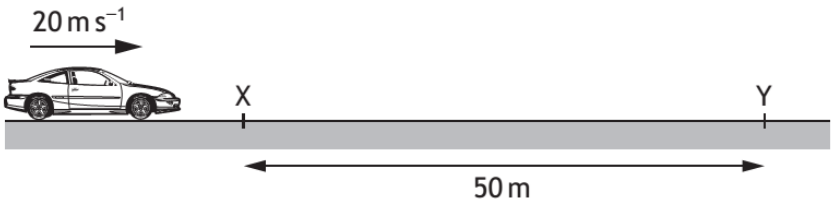
D I and III only

E II and III only

18.

A car of mass 1200 kg is travelling along a straight level road at a constant speed of $20\,m\,s^{-1}$.

The driving force on the car is 2500 N. The frictional force on the car is 2500 N.



The work done moving the car between point X and point Y is

A 0 J

B 11 800 J

C 125 000 J

D 240 000 J

E 250 000 J.

19.

A person sits on a chair which rests on the Earth. The person exerts a downward force on the chair.

Which of the following is the reaction to this force?

A The force of the chair on the person

B The force of the person on the chair

C The force of the Earth on the person

D The force of the chair on the Earth

E The force of the person on the Earth

20.

A package falls vertically from a helicopter. After some time the package reaches its terminal velocity.

A group of students make the following statements about the package when it reaches its terminal velocity.

I The weight of the package is less than the air resistance acting on the package.

II The forces acting on the package are balanced.

III The package is accelerating towards the ground at $9{\cdot}8\,\mathrm{m\,s^{-2}}$.

Which of these statements is/are correct?

A I only

B II only

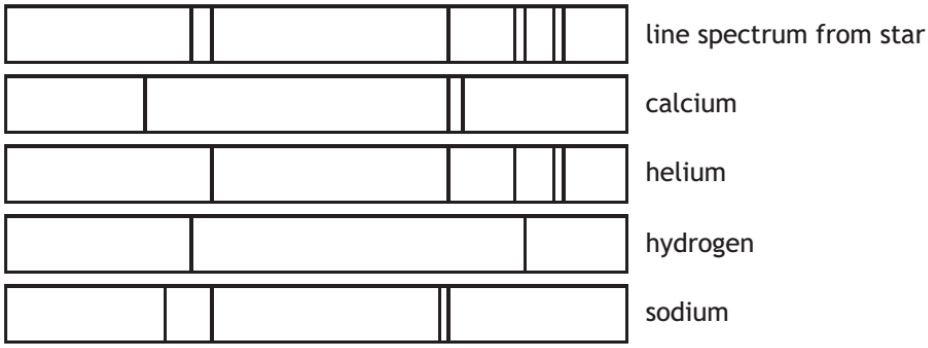
C III only

D I and III only

E II and III only

21.

Light from a star is split into a line spectrum of different colours. The line spectrum from the star is shown, along with the line spectra of the elements calcium, helium, hydrogen and sodium.



The elements present in this star are

A sodium and calcium
B calcium and helium
C hydrogen and sodium
D helium and hydrogen
E calcium, sodium and hydrogen.

22.

A rocket is taking off from the surface of the Earth. The rocket engines exert a force on the exhaust gases.

Which of the following is the reaction to this force?

A The force of the Earth on the exhaust gases.
B The force of the Earth on the rocket engines.
C The force of the rocket engines on the Earth.
D The force of the exhaust gases on the Earth.
E The force of the exhaust gases on the rocket engines.

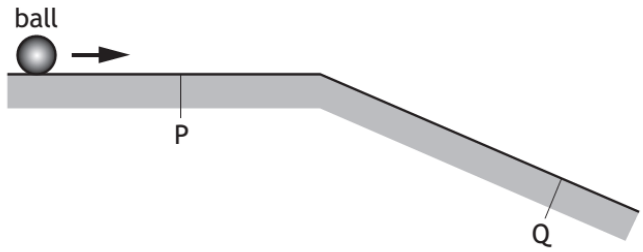
23.

Which of the following is a vector quantity?

A Mass
B Time
C Speed
D Kinetic energy
E Acceleration

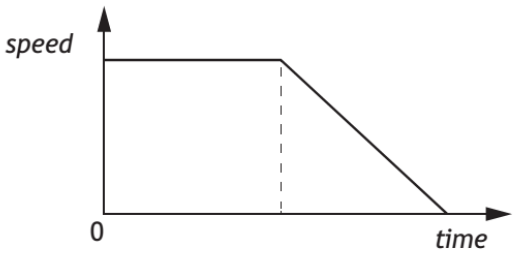
24.

A ball moves along a horizontal frictionless surface and down a slope as shown.

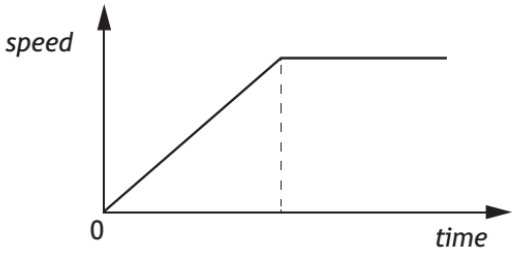


Which of the following graphs shows how the speed of the ball varies with time as it travels from P to Q?

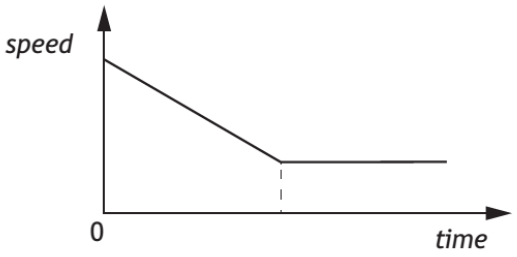
A



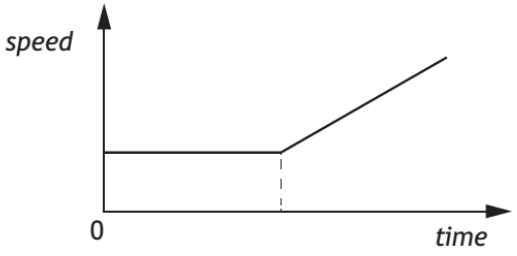
B



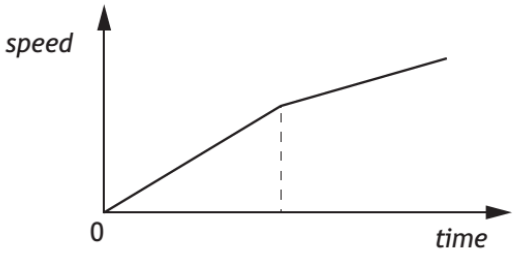
C



D



E



25.

A cyclist is travelling at 10 m s^{-1} along a level road.

The cyclist applies the brakes and comes to rest in a time of 5 s.

The combined mass of the cycle and cyclist is 80 kg.

