SPECIMEN PAPERS

SET 3

Paper 1 SL

Time allowed: 1 hour 30 minutes.

A calculator and the data booklet are required.

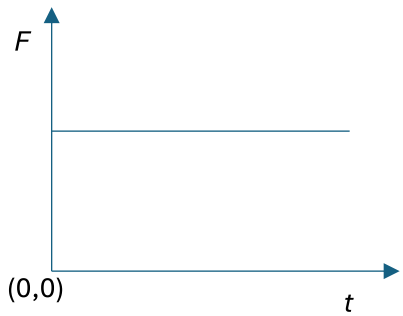
The paper consists of Section A with 25 multiple choice questions and Section B with data-based questions.

SECTION A – Multiple choice questions

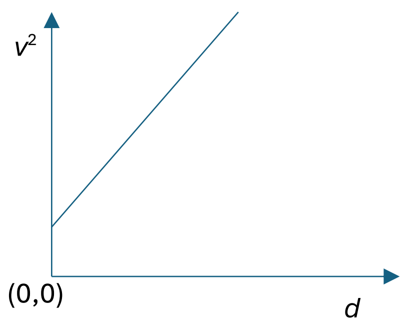
1. A body is dropped vertically from rest at $t = 0$. From $t = 0$ to $t = 1$ s the body falls a distance Z. What distance does it fall between $t = 1$ s and $t = 2$s? Air resistance is negligible.

A Z **B** 2Z **C** 3Z **D** 4Z

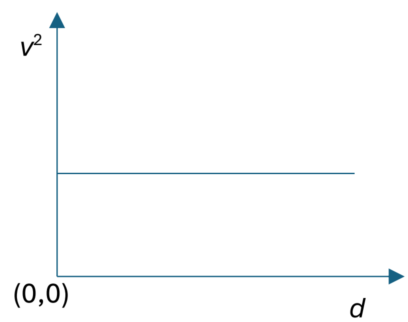
2. The graph shows the variation with time t of the net force F on a body. The initial velocity of the body is not zero.



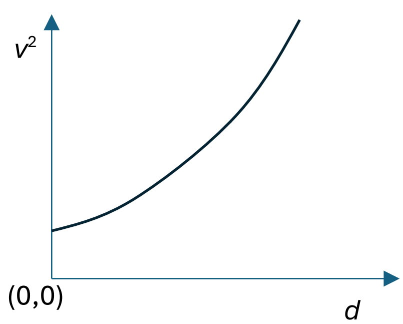
Which graph shows the variation with distance travelled d of the square of the velocity v^2 of the body?



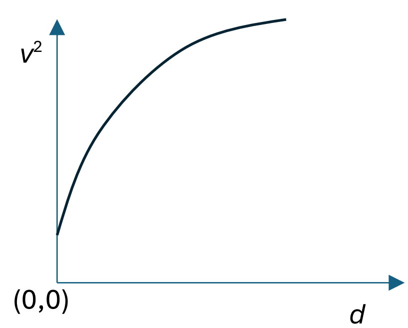
A



B

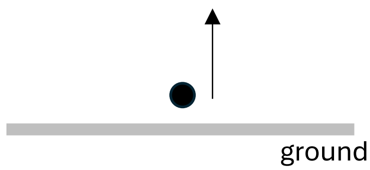


C



D

3. A ball is thrown vertically upwards. After reaching its maximum height it falls back to the ground. Air resistance is negligible.



Which statement about the resultant (net) force on the ball is correct while the ball is in the air?

A It decreases as the ball rises to its maximum height

B It is zero at the maximum height

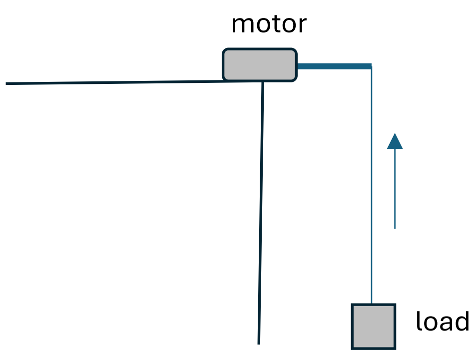
C It changes direction after it reaches the maximum height

D It is constant throughout the motion

4. A particle X of mass *m* moving at speed *v* collides with a stationary particle Y of mass *M*. X comes to rest after the collision.
What is the impulse delivered to *M*?

