National 5 Physics

Christmas homework

My gift to you!!

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
Glycerol	18	290
Lead	328	1737
Iron	1537	2737

Radiation weighting factors

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

$$E_p = mgh$$

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

$$Q = It$$

$$V = IR$$

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

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

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

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

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

$$P = IV$$

$$P = I^2 R$$

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

$$E_h = cm\Delta T$$

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

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

$$p_1 V_1 = p_2 V_2$$

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

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

$$d = vt$$

$$v = f\lambda$$

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

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

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

$$H = Dw_R$$

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

$$s = vt$$

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

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

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

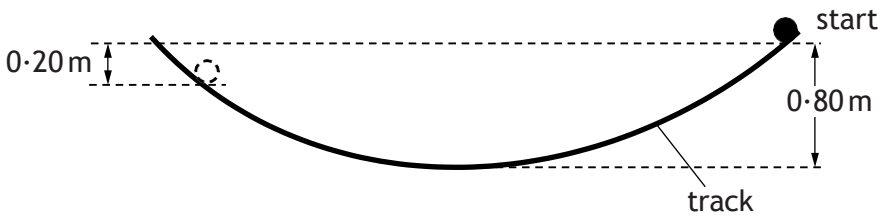
$$W = mg$$

$$F = ma$$

$$E_w = Fd$$

$$E_h = ml$$

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 3·9J

2. Astudent writes the following statements about electromagnetic waves.

I Electromagnetic waves all travel at the same speed in air.

II Electromagnetic waves all have the same frequency.

III Electromagnetic waves all transfer energy.

Which of these statements is/are correct?

A I only

B II only

C I and III only

D II and III only

E I, II and III

3. A satellite orbiting the Earth transmits television signals to a receiver.
The signals take a time of 150 ms to reach the receiver.
The distance between the satellite and the receiver is

A $2{\cdot}0 \times 10^{6}$ m

B $2{\cdot}25 \times 10^{7}$ m

C $4{\cdot}5 \times 10^{7}$m

D $2{\cdot}0 \times 10^{9}$ m

E $4{\cdot}5 \times 10^{10}$m.

4. A wave machine in a swimming pool generates 15 waves per minute.
The wavelength of these waves is 2·0 m.
The frequency of the waves is

A 0·25 Hz

B 0·50 Hz

C 4·0 Hz

D 15 Hz

E 30 Hz.

5. For a ray of light travelling from air into glass, which of the following statements is/are correct?

I The speed of light always changes.

II The speed of light sometimes changes.

III The direction of light always changes.

IV The direction of light sometimes changes.

A I only

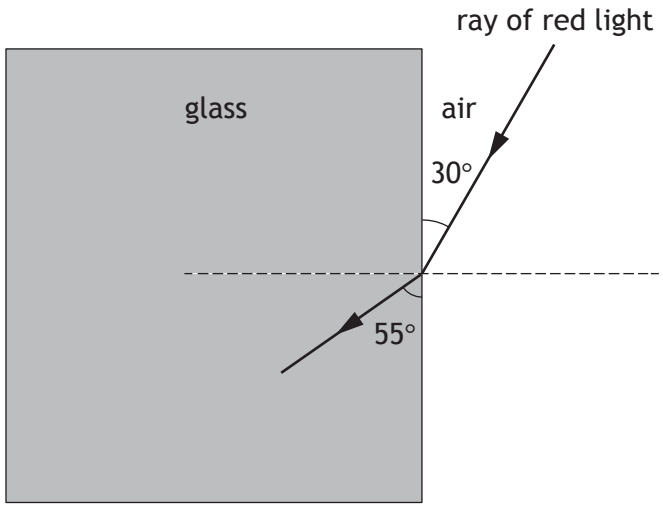
B III only

C I and III only

D I and IV only

E II and IV

6. A ray of red light is incident on a glass block as shown.



Which row in the table shows the values of the angle of incidence and angle of refraction?

	Angle of incidence	*Angle of refraction*
A	35°	60°
B	30°	55°
C	30°	35°
D	60°	55°
E	60°	35°

7. A student writes the following statements about the activity of a radioactive source.

I The activity decreases with time.

II The activity is measured in becquerels.

III The activity is the number of decays per second.

Which of these 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

8. A worker in a nuclear power station is exposed to 3·0 mGy of gamma radiation and 0·50 mGy of fast neutrons.

The radiation weighting factor for gamma radiation is 1 and for fast neutrons is 10.

