Surname	Centre Number	Candidate Number
First name(s)		0

GCSE

3420U20-1

Z22-3420U20-1

WEDNESDAY, 8 JUNE 2022 – AFTERNOON

PHYSICS – Unit 2:
Forces, Space and Radioactivity

FOUNDATION TIER

1 hour 45 minutes

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**6**	
2.	**9**	
3.	**4**	
4.	**5**	
5.	**11**	
6.	**7**	
7.	**12**	
8.	**6**	
9.	**14**	
10.	**6**	
Total	**80**	

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ADDITIONAL MATERIALS

In addition to this paper you will require a calculator and a ruler.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen or correction fluid.

You may use a pencil for graphs and diagrams only.

Write your name, centre number and candidate number in the spaces at the top of this page.

Answer **all** questions.

Write your answers in the spaces provided in this booklet. If you run out of space use the additional page at the back of the booklet, taking care to number the question(s) correctly.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.

The assessment of the quality of extended response (QER) will take place in question **7(b)(i)**.

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Equations

speed = $\frac{\text{distance}}{\text{time}}$	
acceleration [or deceleration] = $\frac{\text{change in velocity}}{\text{time}}$	$a = \frac{\Delta v}{t}$
acceleration = gradient of a velocity-time graph	
resultant force = mass × acceleration	$F = ma$
weight = mass × gravitational field strength	$W = mg$
work = force × distance	$W = Fd$
force = spring constant × extension	$F = kx$
momentum = mass × velocity	$p = mv$
force = $\frac{\text{change in momentum}}{\text{time}}$	$F = \frac{\Delta p}{t}$
u = initial velocity v = final velocity t = time a = acceleration x = displacement	$v = u + at$ $x = \frac{u + v}{2} t$
moment = force × distance	$M = Fd$

SI multipliers

Prefix	Multiplier
m	1×10^{-3}
k	1×10^{3}
M	1×10^{6}

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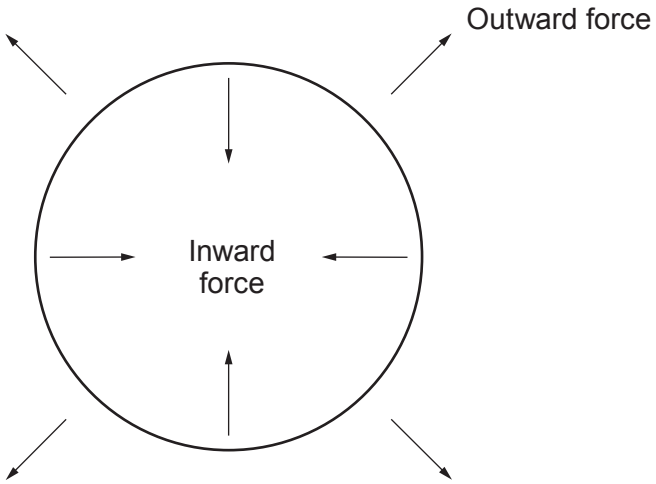
Answer **all** questions.

1. The diagram shows the forces acting on a large star.



(a) Complete the sentences by underlining the correct word in brackets.

(i) The inward force acting on the star is caused by (**gravity** / **pressure** / **helium**). [1]

(ii) The outward force acting on the star is caused by (**gravity** / **pressure** / **helium**). [1]

(b) Use only words from the box to answer the following questions.

space,	**white dwarf,**	**supergiant,**	**neutron star,**	**solar system**

(i) Complete the list of stages that this large star will go through, from the main sequence until it reaches the end of its life. [2]

main sequence star ⟶ ..... ⟶ supernova ⟶ .....

(ii) Complete the following sentence using words from the box. [2]

During the supernova stage, material is returned to .....

where it creates a new .....

.

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2. The following results were obtained from an investigation into stretching a spring.