A mv **B** $-mv$ **C** Mv **D** $-Mv$

5. An electric motor has 50% efficiency. It lifts a load of weight 80 N vertically, for a distance of 5.0 m at constant acceleration 2.0 m s^{-2}.



What is the work done by the tension in the rope? (Take g = 10 m s^{-2}.)

A 480 J **B** 400 J **C** 240 J **D** 200 J

6. A mass $\underline{m}$ of ice at 0° C is placed in water at 0° C in an insulated container. The mass of the water is much greater than m. What mass of ice will be present in the container after a long time?

A 0
B Less than m but not zero
C m
D Greater than m

7. Two ideal gases X and Y are kept in different containers. X is kept at pressure P, volume V and temperature T. Y is kept at pressure $2P$, volume $\frac{V}{3}$ and temperature $\frac{T}{4}$.

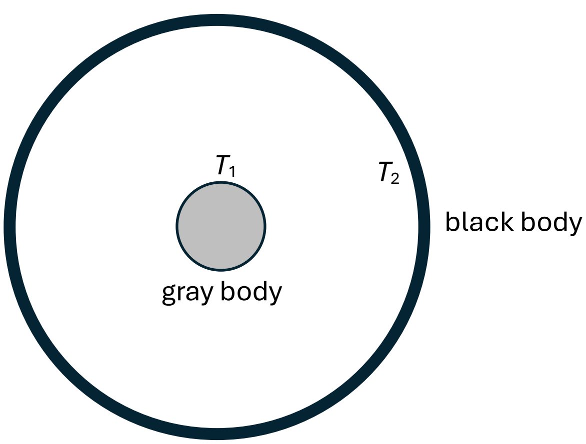
What is the ratio $\frac{N_X}{N_Y}$ of the number of molecules of X to the number of molecules of Y?

A $\frac{3}{8}$ **B** $\frac{1}{6}$ **C** $\frac{2}{3}$ **D** $\frac{3}{4}$

8. The temperature of an ideal gas of density ρ is quadrupled and the pressure is doubled. What is the new density of the gas?

A $\frac{\rho}{4}$ **B** $\frac{\rho}{2}$ **C** 2ρ **D** 4ρ

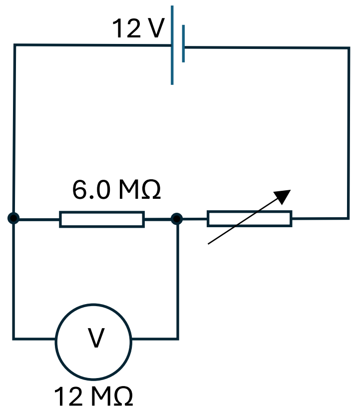
9. A gray body of emissivity e and temperature T_1 is surrounded by a black body of temperature T_2.



The intensity of radiation radiated by the gray body is equal to the intensity it absorbs. What is the correct relationship between the temperatures of the bodies?

A $eT_1 = T_2$ **B** $T_1 = eT_2$ **C** $e^{\frac{1}{4}}T_1 = T_2$ **D** $T_1 = T_2$

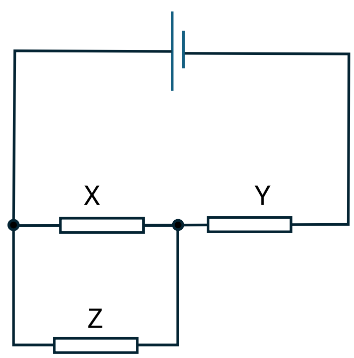
10. A cell of emf 12 V and negligible internal resistance is connected to a resistor of constant resistance 6.0 MΩ and a variable resistor. The voltmeter has resistance 12 MΩ.