The maximum energy converted to heat by the brakes is

A 160 J

B 400 J

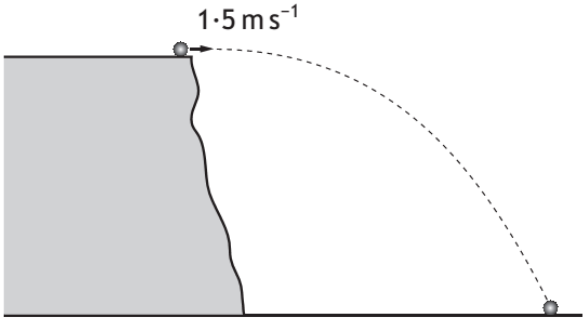
C 800 J

D 4000 J

E 8000 J.

26.

A ball is projected horizontally with a velocity of 1·5 m s^{-1} from a cliff as shown.



The ball hits the ground 1·2 s after it leaves the cliff.

The effects of air resistance are negligible.

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

	Horizontal velocity (m s^{-1})	*Vertical velocity* (m s^{-1})
A	12	12
B	12	1·5
C	1·5	12
D	1·5	13
E	0	12

Section 1 - Answers

1. C	**8. C**	**15. C**	**22. E**
2. D	**9. D**	**16. E**	**23. E**
3. A	**10. A**	**17. B**	**24. D**
4. D	**11. C**	**18. A**	**25. D**
5. D	**12. E**	**19. A**	**26. C**
6. A	**13. E**	**20. B**	
7. B	**14. D**	**21. D**	

Section 1 – Key Explanations

1. Calculate the potential energy (E_p = mgh) at 1.0 m (4.9 J); now calculate the potential energy at 0.8 m (3.92 J); energy lost is difference between these values (0.98 J)

2., 10. and 23. To remember scalars use S.T.D.M.E. where S = Speed, T = Time, D = Distance, M= Mass and E = Energy

3., 19. and 22. For Newton Pairs always swap the objects around e.g. engine on air swaps to air on engine

4. Brakes cause a deceleration; look for downward slope on graph

5. Use the data sheet to find the g.f.s for Mars 3.7 Nkg^{-1}

6. Instantaneous calculations use the length of card and the time generated from the light gate; remember to convert "mm" to metres for the calculation (milli = x 10^{-3})

7. The unbalanced force, F_{un}, on the block is 12 N (3 x 4); forward force is 20 N; frictional force must be 20 N – 12 N = 8 N

8. Remember when re-arranging $E_k = ½mv^2$ to find "v", use the square root button!

9. II is wrong because the universe is about **14 billion** years old

11. Calculate the potential energy (E_p = mgh) at 1.0 m (4.9 J); now calculate the potential energy at 0.25 m (1.2 J); by applying conservation of energy the potential energy "lost" will be equal to the kinetic energy "gained"; the kinetic energy is the difference between these values (3.7 J)

12. Constant speed always implies balanced forces

13. Average speed = total distance / time ((2.4 + 1.0) / 1 = 3.4); answer must be D or E; as journey starts at "R" and ends at "T" the direction of the velocity is greater than 180^o; answer E must be correct

14. Need to ignore extra data; this is a straightforward $E_w = Fd$ calculation

15. In both journeys the ball falls from same point "R"; time to land must be the same; in second journey horizontal speed is greater so horizontal distance will be greater

16. Must be E as one light year is 9.5×10^{15}m

17. I is wrong the values are all different, II is correct (acceleration for each second is 1 ms^{-2}); III is incorrect the acceleration values are all different

18. Unbalanced force is zero (2500 -2500 = 0) the work done is zero

20. Terminal velocity is a constant velocity implying balanced forces; only II is correct

21. Matching task; line up elements lines with those from the star

24. On flat surface constant speed; on slope acceleration

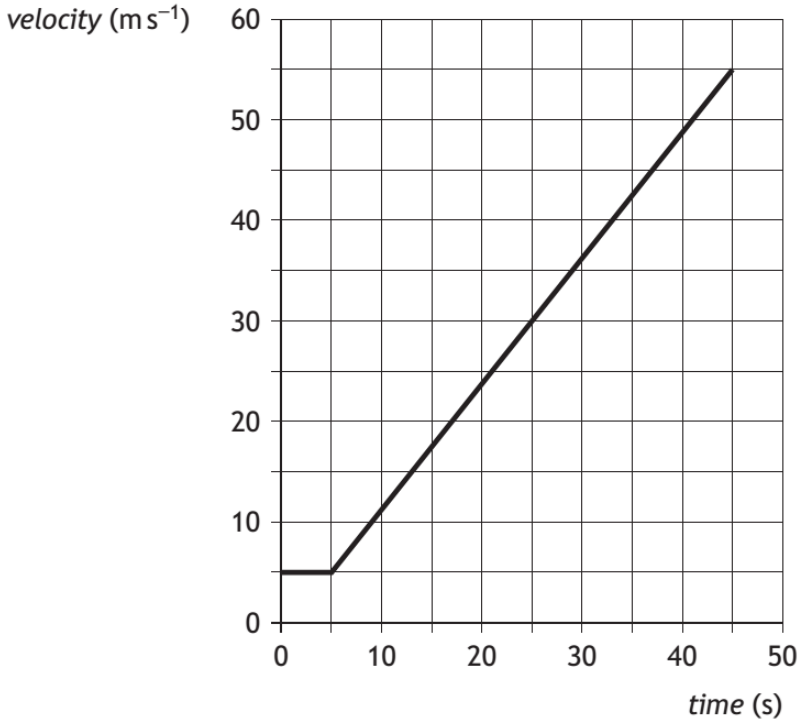
25. Need to ignore extra data; this is a straightforward $E_k = ½mv^2$ calculation

26. Horizontal velocity is constant; vertical velocity = u + at but u = 0 so vertical velocity must be 12 ms^{-1} (9.8 x 1.2)

Section 2 – Questions

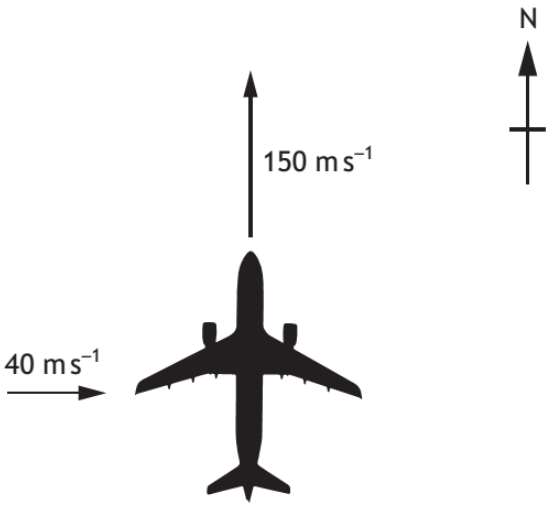
1.

An aircraft is making a journey between two airports. A graph of the aircraft's velocity during take-off is shown.



(a) Calculate the acceleration of the aircraft during take-off. **3**

(b) During flight, the aircraft is travelling at a velocity of 150 ms^{-1} due north and then encounters a crosswind of 40 ms^{-1} due east.