Force (N)	Length of spring (cm)
1.0	12.0
2.5	15.0
4.0	18.0
5.0	20.0
6.0	22.0
7.5	25.0

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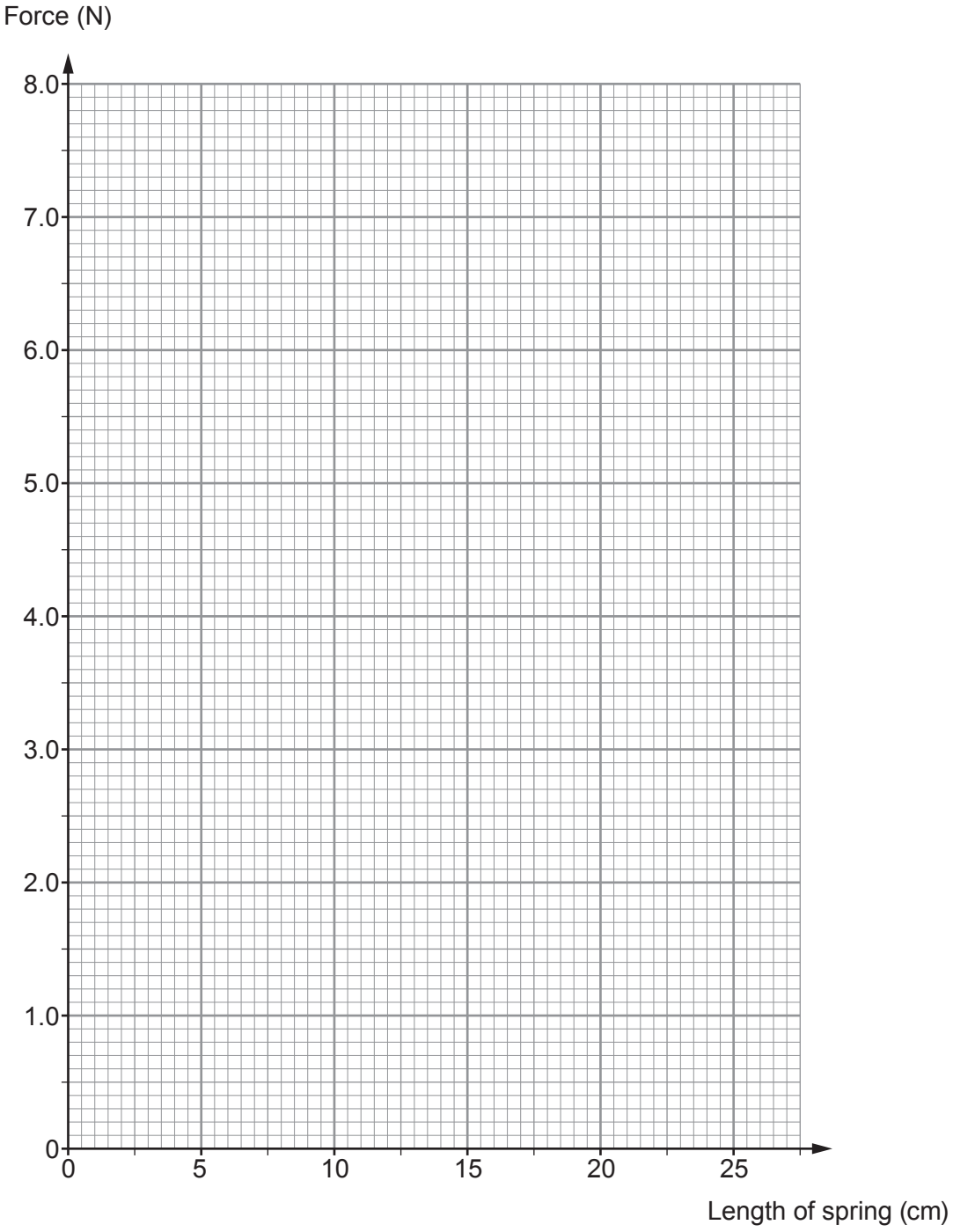
(a) Plot the data on the grid below and draw a suitable straight line. [3]



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(b) Use the graph to answer the following questions.