What is the smallest voltmeter reading as the resistance of the variable resistor is varied from 6.0 MΩ to 0 Ω.

A 4.0 V **B** 4.8 V **C** 6.0 V **D** 7.2 V

11. Three identical resistors X, Y and Z are connected to a cell of negligible internal resistance as shown. The power dissipated in the circuit is 12 W.



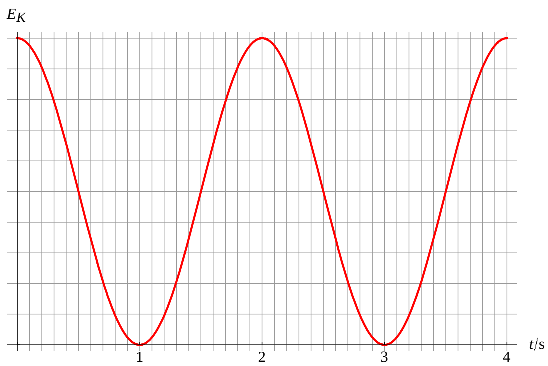
Resistor Z burns out.
What is the power dissipated in the circuit now?

A 8.0 W **B** 9.0 W **C** 16 W **D** 18 W

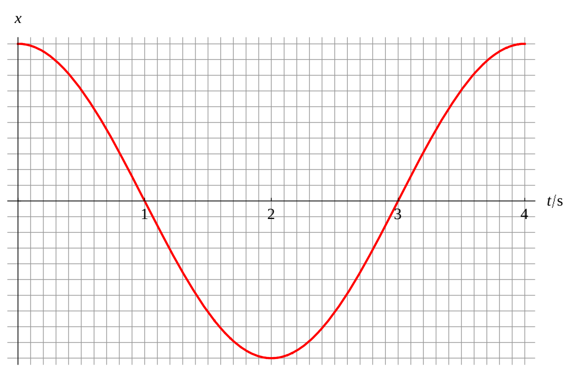
12. A body performs simple harmonic oscillations with period *T*. The amplitude of oscillations is *Z*. The amplitude is halved. What is the new period of oscillations?

A T **B** $\frac{T}{\sqrt{2}}$ **C** $\frac{T}{2}$ **D** $\frac{T}{4}$

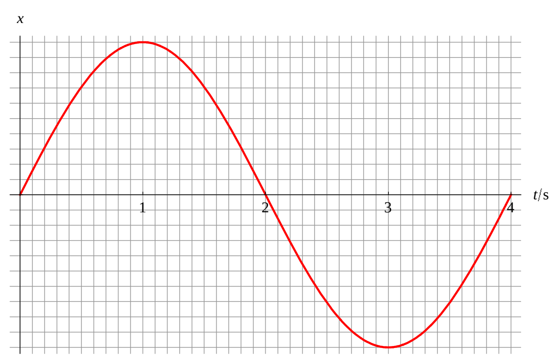
13. The graph shows the variation with time *t* of the kinetic energy E_K of a particle in simple harmonic motion.



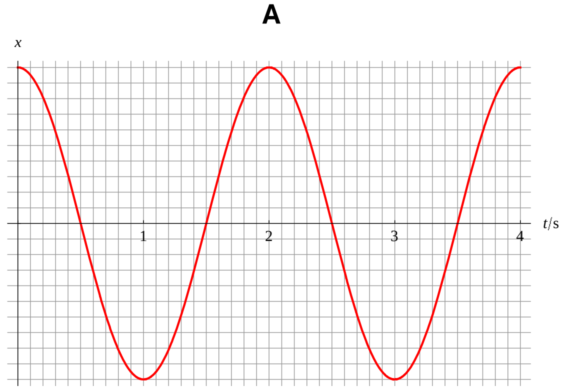
Which is a possible graph that gives the variation with time *t* of the displacement *x* of the particle?