By scale drawing, or otherwise, determine:

(i) The magnitude of the resultant velocity of the aircraft **2**

(ii) The direction of the resultant velocity of the aircraft **2**

1. (Continued)

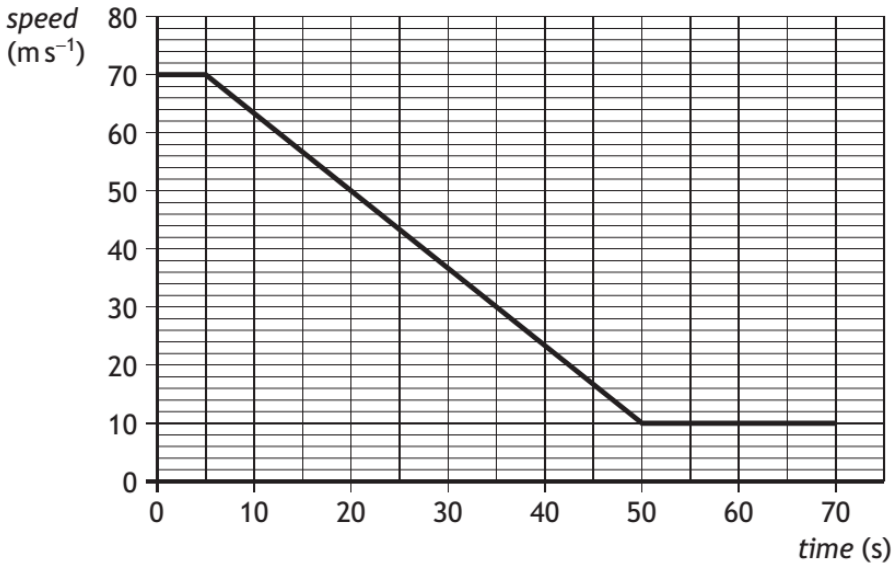
(c) The aircraft arrives at the destination airport.

There are three runways, X, Y, and Z, available for the aircraft to land on.

The length of each runway is given in the table.

Runway	*Length* (m)
X	3776
Y	3048
Z	2743

(i) The speed-time below shows the speed of the aircraft during landing on the runway, from the moment the wheels touch down



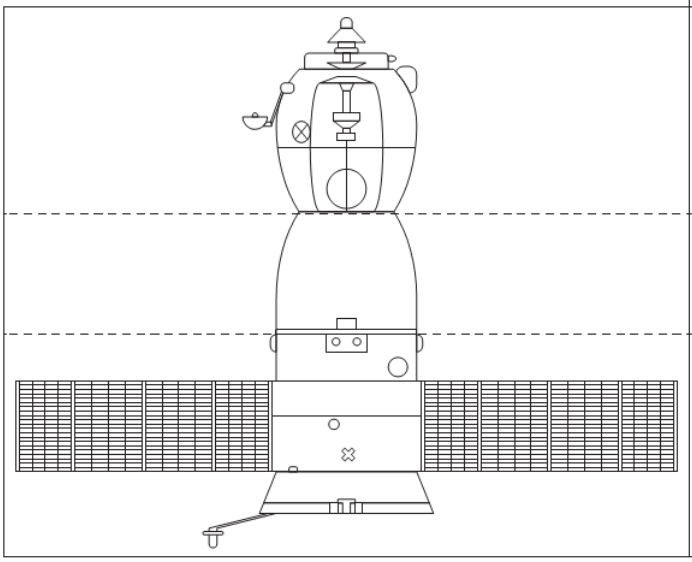
Determine which runways the aircraft could have used to land safely.
Justify your answer by calculation. **4**

(ii) This airport has runways of different lengths to accommodate different sizes of aircraft.
Explain why larger aircraft requires a longer runway to land safely. **2**

Total marks 13

2.

The Soyuz Spacecraft is used to transport astronauts from the International Space Station (ISS) to Earth. The spacecraft contains three parts.



Part	*Mass* (kg)
Orbital Module	1300
Descent Module (including astronauts)	2950
Instrumentation/ Propulsion Module	2900

(a) When the spacecraft leaves the ISS, the three parts are launched together. The propulsion module produces a force of 1430 N.

Calculate the acceleration of the spacecraft as it leaves the ISS. **4**

(b) During the flight, the Orbital Module and the Instrumentation/Propulsion Module are jettisoned. Instead of returning to Earth, they burn up in the atmosphere at a very high temperature.

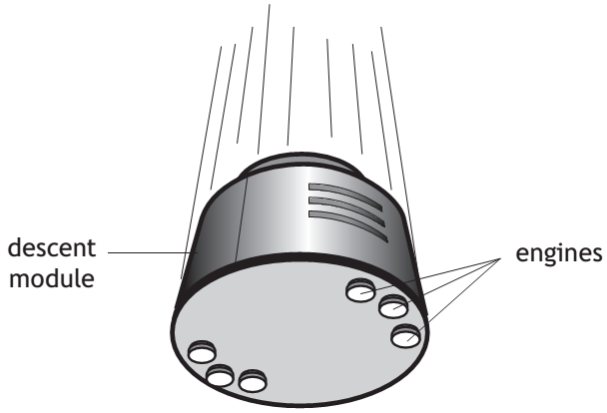
Explain why these Modules burn up on re-entry into the atmosphere. **2**

(c) (i) After the Descent Module has re-entered the atmosphere, its speed is dramatically reduced. Four parachutes are used to slow the Module's rate of descent.

Explain, in terms of forces, how the parachutes reduce the speed of the Module. **2**

2. c) (Continued)

c) ii) Just before touchdown, small engines fire on the bottom of the Module, slowing it down further. The work done by the engines is 8.0 x 10^4 J over a distance of 5.0 m.



Calculate the force produced by the engines. **3**

(d) The ISS orbits the Earth.

Explain, in terms of horizontal velocity and weight, how the ISS remains in orbit around the Earth. **2**

Total marks 13

3.

Read the passage below about the Dragonfish nebula, an interstellar cloud of dust and gases and star-forming region in space. Answer the questions that follow.

Dragonfish nebula conceals giant cluster of young stars

The Dragonfish nebula may contain the Milky Way's most massive cluster of young stars. Scientists from the University of Toronto found the first hint of the cluster in 2010 in the form of a big cloud of ionised gas 30 000 light years from Earth. They detected the gas from its microwave emissions, suspecting that radiation from massive stars nearby had ionised the gas.

Now the scientists have identified a cluster of 400 massive stars in the heart of the gas cloud using images from an infrared telescope. The cluster probably contains more stars which are too small and dim to detect.

The surrounding cloud of ionised gas is producing more microwaves than the clouds around other star clusters in our galaxy. This suggests that the Dragonfish nebula contains the brightest and most massive young cluster discovered so far, with a total mass of around 100 000 times the mass of the Sun.