The total equivalent dose, in mSv, received by the worker is

A 3·50

B 8·00

C 30·5

D 35·0

E 38·5.

9. Which of the following contains two scalar quantities?

A Force and mass

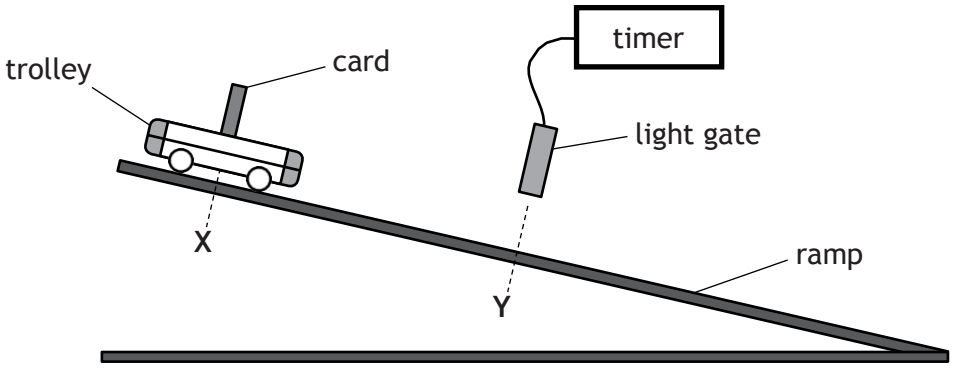
B Weight and mass

C Displacement and speed

D Distance and speed

E Displacement and velocity

10. 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 $0{\cdot}5\ m\ s^{-1}$

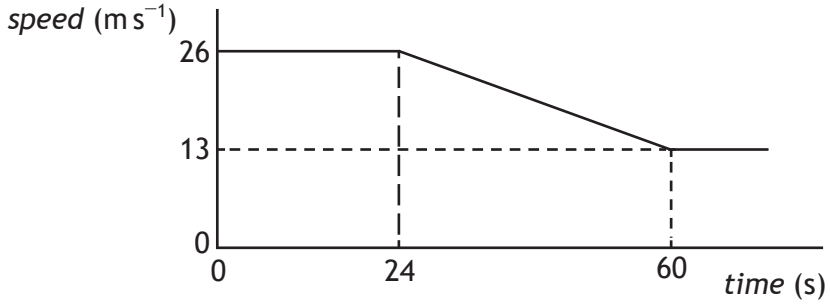
B $1{\cdot}6\ m\ s^{-1}$

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

D $3{\cdot}2\ m\ s^{-1}$

E $6{\cdot}3\ m\ s^{-1}$.

11. 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.

12. 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

13. 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

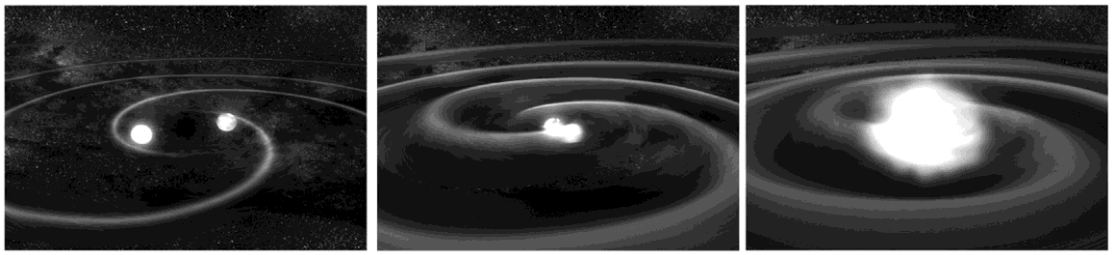
D The force of the Earth on the aircraft engine