(i) The unstretched length of the spring is its length when the force applied is zero. State the unstretched length of the spring. [1]

Unstretched length = ... cm

(ii) I. State the length of the spring produced by a force of 3.0 N. [1]

Length = ... cm

II. Use the equation:

extension = length produced by 3.0 N – unstretched length

to calculate the extension produced by a force of 3.0 N. [1]

Extension = ... cm

(iii) Use your previous answer and the equation:

$$\text{spring constant} = \frac{\text{force}}{\text{extension}}$$

to calculate the spring constant of the spring for a force of 3.0 N. [2]

Spring constant = ... N/cm

(iv) Complete the sentence by underlining the correct answer in the brackets. [1]

If the force on the spring is doubled to 6.0 N, then the spring constant (**halves** / **stays the same** / **doubles**).

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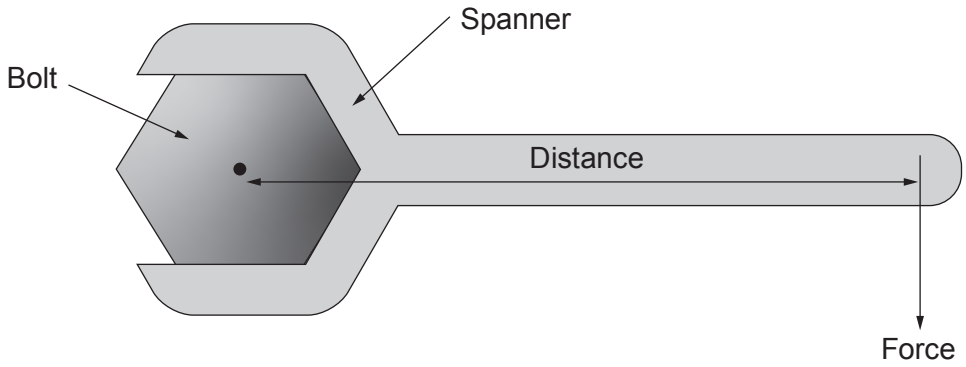
3. The diagram shows a spanner being used to tighten a bolt.



A force at the end of the spanner produces a moment about the bolt.

(a) In the diagram above, the force is 80 N and the distance is 0·25 m.

Use the equation:

moment = force × distance

to calculate the moment of the force about the bolt. [2]

Moment = ... N m

(b) Henry says it is easier to tighten the bolt if a longer spanner is used.
Explain why Henry is correct. [2]

.....

.....

.....

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Turn over.

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4. This question is about nuclear fusion in a star.

(a) State the **two** conditions that are required for nuclear fusion to take place. [2]

1. .....

2. .....

(b) Deuterium and tritium are isotopes of hydrogen.
In one nuclear fusion reaction, deuterium and tritium undergo nuclear fusion to form helium and one neutron.

Complete the nuclear equation below for the fusion of deuterium and tritium. [3]

$$ {}^{2}_{1}\mathrm{H} + {}^{3}_{1}\mathrm{H} \longrightarrow {}^{\cdots\cdots}_{\cdots\cdots}\mathrm{He} + {}^{1}_{\cdots\cdots}\mathrm{n} $$

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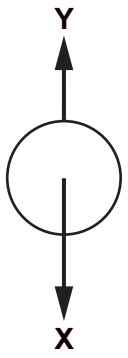
5. A ball is dropped from rest.
Two forces, X and Y, act on the ball during its fall.



(a) (i) Name the forces X and Y. [2]

X ..... Y .....

(ii) State what happens to the size of the forces, if anything, as the ball speeds up. [2]

Force X .....

Force Y .....

(b) Complete the following sentences by underlining the correct phrase in the brackets. [2]

(i) The ball speeds up at the start of its fall because force Y is (**smaller than** / **equal to** / **larger than**) force X.

(ii) The ball eventually reaches a constant speed because force Y is (**smaller than** / **equal to** / **larger than**) force X.

(c) After being dropped from rest, the ball takes 2 seconds to hit the ground.

(i) Use the equation:

$$v = u + at$$

to calculate the final speed, v, with which the ball hits the ground. [2]
(Acceleration due to gravity, g = 10 m/s^2)

v = ... m/s

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(ii) Use an equation from page 2 and your answer to part (c)(i) to calculate the height, x, from which the ball was dropped. [3]

x = ... m

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6. A group of students use 6-sided dice to model radioactive decay.
There are 240 dice in total.
Dice with a 6 facing upward represent decayed nuclei.