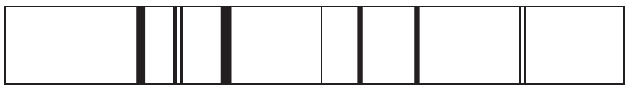
(a) Name the galaxy mentioned in the passage. **1**

3. (Continued)

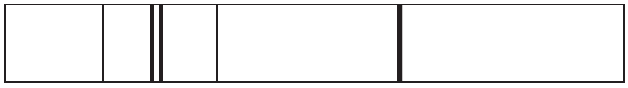
(b) Show that the dragonfish nebula is approximately 2.8 x 10^{20} m away from Earth. **3**

(c) A line spectrum from a nebula is shown below.

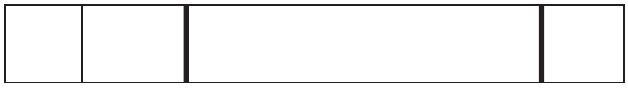
spectral lines from gases in the nebula



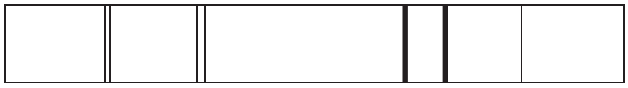
nitrogen



helium



hydrogen



krypton

Identify which of these elements is present in the nebula. **2**

Total marks 6

4.

A helicopter is used to take tourists on sightseeing flights.

Information about the helicopter is shown on the table on the next page.

4. (Continued)

weight of empty helicopter	13 500 N
maximum take-off weight	24 000 N
cruising speed	67 $m\,s^{-1}$
maximum speed	80 $m\,s^{-1}$
maximum range	610 km

(a) The pilot and passengers are weighed before they board the helicopter.

Explain the reason for this. **1**

(b) Six passengers and the pilot with a combined weight of 6125 N board the helicopter.

Determine the minimum upward force required by the helicopter at take-off. **1**

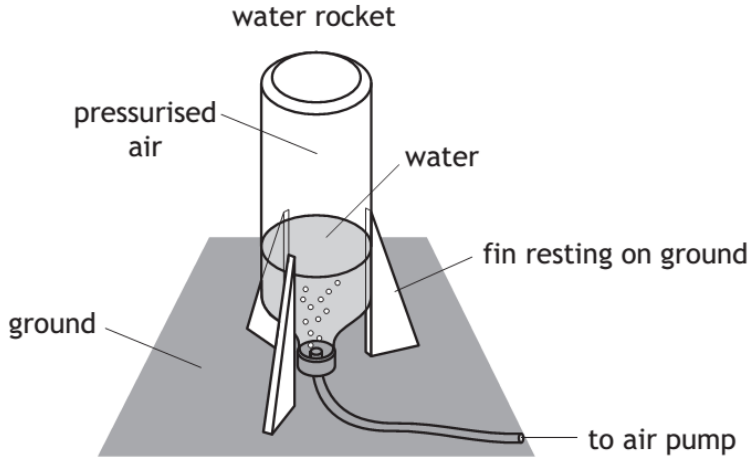
(c) The helicopter travels 201 km at its cruising speed.

Calculate the time taken to travel this distance. **3**

Total marks 5

5.

A student is investigating the motion of water rockets. The water rocket is made from an upturned plastic bottle containing some water. Air is pumped into the bottle. When the pressure of the air is great enough the plastic bottle is launched upwards.



The mass of the rocket before launch is 0·94 kg.

(a) Calculate the weight of the water rocket. **3**

5. (Continued)

(b) Use Newton's Third Law to explain how the rocket launches. **1**

(c)

At launch, the initial upward thrust of the rocket is 370 N.

Calculate the initial acceleration of the rocket. **4**

(d)

The student launches the rocket a second time.

For this launch, the student adds a greater volume of water than before.

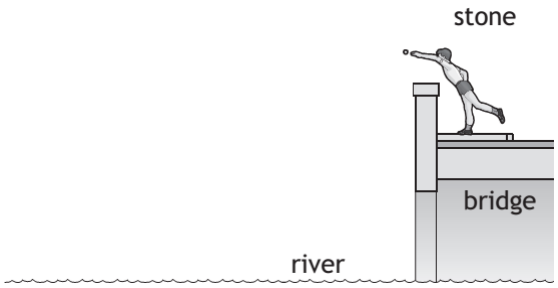
The same initial upward thrust acts on the rocket but it fails to reach the same height.

Explain why the rocket fails to reach the same height. **2**

Total marks 10

6.

A child throws a stone horizontally from a bridge into a river.



(a) Sketch the path taken by the stone between leaving the child's hand and hitting the water. **1**

(b) The stone reaches the water 0·80 s after it was released.

(i) Calculate the vertical velocity of the stone as it reaches the water.

The effects of air resistance can be ignored. **3**

(ii) Determine the height above the water at which the stone was released. **4**

(c) The child now drops a similar stone vertically from the same height into the river.

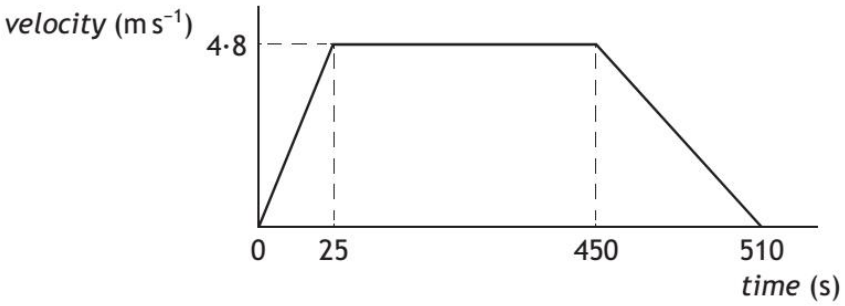
State how the time taken for this stone to reach the water compares with the time taken for the stone in (b). **1**

Total marks 9

7.

In a rowing event a boat moves off in a straight line.

A graph of the boat's motion is shown.



(a) (i) Calculate the acceleration of the boat during the first 25 s. **3**

(ii) Describe the motion of the boat between 25 s and 450 s. **1**

(iii) Draw a diagram showing the horizontal forces acting on the boat between 25 s and 450 s.

You **must** name these forces and show their directions. **2**

(b) The boat comes to rest after 510 s.

(i) Calculate the total distance travelled by the boat. **3**

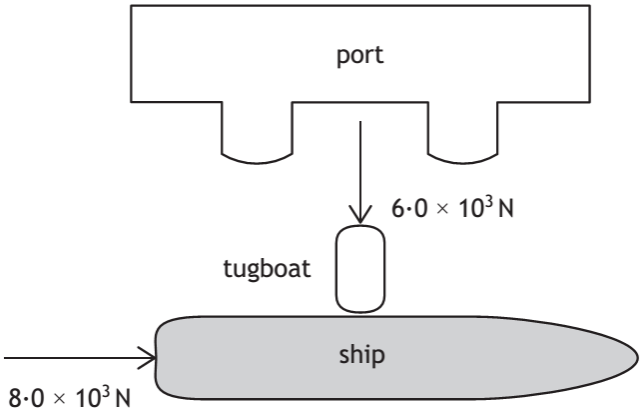
(ii) Calculate the average velocity of the boat.

A direction is not required. **3**

Total marks 12

8.