E The force of the aircraft engine on the Earth

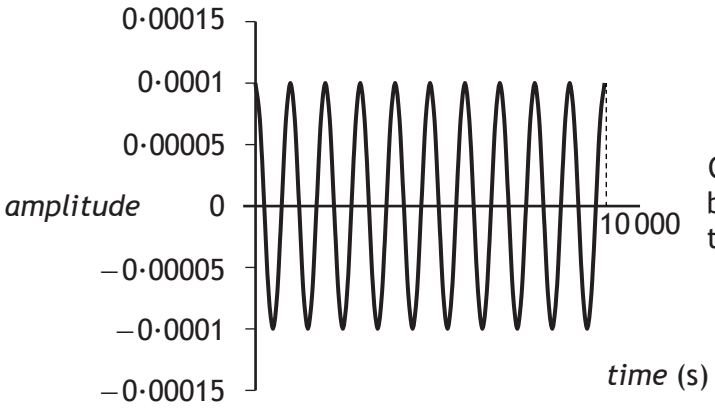
SECTION 2
Attempt ALL questions

DO NOT WRITE IN THIS MARGIN

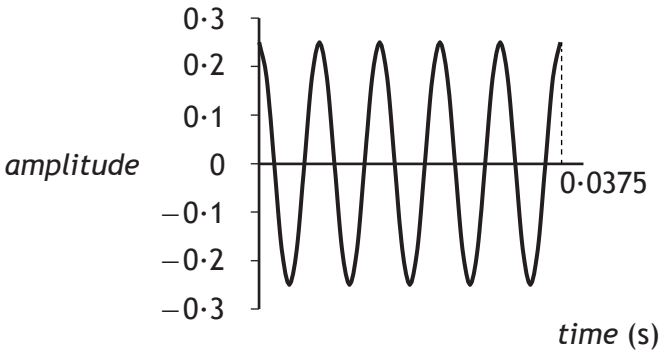
1 A pair of neutron stars which orbit one another will over time move closer together and eventually join.



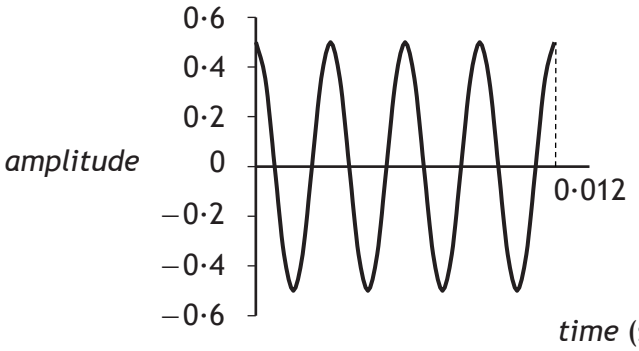
Astronomers believe that as the neutron stars move closer, they emit energy in the form of gravitational waves. It is predicted that gravitational wave detectors will produce the graphs shown.



One million years before stars join together



One second before stars join together



0·1 seconds before stars join together

1 (continued)

(a) Use the graphs to complete the following table. The first row has already been completed. **4**

Time before the stars join	*Period of gravitational waves* (s)	*Frequency of gravitational waves* (Hz)
1 million years	1000	0·001
1 second		
0·1 second		

Space for working

(b) State what happens to the frequency of the gravitational waves as the neutron stars move closer together. **1**

(c) The orbital speed, in metres per second, of the rotating neutron stars is given by the equation:

$$v = \frac{2\pi}{T}R$$

where T is the orbital period in seconds and R is half the distance between the stars in metres.

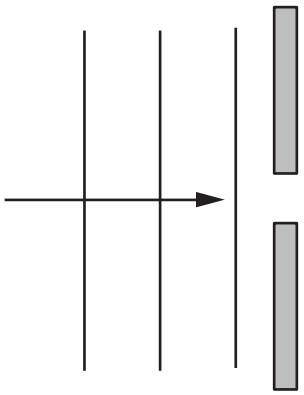
Calculate the orbital speed of the neutron stars when they are 340 000 km apart and the orbital period is 1150 s. **2**

Space for working and answer

Total marks 7

MARKS DO NOT WRITE IN THIS MARGIN

2 A water wave is diffracted when it passes through a gap in a barrier. The wavelength of the wave is 10 mm. The gap is less than 10 mm.



a) Complete the diagram above to show the pattern of the wave to the right of the barrier. **2**

b) The diagram below represents the electromagnetic spectrum.