(a) (i) State what the students should do after throwing the 240 dice for the first time. [1]

.....

.....

(ii) Describe how they should continue the experiment. [1]

.....

.....

(iii) I. State the chance (probability) of any one of the dice landing with a 6 facing upward. [1]

.....

II. Use your previous answer to predict how many dice will land with a 6 facing up on the first throw. [1]

.....

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(b) The table shows the results.

Throw	Number of sixes	Number of dice remaining
0	0	240
1	38	202
2	30	.....
3	28	144
4	22	122
5	22	100

(i) **Complete** the table. [1]

(ii) State how many dice remain after one half-life. ..... [1]

(iii) Use the data in the table to estimate the half-life of the 'dice' in throws. [1]

Half-life = ... throws

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7. (a) In dry conditions, a Formula One (F1) car can accelerate from 0 to 30 m/s in 1.5 seconds in a straight line.

(i) State the change in velocity. [1]

Change in velocity = ... m/s

(ii) Use the equation:

$$\text{acceleration} = \frac{\text{change in velocity}}{\text{time}}$$

to calculate the acceleration of the racing car. [2]

Acceleration = ... m/s^2

(b) The photograph shows F1 cars lined up on the grid.

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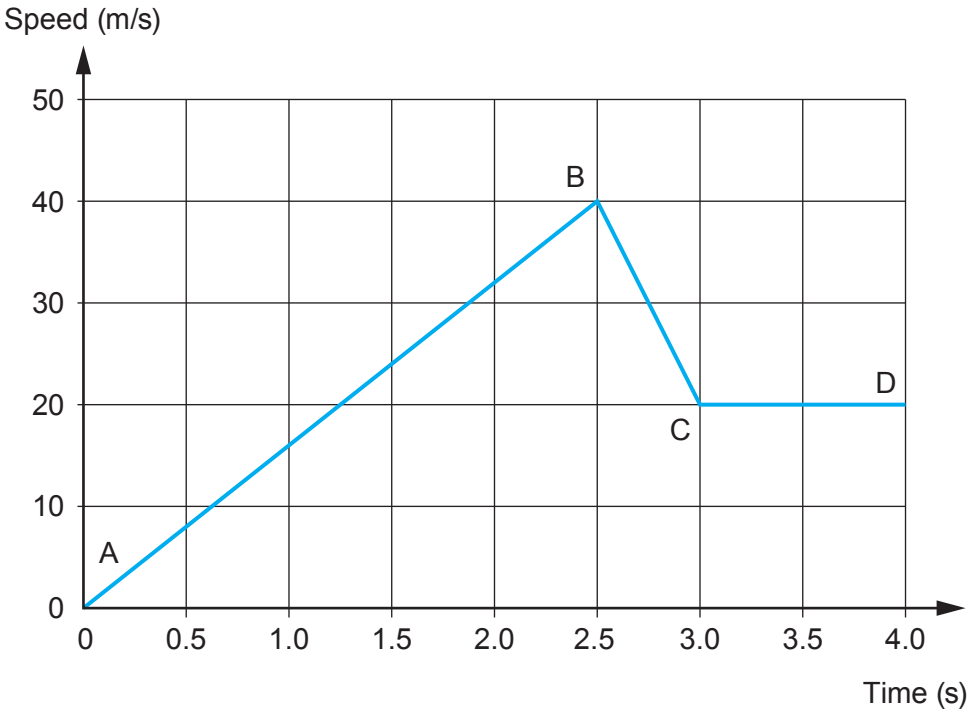
The graph below shows how the speed of a F1 racing car changes at the start of a race as it leaves the grid and goes around the first bend.



(i) **Use data from the graph** to describe the motion of the car during the time shown. No calculations are required. [6 QER]

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(ii) The car travels 85 m during the time shown by the graph.
Use an equation from page 2 to calculate the mean speed of the car during this time. [3]

Mean speed = ... m/s

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8. Astronomers have studied light from distant galaxies.
They found that the light from these galaxies has increased in wavelength.