A ship of mass $5{\cdot}0 \times 10^6$ kg leaves a port. Its engine produces a forward force of $8{\cdot}0 \times 10^3$ N. A tugboat pushes against one side of the ship as shown. The tugboat applies a pushing force of $6{\cdot}0 \times 10^3$ N.

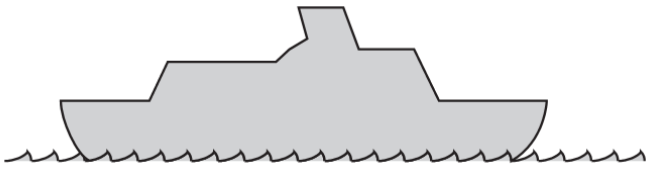


(a) (i) By scale drawing, or otherwise, determine the size of the resultant force acting on the ship. **2**

(ii) Determine the direction of the resultant force relative to the $8{\cdot}0 \times 10^3$ N force. **2**

(iii) Calculate the size of the acceleration of the ship. **3**

(b) Out in the open sea the ship comes to rest.



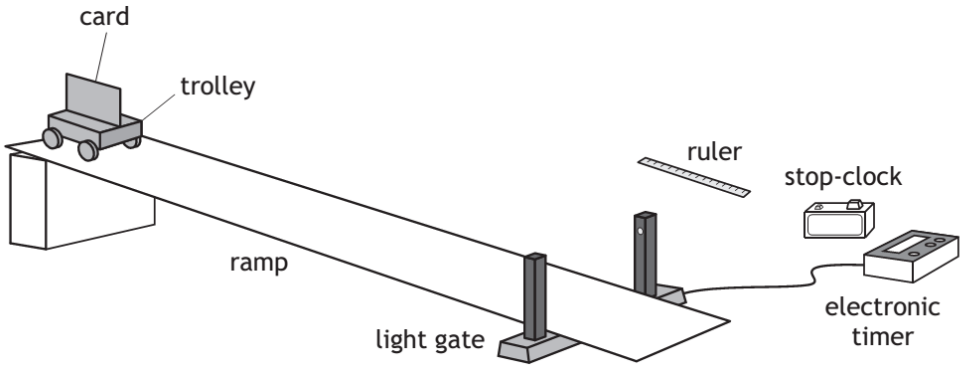
Explain, with the aid of a labelled diagram, why the ship floats. **3**

Total marks 10

9. A student is investigating the motion of a trolley down a ramp.

(a) The student uses the apparatus shown to carry out an experiment to determine the acceleration of a trolley as it rolls down a ramp.

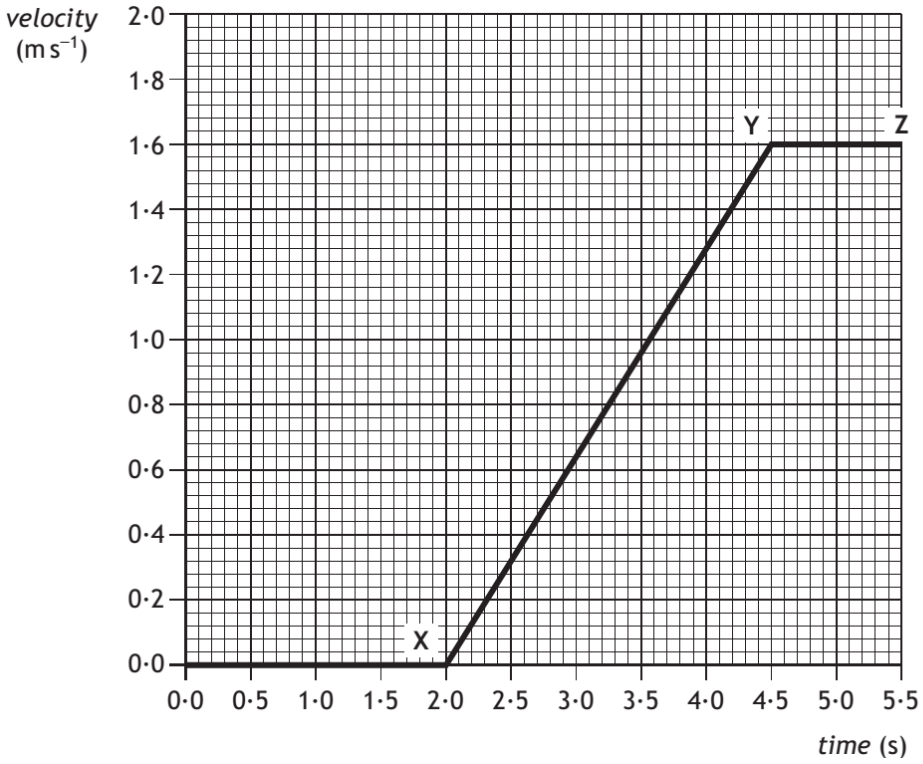
The trolley is released from rest at the top of the ramp.



(i) State the measurements the student must make to calculate the acceleration of the trolley. **3**

(ii) Suggest one reason why the acceleration calculated from these measurements might not be accurate. **1**

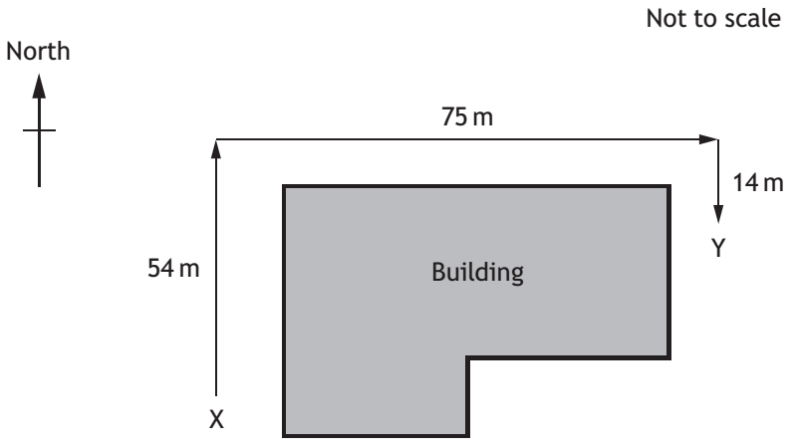
(b) In a second experiment, the student uses a motion sensor and computer to produce the following velocity-time graph for the trolley



Calculate the acceleration of this trolley between X and Y. **3**

Total marks 7

10. A student walks around a building from point X to point Y.



(a) By scale diagram, or otherwise, determine:

(i) the magnitude of the displacement of the student from point X to point Y; **2**

(ii) the direction of displacement of the student from point X to point Y. **2**

(b) The student takes 68 s to travel from point X to point Y.