Radio & TV waves	A	Infrared radiation	Visible light	Ultraviolet light	X-rays	Gamma radiation

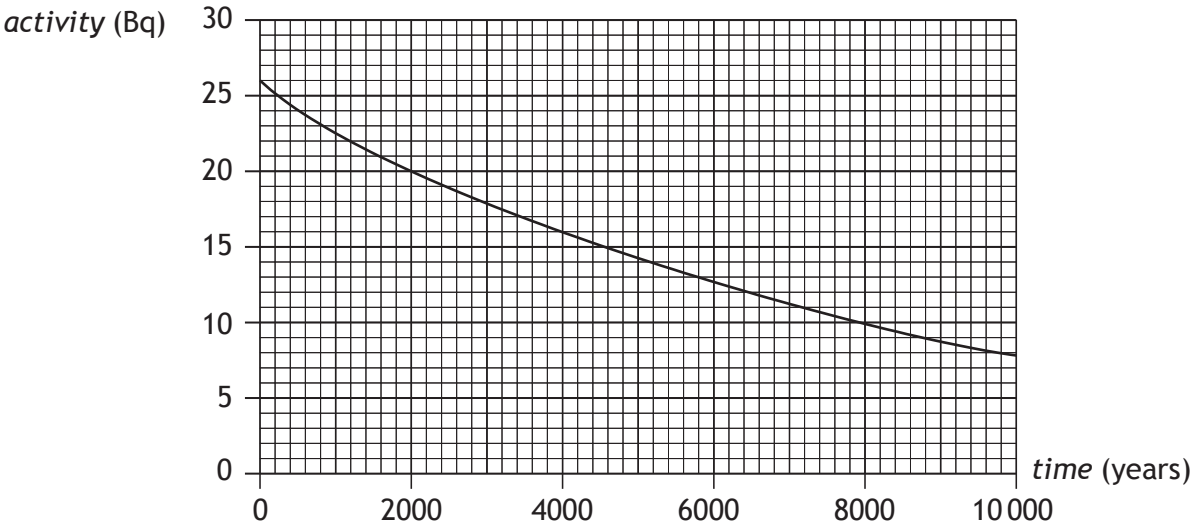
i. Identify radiation A. **1**

ii. Apart from diffraction, state one property that all electromagnetic waves have in common. **1**

Total marks 4

3 Trees continually absorb carbon-14 when they are alive. When a tree dies the carbon-14 contained in its wood is not replaced. Carbon-14 is radioactive and decays by beta emission.

(a) Following the tree's death, the activity of the carbon-14 within a **25 mg** sample of its wood changes as shown.



(i) Use the graph to determine the half-life of carbon-14. **2**

(ii) Calculate the time taken for the activity of this sample of carbon-14 to fall to 6·5 Bq. **3**

Space for working and answer

3 (a) (continued)

(iii) During an archaeological dig, a 125 mg sample of the same type of wood was obtained. The activity of this sample was 40 Bq.

Estimate the age of this sample. **3**

Space for working and answer

(b) Explain why this method could not be used to estimate the age of a tree that died 100 years ago. **1**

Total marks 9

4 A technician uses a radioactive source to investigate the effect of gamma rays on biological tissue.

(a) State what is meant by the term *gamma rays*. **1**

(b) The wavelength of a gamma ray is $6{\cdot}0 \times 10^{-13}$ m.

Calculate the frequency of the gamma ray. **3**

Space for working and answer

(c) In one experiment, a biological tissue sample of mass 0·10 kg receives an absorbed dose of 50 μGy.