(a) Complete each sentence below by **drawing a line** to the correct ending. [2]

(i) The increase in wavelength of light is due to the Universe…

- contracting
- staying the same size
- expanding

(ii) The increase in wavelength of light supports the Big Bang model which states the Universe started from…

- different points
- a single point
- a supernova

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(b) Look at the diagrams below.
They show absorption spectra of hydrogen in a laboratory on Earth (**Diagram A**), from a distant galaxy X (**Diagram B**) and from another distant galaxy Y (**Diagram C**).

Diagram A: Laboratory on Earth

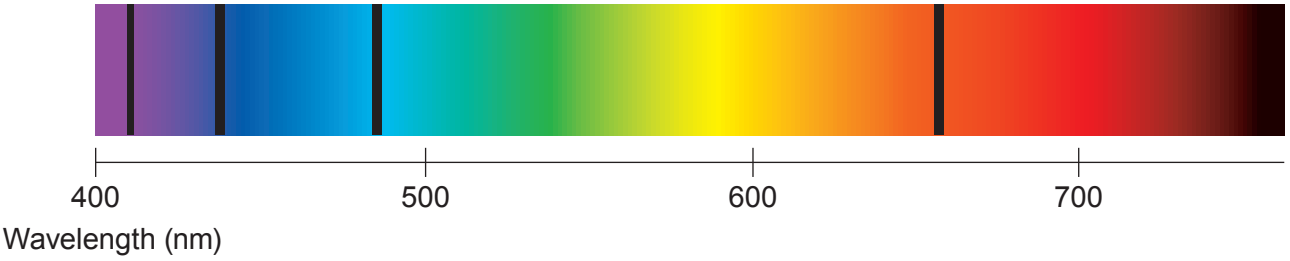


Diagram B: From galaxy X

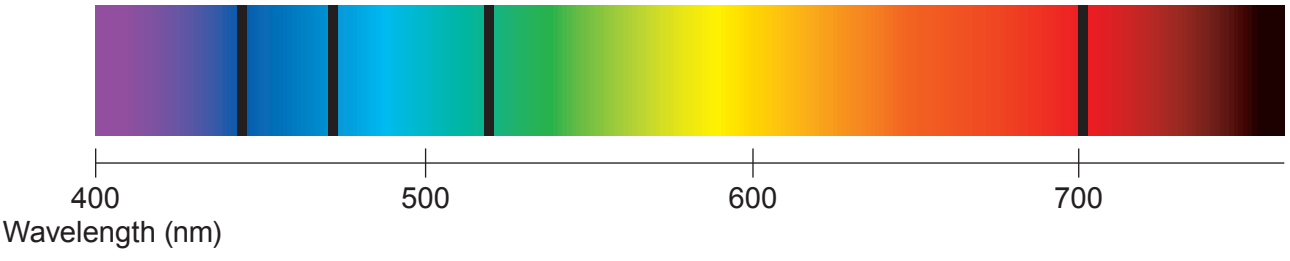
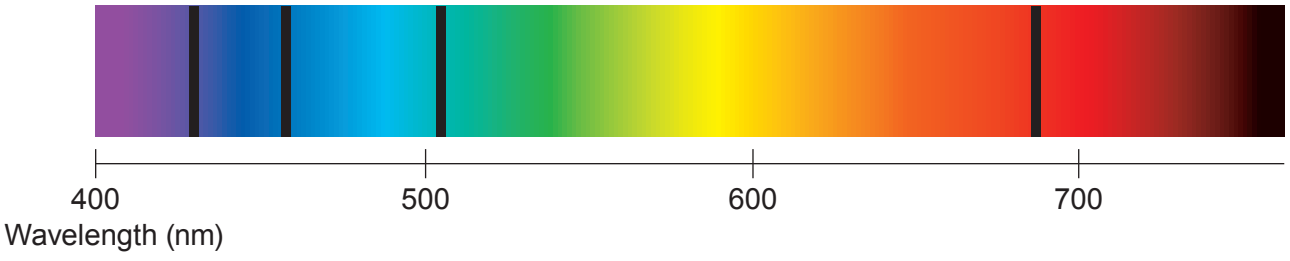


Diagram C: From galaxy Y



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Use the spectra opposite to answer the following questions.