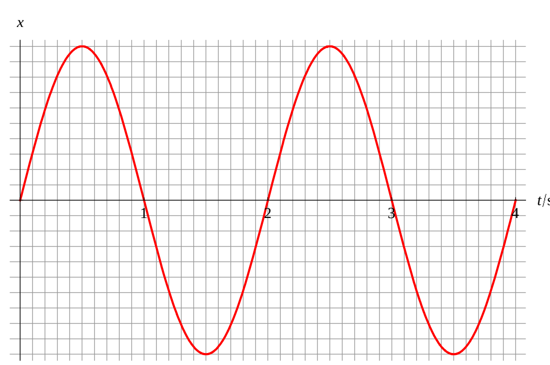
A



B

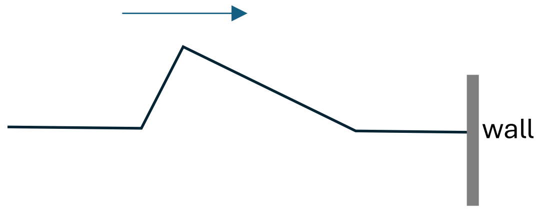


C

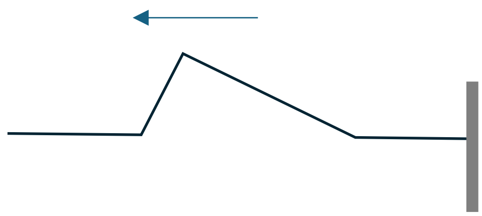


D

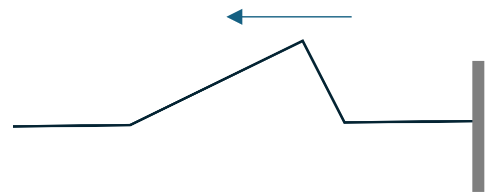
14. A pulse moves on a string whose right-hand end is tied to a wall.



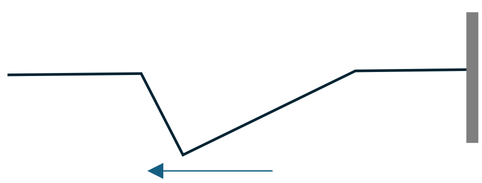
Which diagram shows the reflected pulse?



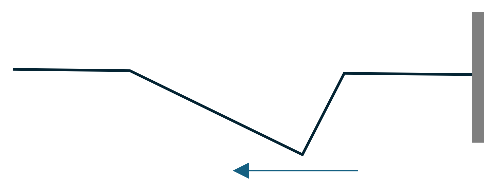
A



B

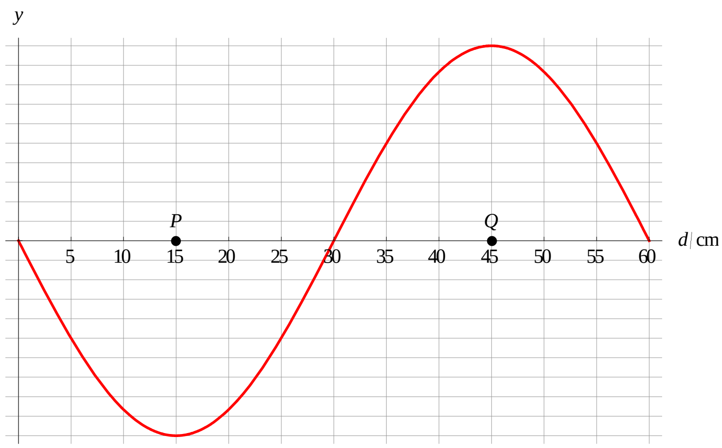


C



D

15. A longitudinal wave travels through a medium. The graph shows, at an instant of time, the variation with distance *d* of the displacement *y* of the particles in the medium. P and Q are the **equilibrium** positions of two particles in the medium.



At this instant the distance between P and Q is 34 cm.