(i) Determine the average velocity of the student from point X to point Y. **3**

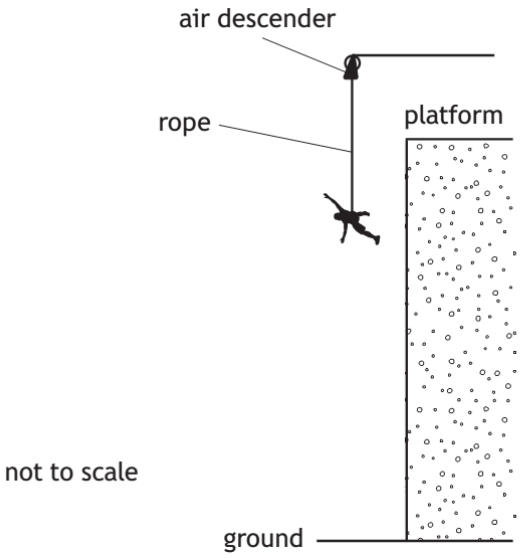
(ii) The student states that their average speed between point X and point Y is greater than the magnitude of their average velocity between point X and point Y.

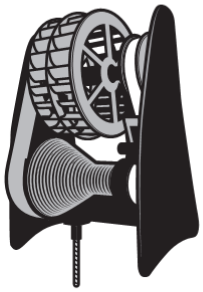
Explain why the student is correct. **2**

11.

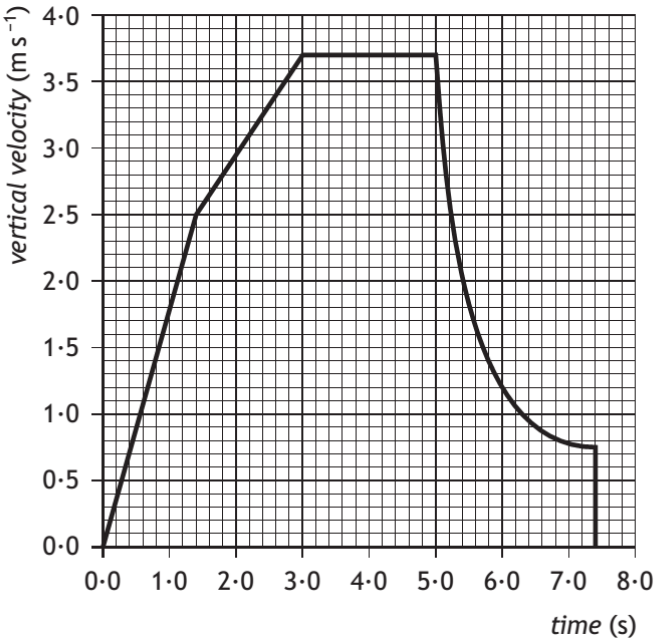
An air descender is a machine that controls the rate at which a climber drops from a platform at the top of a climbing wall.

A climber, attached to the air descender by a rope, steps off the platform and drops towards the ground and lands safely.





The graph shows how the vertical velocity of the climber varies with time from the instant the climber leaves the platform until landing.



(a) Calculate the acceleration of the climber during the first 1·4 s of the drop. **3**

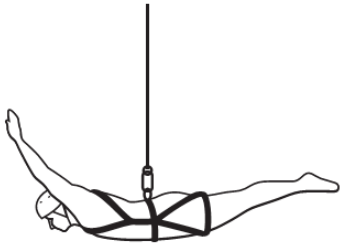
(b) Calculate the distance the climber drops during the first 3·0 s. **3**

11. (Continued)

(c) During part of the drop the forces on the climber are balanced.

On the diagram below show all the forces acting vertically on the climber during this part of the drop.

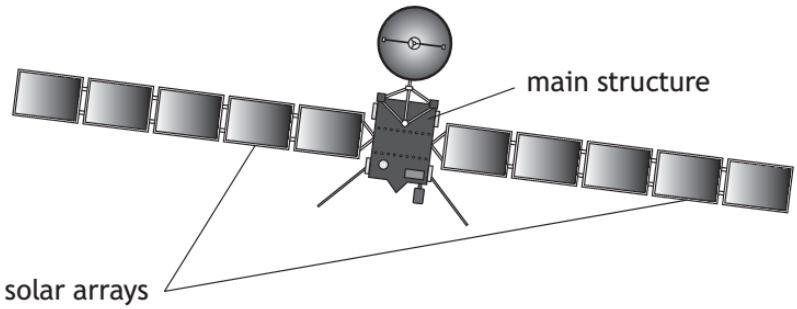
You must name these forces **and** show their directions. **3**



Total marks 9

12.

On 12th November 2014, on a mission known as Rosetta, the European Space Agency successfully landed a probe on the surface of a comet.



The main structure of the Rosetta spacecraft consists of an orbiter, a lander and propellant.

Rosetta spacecraft data		
Launch mass	Orbiter Lander Propellant	$1{\cdot}23 \times 10^3$ kg $0{\cdot}10 \times 10^3$ kg $1{\cdot}67 \times 10^3$ kg
	Total	$3{\cdot}00 \times 10^3$ kg
Energy source	Solar array output	850 W at 3·4 AU 395 W at 5·25 AU
Trajectory control	24 Thrusters	10 N of force each

(a) Calculate the total weight of the spacecraft on Earth. **3**

12. (Continued)

(b)

At a point on its journey between Earth and the comet, the spacecraft was travelling at a constant velocity.

(i) The spacecraft switched on four of its thrusters to accelerate it in the direction of travel.

The four thrusters exerted a force on the spacecraft in the same direction.

Determine the total force produced by these thrusters. **1**

(ii) At this point, the spacecraft had used $1{\cdot}00 \times 10^3$ kg of propellant.

Calculate the acceleration of the spacecraft. **4**

Total marks 8

13. Read the passage and answer the questions that follow.

Supernova explosion

The average temperature of the surface of the Sun is 5778 K. In the core of the Sun energy is produced by nuclear fusion. Once the Sun has used all its nuclear fuel it will collapse to form a white dwarf.

A star with a mass much larger than that of the Sun will end its life in an enormous explosion called a supernova. The energy released in a supernova explosion is more than a hundred times the energy that the Sun will radiate over its entire 10 billion year lifetime.

In our galaxy, the star Betelgeuse is predicted to explode in a supernova. Betelgeuse has a mass of around 8 times the mass of the Sun. Even though Betelgeuse is 640 light-years from Earth, the supernova will be as bright as a full moon at night in our sky.

(a) Show that the distance from Earth to Betelgeuse is 6.1×10^{18} m. 3

(b) Betelgeuse may have already exploded as a supernova. Explain this statement. 1

Total marks 4

Section 2 – Answers and Marking Instructions

1. a)

$a = \frac{v-u}{t}$ **(1 mark)**

$a = \frac{55-5}{40}$ **(1 mark)**

a = 1.25 ms^{-2} **(1 mark)**

1. b) i)

$v = \sqrt{150^2 + 40^2}$ **(1 mark)**

v = 155 ms^{-1} **(1 mark)**

1. b) ii)

$\tan\theta = \frac{40}{150}$ **(1 mark)**

Θ = 15° **(1 mark)**

1. c) i) (Any time there is a speed-time graph remember distance = area under graph)

length of runway (distance) = area under the speed-time graph **(1 mark)**

length of runway = (10 x 70) + (60 x 5) + (½ x 60 x 45) **(1 mark)**

length of runway = 2350 m **(1 mark)**

Runways X, Y and Z could all have used **(1 mark)**

1.c) ii) (Other explanations can also be used)

Larger aircraft will have an increased mass **(1 mark)**

Will be more difficult for aircraft to decelerate to zero **(1 mark)**

2. a) (As this is worth 4 marks there will be an extra step as well as using an equation.)