(i) Compare the spectral dark lines in diagrams **A** and **B**. [2]

.....

.....

.....

(ii) State the **differences** between the speed **and** distance from Earth for galaxies **X** and **Y**. [2]

.....

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.....

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9. (a) Background radiation occurs due to the decay of an unstable nucleus releasing alpha, beta or gamma radiation.

Complete the table below to state what each type of radiation is. [3]

Type of radiation	Symbol	What it is
Alpha	$^{4}_{2}\alpha$	.....
Beta	$^{0}_{-1}\beta$	.....
Gamma	γ	.....

(b) A teacher demonstrates how to determine the background radiation count in her laboratory.
She uses a radiation detector and measures 18 counts in 30 seconds.

(i) Determine the background radiation count in counts per second. [1]

Background radiation = ... counts per second

(ii) Suggest **two** ways that the teacher could improve her measurement of background radiation. [2]

1. .....

2. .....

(iii) Explain why the background radiation count is much higher in some parts of the country than others. [2]

.....

.....

.....

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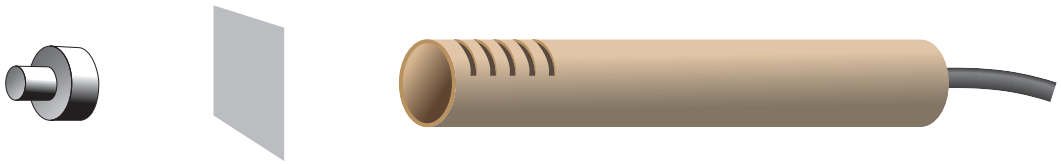
(c) The teacher now demonstrates an experiment to identify the radiation emitted by different sources.
The count rate is measured, first with no absorber present and then with paper and aluminium absorbers separately.



The results are shown in the table below. They are corrected for background radiation.

Source	Count rate (counts per second)		
	No absorber	Paper	Thin aluminium
1	312	313	312
2	389	57	0

(i) Write **yes (Y) or no (N)** in each box to show which type(s) of radiation is (are) emitted by each source. [4]

	Alpha	Beta	Gamma
Source 1			
Source 2			

(ii) Explain **one** change the teacher could make to extend the investigation to confirm to the class the conclusions made. [2]

.....

.....

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10. The table below gives data about some objects in our solar system.

Object	Mass (units)	Diameter (km)	Length of day (hours)	Year length (days)	Orbital speed (km/s)	Mean temperature (°C)	Distance from Sun (units)
Mercury	0.330	4879	4222.6	88	47.4	167	0.39
Venus	4.87	12104	2802	225	35	464	0.72
Earth	5.97	12756	24	365	29.8	15	1.00
Moon	0.073	3475	708.7		1	–20	
Mars	0.642	6792	24.7	687	24.1	–65	1.52
Jupiter	1898	142984	9.9	4331	13.1	–110	5.20
Saturn	568	120536	10.7	10747	9.7	–140	9.54
Uranus	86.8	51118	17.2	30589	6.8	–195	19.18
Neptune	102	49528	16.1	59800	5.4	–200	30.06
Pluto	0.0146	2370	163.3	90560	4.7	–225	39.53

(a) (i) Use the information from the table to **tick (✓)** the **two** correct statements below. [2]

Neptune is hotter than the Moon. ☐

The mean temperature of the Moon is 5 degrees less than the Earth. ☐

A year on Earth is about 4 times longer than a year on Mercury. ☐

Mercury orbits the Sun with a speed around 10 times greater than Pluto. ☐

(ii) Pluto was once considered to be a planet but is now classed as a dwarf planet. Use the data in the table to suggest a reason for the change. [1]

.....

.....

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(iii) Ceres is another dwarf planet and it is the only dwarf planet located in the asteroid belt. Estimate its distance from the Sun. [1]

Distance from the Sun = ... units

(b) Elin concludes that rocky planets with the greatest mass have the shortest day length. Explain the extent to which the data supports this conclusion. [2]

.....

.....

.....

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END OF PAPER

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Question number	Additional page, if required. Write the question number(s) in the left-hand margin.

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