Calculate the energy absorbed by the tissue. **3**

Space for working and answer

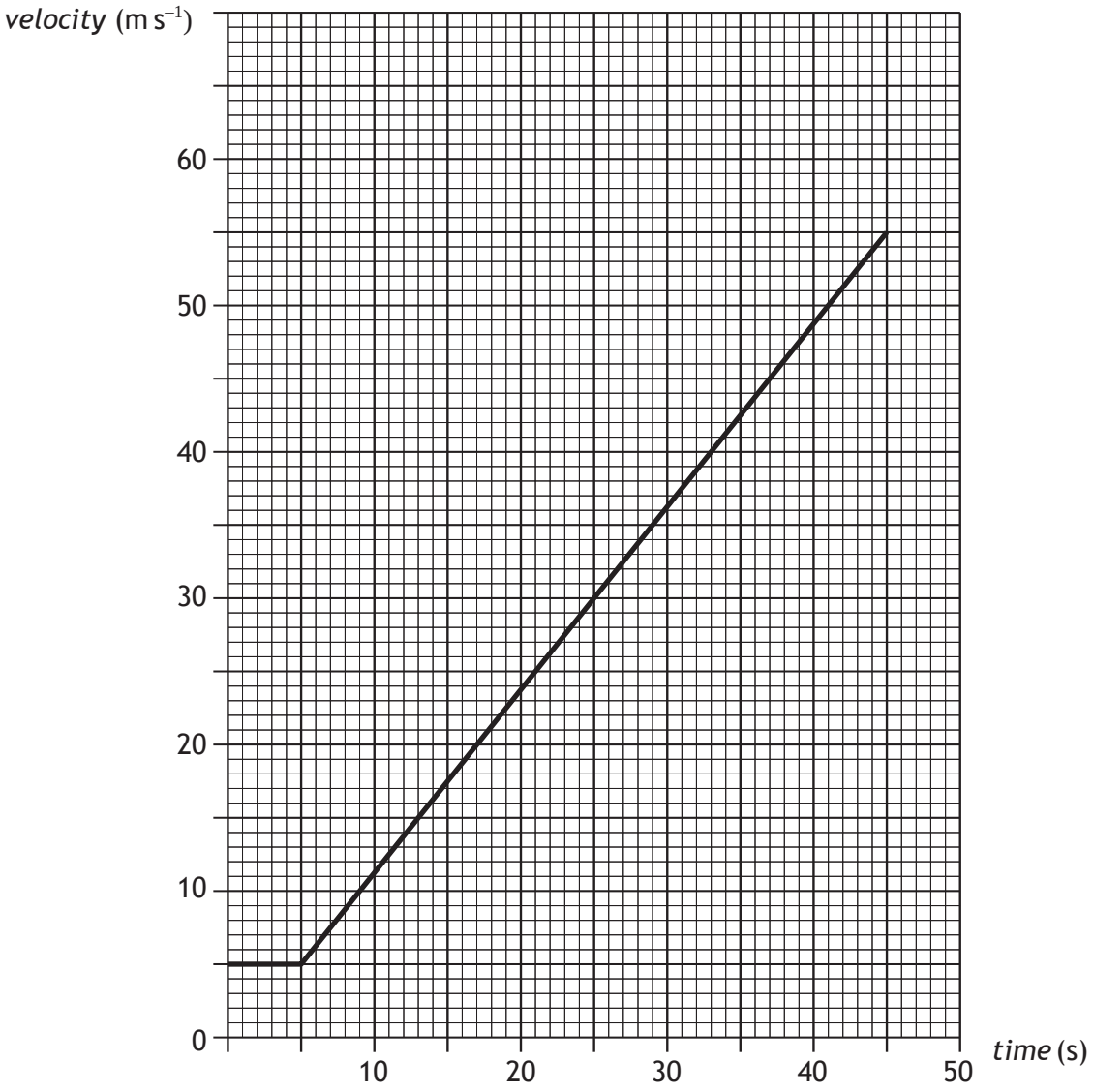
4 (continued)

(d) The radioactive source must be stored in a lead-lined container.
Explain why a lead-lined container should be used. **1**

Total marks 8

MARKS | DO NOT WRITE IN THIS MARGIN

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



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

Space for working and answer

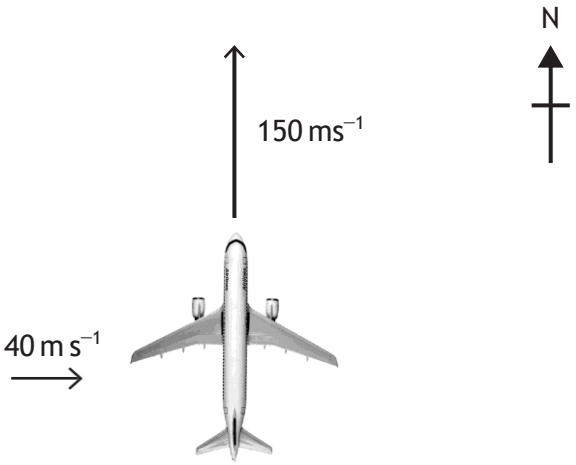
5. (continued)

DO NOT WRITE IN THIS MARGIN

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

By scale diagram, or otherwise, determine the resultant velocity of the aircraft.

4



Space for working and answer

5 (b) (continued)

(ii) Describe what action the pilot could take to ensure that the aircraft remains travelling north at 150 m s^{-1}. **2**

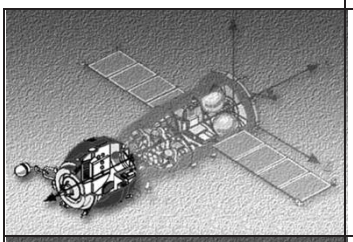
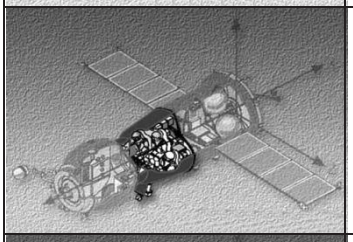
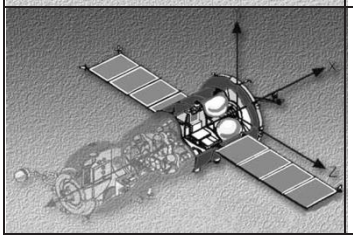
(c) The aircraft arrives at the destination airport.