What is the amplitude of the wave?

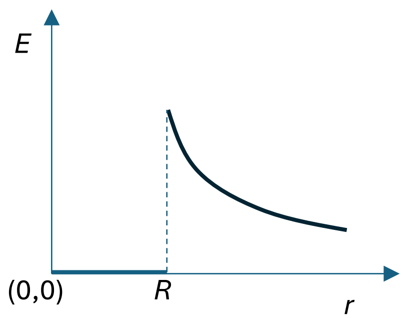
A 2.0 cm **B** 4.0 cm **C** 8.0 cm **D** 16 cm

16. Standing waves of the same frequency are established in two pipes X and Y. X is open at both ends and Y is closed at one end and open at the other. What is a possible ratio $\frac{L_X}{L_Y}$ of the lengths of the pipes?

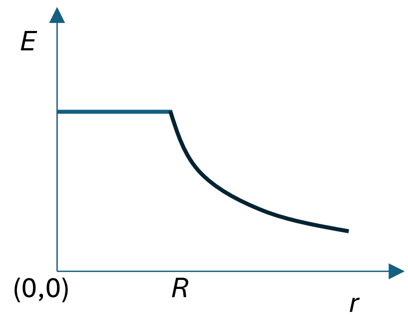
A $\frac{1}{2}$ **B** $\frac{3}{5}$ **C** $\frac{2}{3}$ **D** $\frac{3}{4}$

17. Two isolated spheres of the same radius and mass *M* and 2*M* are some distance apart. At which point is the magnitude of the gravitational field strength the largest?

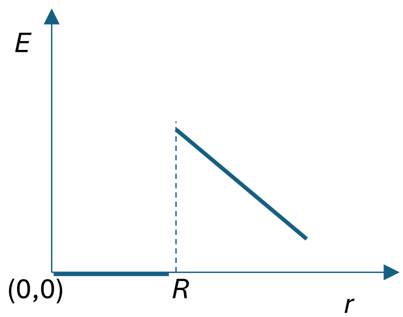
18. A conducting sphere of radius R has positive charge on its surface. Which diagram shows the variation with distance r from the center of the sphere of the electric field E produced by the sphere?



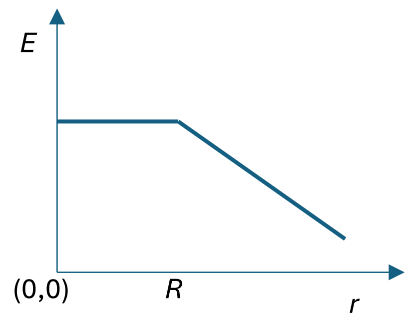
A



B

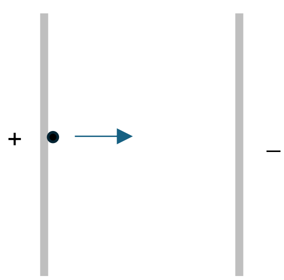


C



D

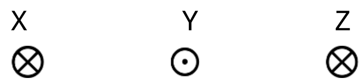
19. The figure shows two oppositely charged parallel plates. A proton, released from rest at the positive plate, arrives at the negative plate with kinetic energy K after time T.



The separation of the plates is doubled but the potential difference stays the same.
What is the kinetic energy of the proton now and how long does it take to reach the negative plate?

	Kinetic energy	Time
A	K	$T\sqrt{2}$
B	K	$2T$
C	$2K$	$T\sqrt{2}$
D	$2K$	$2T$

20. Three equidistant, parallel wires X, Y and Z carry equal currents perpendicularly to the plane of the page as shown.



The magnitude of the force per unit length exerted by X on Y is *f*. What is the resultant (net) force per unit length on Z in magnitude and direction?