Total mass = (1300 + 2950 + 2900) = 7150 kg **(1 mark)**

F = ma **(1 mark)**

1430 = 7150 x a **(1 mark)**

a = 1430 / 7150

a = 0.2 ms^{-2} **(1 mark)**

2. b)

There will be a force of **friction** on the surface of the modules **(1 mark)**

The friction causes **heat** to be produced (making the modules burn up) **(1 mark)**

2. c) i)

(The parachutes) increase the upwards force **(1 mark)**

This creates an unbalanced force upwards (reducing the speed of the module) **(1 mark)**

2. c) ii)

$E_w = F \times d$ **(1 mark)**

$8.0 \times 10^4 = F \times 5$ **(1 mark)**

$F = 8.0 \times 10^4 / 5$

F = 16000N **(1 mark)**

2. d)

The horizontal velocity of the ISS is large enough to ensure that it does not get closer to the Earth's surface. **(1 mark)**

The weight of the ISS is large enough to ensure that it does not move further away from the Earth's surface. **(1 mark)**

3. a)

Milky Way **(1 mark)**

3. b)

For calculating (3×10^8 x 365 x 24 x 60 x 60) one light year **OR**

Correctly quoting the value of one light year 9.46×10^{15} **(1 mark)**

Selecting 30000 from the passage **(1 mark)**

$30000 \times 9.46 \times 10^{15}$ **(1 mark)**

2.8×10^{20} m (Need to state your final answer to gain full marks)

3. c) Hydrogen **(1 mark)** Helium **(1 mark)**

4. a) To check that the maximum take-off weight is not exceeded. **(1 mark)**

4. b) (Minimum upward force will be equal to take-off weight.)

Take-off weight = **19 625 N** (13500 + 6125) **(1 mark)**

4. c) (Remember that "k" for kilo = x 10^3)

d = v x t **(1 mark)**

201000 = 67 x t **(1 mark)**

t = 201000 / 67

t = 3000 s **(1 mark)**

5. a)

W = m x g **(1 mark)**

W = 0.94 x 9.8 **(1 mark)**

W = 9.2 N **(1 mark)**

5. b) (Answer must show understanding of a Newton Pair **OR** action and reaction)

Rocket pushes down on water (action), water pushes up on rocket (reaction) **(1 mark)**

5. c) (As this is worth 4 marks there will be an extra step as well as using an equation.)

Before using F = ma, need to know the unbalanced force. In this case…

F unbalanced = Force upwards – Force downwards (or weight)

F_{un} = 370 – 9.2

F_{un} = 360.8 N **(1 mark)**

F = m x a **(1 mark)**

360.8 = 0.94 x a **(1 mark)**

a = 360.8 / 0.94

a = 384 ms^{-2} **(1 mark)**

Note: If no attempt is made to find the unbalanced force at the start the maximum number of marks that can be awarded is one.

5. d) Any **two** of the following statements will gain **1 mark each**.

The rocket fails to reach the same height because:

- More water will increase the weight/mass
- The unbalanced force will decrease
- The acceleration is less

6. a)

Any correct path that shows a projectile curve. **(1 mark)**

6. b) i)

$v = u + at$ **(1 mark)**

$v = 0 + (9.8 \times 0.8)$ **(1 mark)**

$v = 7.84\ ms^{-1}$ **(1 mark)**

6. b) ii) (As this is worth 4 marks there will be an extra step as well as using an equation.)

This can be solved by using **conservation of energy**. This must be stated OR clearly shown as the first line in the answer. (Other methods can also be used.)

$E_p = E_k$ **(1 mark)**

$mgh = ½mv^2$ **(1 mark)**

$m \times 9.8 \times h = ½ \times m \times (7.84)^2$ **(1 mark)**

The "m" on either side cancel each other out to leave…

$9.8 \times h = ½ \times (7.84)^2$

$9.8 \times h = 30.7328$

$h = 30.7328 / 9.8$

$h = 3.1\ m$ **(1 mark)**

6. c) It will take the same time**.** **(1 mark)**

7. a) i)

$a = \frac{v-u}{t}$ **(1 mark)**

$= \frac{4 \cdot 8 - 0}{25}$ **(1 mark)**

$a = 0.19\ ms^{-2}$ **(1 mark)**

7. a) ii) constant velocity **(1 mark)**

7. a) iii) (Other diagrams may also gain full marks)

Friction boat Forward force

1 mark for each correctly labelled force and direction.

7. b) i) (Any time there is a speed-time graph remember distance = area under graph)

distance = area under graph **(1 mark)**

distance = (½ x 25 x 4.8) + (4.8 x 425) + (½ x 60 x 4.8) **(1 mark)**

distance = 2244 m **(1 mark)**

7. b) ii)

d = v x t **(1 mark)**

2244 = v x 510 **(1 mark)**

v = 2244 / 510

v = 4.4 ms^{-1} **(1 mark)**

8. a) i) (Method: By drawing a vector (right-angled) triangle and using Pythagoras)

$(\text{Resultant force})^2 = (6.0 \times 10^3)^2 + (8.0 \times 10^3)^2$ **(1 mark)**

Resultant force = 10×10^3 N **(1 mark)**

8. a) ii) (Method: By drawing a vector (right-angled) triangle and using SOHCAHTOA)

$\tan \Theta = 6.0 \times 10^3 / 8.0 \times 10^3$ **(1 mark)**

$\Theta = 37^o$ **(1 mark)**

8. a) iii)

F = m x a **(1 mark)**

$10 \times 10^3 = 5.0 \times 10^6 \times a$ **(1 mark)**

$a = 10 \times 10^3 / 5.0 \times 10^6$

$a = 2.0 \times 10^{-3}$ ms^{-2} **(1 mark)**

8. b) Two correct labels, one from each list, one mark each.