This airport has three runways of different lengths to accommodate different sizes of aircraft.

Explain why larger aircraft require a much longer runway to land safely. **2**

Total marks 11

6 The Soyuz Spacecraft is used to transport astronauts to the International Space Station (ISS). The spacecraft contains three parts that are launched together.

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

(a) When the spacecraft leaves the ISS, its propulsion module produces a force of 1430 N.

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

Space for working and answer

6 (continued)

(b) On the return 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**

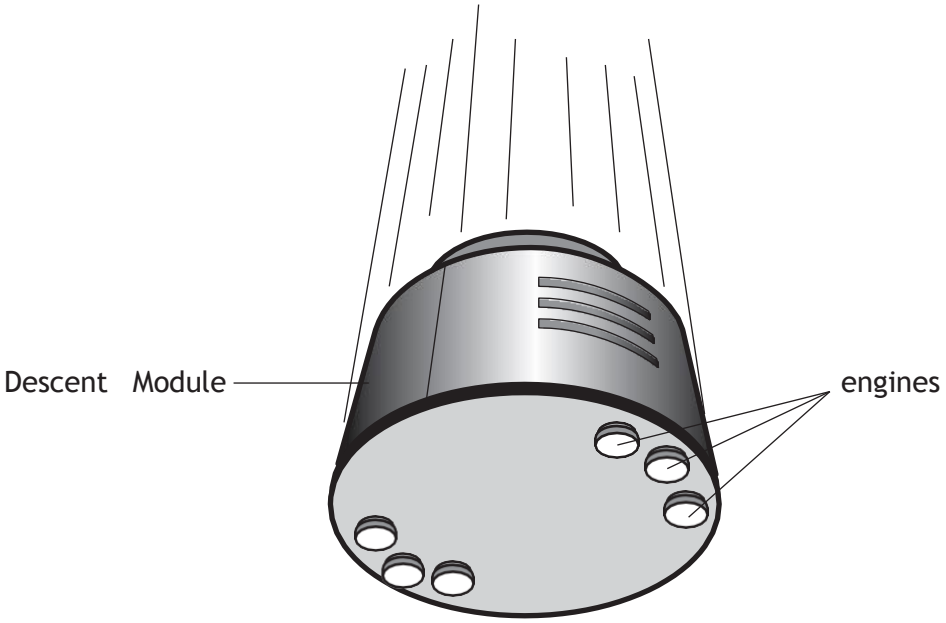
(c) After the Descent Module has re-entered the atmosphere, its speed is dramatically reduced.

(i) Four parachutes are used to slow the Module's rate of descent from $230\,m\,s^{-1}$ to $80\,m\,s^{-1}$.

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

6 (c) (continued)

(ii) Just before touchdown, small engines fire on the bottom of the Module, slowing it down further. The work done by the engines is 80 kJ over a distance of 5 m.



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

Space for working and answer

Total marks 11

MARKS

7 Read the passage below and 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.

i. Name the galaxy mentioned in the passage. **1**

ii. Show that the Dragonfish nebula is approximately $2{\cdot}84 \times 10^{20}$ m away from Earth. **3**

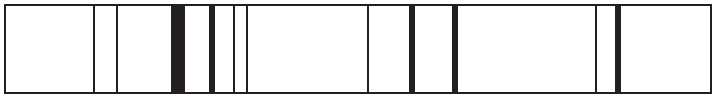
Space for working and answer

7 (continued)

iii. Complete the sentence by circling the correct words.

Compared to infrared radiation, microwaves have a {longer / shorter} wavelength which means they have a {higher / lower} frequency. **1**

iv. A line spectrum from a nebula is shown below.



spectral lines from gases in the nebula

nitrogen

helium

hydrogen

krypton

Identify the elements present in the nebula. **2**

Total marks 7

YOU ARE FINISHED!!!!

WELL DONE!!!!