	Magnitude	Direction
A	$\frac{f}{2}$	To the right
B	$\frac{f}{2}$	To the left
C	$\frac{3f}{2}$	To the right
D	$\frac{3f}{2}$	To the left

21. How many protons, neutrons and electrons are there in the neutral atom of $^{98}_{42}\mathrm{Mo}$?

	Protons	Neutrons	Electrons
A	42	56	56
B	56	98	42
C	56	42	56
D	42	56	42

22. Which is **not** a conclusion of the Rutherford-Geiger-Marsden experiment?

A Most of the mass of an atom is concentrated in a small nucleus
B The nucleus consists of protons and neutrons
C The radius of the nucleus is very small compared to the size of the atom
D Most of the volume of an atom is empty space

23. Which sequence of decays of the nuclide X will produce an isotope of X?

A Two alpha decays and one beta plus decay
B One alpha decay and two beta plus decays
C One alpha decay and two beta minus decays
D One alpha, one beta minus and one beta plus decay

24. Star X has luminosity $12L_{\odot}$ and parallax 0.030 arc seconds. Star Y has luminosity $3L_{\odot}$ and parallax 0.15 arc seconds. What is the ratio $\frac{b_X}{b_Y}$ of the apparent brightness of X to that of Y?

A $\frac{4}{25}$ **B** $\frac{4}{5}$ **C** 20 **D** 100

25. Three stages in the evolution of a main sequence star are:

I Planetary nebula
II Red giant
III White dwarf

Which of these apply to the evolution of a 2 solar mass star?

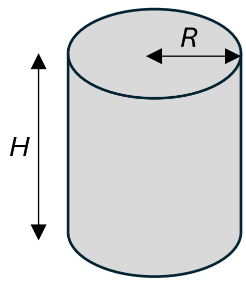
A I and II only
B I and III only
C II and III only
D I, II and III

Markscheme

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

SECTION B – Data based questions

1. A group of students wanted to measure the density of a metallic cylinder of radius *R* and height *H*. The volume *V* is given by $V = \pi R^2 H$.



not to scale

The approximate values of *R* and *H* are $R \approx 5$ mm and $H \approx 15$ mm.

(a) State an appropriate instrument with which to measure *R* and *H*. [1]

(b) The students measured that $R = (4.9 \pm 0.1)$ mm and $H = (15.2 \pm 0.1)$ mm. Calculate the fractional uncertainty in the volume of the cylinder. [2]

(c) The mass *M* of the cylinder was measured to be $M = (8.9 \pm 0.1)$ g. Estimate the density of the cylinder in kg m^{-3}. Give the absolute uncertainty to one significant figure. [4]

2. A student investigated the hypothesis that there is a relationship between the luminosity *L* and the mass *M* of main sequence stars. The hypothesis is that

$$\frac{L}{L_\odot} = \left(\frac{M}{M_\odot}\right)^n$$

where *n* is a constant and $L_\odot$ and $M_\odot$ are the luminosity and mass of the Sun.
The student obtained the following data from a database for *M* and *L*.

$\frac{M}{M_\odot}$	$\frac{L}{L_\odot}$
5.8 ± 0.2	4.70×10^2
8.6 ± 0.4	1.87×10^3
12 ± 0.1	5.99×10^3
25 ± 2	7.81×10^4
42 ± 2	4.80×10^5
68 ± 4	2.59×10^6
83 ± 5	5.21×10^6

(a) One entry in the column for mass looks inconsistent. State which one and identify the inconsistency.. [2]