Buoyancy force OR Upthrust OR Force of water on ship OR Flotation force

Weight OR Force of gravity

The ship floats because the forces are balanced. **(1 mark)**

9. a) i)

Length of card **(1 mark)**

Time taken for card to pass through the light gate **(1 mark)**

Time taken for trolley to travel from starting position to light gate **(1 mark)**

9. a) ii) Any suitable reason for one mark. Some acceptable answers are…

- Reaction time can cause error with stop clock reading
- Card may not have passed straight through light gate
- Length of card not measured properly as ruler may not have been straight along card

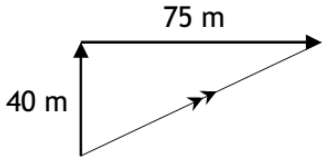
9. b)

$a = \frac{v-u}{t}$ **(1 mark)**

$= \frac{1 \cdot 6 - 0}{2 \cdot 5}$ **(1 mark)**

a = 0.64 ms^{-2} **(1 mark)**

10. a) i) (Method: By drawing a vector (right-angled) triangle and using Pythagoras)



$(Resultant)^2 = (40)^2 + (75)^2$ **(1 mark)**

Resultant = 85 m **(1 mark)**

10. a) ii) (Method: By drawing a vector (right-angled) triangle and using SOHCAHTOA)

tan Θ = 75 / 40 **(1 mark)**

Θ = 62°

Direction = 062 **(1 mark)**

10. b) i)

$\bar{v} = \frac{s}{t}$ **(1 mark)**

$\bar{v} = \frac{85}{68}$ **(1 mark)**

$\bar{v} = 1 \cdot 3 m\,s^{-1}$ at bearing 062

(1 mark – only awarded if the correct direction is stated)

10. b) ii)

The average speed is greater than the average velocity because…

- in the same time **(1 mark)**
- distance (143m) is greater than the magnitude (85m) of the displacement **(1 mark)**

11. a)

$a = \frac{v-u}{t}$ **(1 mark)**

$a = \frac{2 \cdot 5 - 0}{1 \cdot 4}$ **(1 mark)**

a = 1.8 ms^{-2} **(1 mark)**

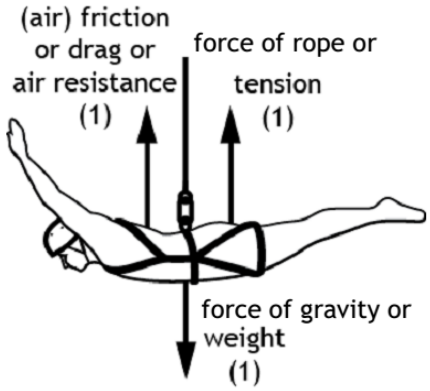
11. b) (Any time there is a speed-time graph remember distance = area under graph)

distance = area under graph **(1 mark)**

distance = (½ x 1.4 x 2.5) + (1.6 x 2.5) + (½ x 1.6 x 1.2) **(1 mark)**

distance = 6.71 m **(1 mark)**

11. c) 1 mark for each force correctly labelled with corresponding direction



12. a)

W = m x g **(1 mark)**

W = 3.00 x 10^3 x 9.8 **(1 mark)**

W = 2.94 x 10^4 N **(1 mark)**

12. b) i)

4 x 10 = 40 N **(1 mark)**

12. b) ii) (As this is worth 4 marks there will be an extra step as well as using an equation.)

mass remaining at this point in journey = 3.00 x 10^3 – 1.00 x 10^3 = 2.00 x 10^3 kg **(1 mark)**

F = m x a **(1 mark)**

40 = 2.00 x 10^3 x a **(1 mark)**

a = 40 / 2.00 x10^3

a = 0.02 ms^{-2} **(1 mark)**

13. a)

For calculating (3 x 10^8 x 365 x 24 x 60 x 60) one light year **OR**

Correctly quoting the value of one light year 9.46 x 10^{15} **(1 mark)**

Selecting 640 from the passage **(1 mark)**

640 x 9.46 x 10^{15} **(1 mark)**

6.1 x 10^{18} m (Need to state your final answer to gain full marks)

13. b)

The light/radiation from the explosion has not reached Earth yet. **(1 mark)**

DATA SHEET

Speed of light in materials

Material	*Speed* in $m\,s^{-1}$
Air	$3{\cdot}0 \times 10^8$
Carbon dioxide	$3{\cdot}0 \times 10^8$
Diamond	$1{\cdot}2 \times 10^8$
Glass	$2{\cdot}0 \times 10^8$
Glycerol	$2{\cdot}1 \times 10^8$
Water	$2{\cdot}3 \times 10^8$

Gravitational field strengths

	Gravitational field strength on the surface in $N\,kg^{-1}$
Earth	9·8
Jupiter	23
Mars	3·7
Mercury	3·7
Moon	1·6
Neptune	11
Saturn	9·0
Sun	270
Uranus	8·7
Venus	8·9

Specific latent heat of fusion of materials

Material	*Specific latent heat of fusion* in $J\,kg^{-1}$
Alcohol	$0{\cdot}99 \times 10^5$
Aluminium	$3{\cdot}95 \times 10^5$
Carbon Dioxide	$1{\cdot}80 \times 10^5$
Copper	$2{\cdot}05 \times 10^5$
Iron	$2{\cdot}67 \times 10^5$
Lead	$0{\cdot}25 \times 10^5$
Water	$3{\cdot}34 \times 10^5$

Specific latent heat of vaporisation of materials

Material	*Specific latent heat of vaporisation* in $J\,kg^{-1}$
Alcohol	$11{\cdot}2 \times 10^5$
Carbon Dioxide	$3{\cdot}77 \times 10^5$
Glycerol	$8{\cdot}30 \times 10^5$
Turpentine	$2{\cdot}90 \times 10^5$
Water	$22{\cdot}6 \times 10^5$

Speed of sound in materials

Material	*Speed* in $m\,s^{-1}$
Aluminium	5200
Air	340
Bone	4100
Carbon dioxide	270
Glycerol	1900
Muscle	1600
Steel	5200
Tissue	1500
Water	1500

Specific heat capacity of materials

Material	*Specific heat capacity* in $J\,kg^{-1}\,°C^{-1}$
Alcohol	2350
Aluminium	902
Copper	386
Glass	500
Ice	2100
Iron	480
Lead	128
Oil	2130
Water	4180

Melting and boiling points of materials

Material	*Melting point* in °C	*Boiling point* in °C
Alcohol	−98	65
Aluminium	660	2470
Copper	1077	2567
Lead	328	1737
Iron	1537	2737
Water	–	100

Radiation weighting factors

Type of radiation	*Radiation weighting factor*
alpha	20
beta	1
fast neutrons	10
gamma	1
slow neutrons	3
X-rays	1

$$E_p = mgh$$

$$E_k = \tfrac{1}{2}mv^2$$

$$Q = It$$

$$V = IR$$

$$R_T = R_1 + R_2 + \ldots$$

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots$$

$$V_2 = \left(\frac{R_2}{R_1 + R_2} \right) V_s$$

$$\frac{V_1}{V_2} = \frac{R_1}{R_2}$$

$$P = \frac{E}{t}$$

$$P = IV$$

$$P = I^2 R$$

$$P = \frac{V^2}{R}$$

$$E_h = cm\Delta T$$

$$p = \frac{F}{A}$$

$$\frac{pV}{T} = \text{constant}$$

$$p_1 V_1 = p_2 V_2$$

$$\frac{p_1}{T_1} = \frac{p_2}{T_2}$$

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

$$d = vt$$

$$v = f\lambda$$

$$T = \frac{1}{f}$$

$$A = \frac{N}{t}$$

$$D = \frac{E}{m}$$

$$H = Dw_R$$

$$\dot{H} = \frac{H}{t}$$

$$s = vt$$

$$d = \bar{v}t$$

$$s = \bar{v}t$$

$$a = \frac{v - u}{t}$$

$$W = mg$$

$$F = ma$$

$$E_w = Fd$$

$$E_h = ml$$