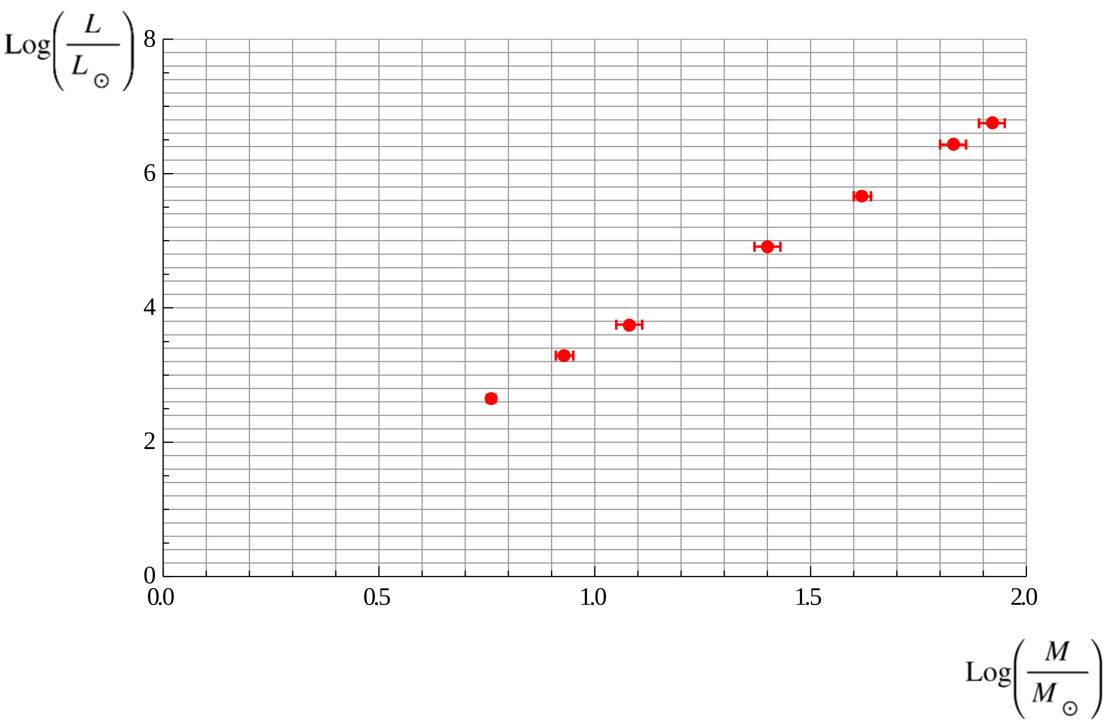
(b) For the data point with $\frac{M}{M_{\odot}} = 42$ calculate

(i) $\text{Log}\left(\frac{M}{M_{\odot}}\right)$, [1]

(ii) $\text{Log}\left(\frac{L}{L_{\odot}}\right)$, [1]

(iii) the absolute uncertainty in $\text{Log}\left(\frac{M}{M_{\odot}}\right)$. [2]

The graph shows the student's plotted data.



(c)

(i) Suggest whether the data support the hypothesis. [2]

(ii) Determine *n*. [3]

(iii) Predict the mass of a main sequence star whose luminosity is $8.0 \times 10^{7} L_{\odot}$. [2]

Markscheme

1				
a		Vernier calipers ✓		[1]
b		$\frac{\Delta V}{V}=2\frac{\Delta R}{R}+\frac{\Delta H}{H}$ ✓ $\frac{\Delta V}{V}=2\times\frac{0.1}{4.9}+\frac{0.1}{15.1}=4.7439\times10^{-2}\approx4.7\times10^{-2}$ ✓		[2]
c		$\rho=\frac{M}{V}=\frac{8.9\times10^{-3}}{\pi\times\left(4.9\times10^{-3}\right)^{2}\times15.1\times10^{-3}}=7.8140\times10^{3}\ \text{kg m}^{-3}$ ✓ $\frac{\Delta\rho}{\rho}=\frac{\Delta M}{M}+\frac{\Delta V}{V}=\frac{0.1}{8.9}+4.7439\times10^{-2}=5.8675\times10^{-2}$ ✓ $\Delta\rho=5.8675\times10^{-2}\times\rho=5.8675\times10^{-2}\times7.8140\times10^{3}=458.49\ \text{kg m}^{-3}$ ✓ $\rho=(7.8\pm0.5)\times10^{3}\ \text{kg m}^{-3}$ ✓		[4]

2				
a		For the data point with $\frac{M}{M_{\odot}}=12$ ✓ The precision in the uncertainty does not match the precision of the mass ✓		[2]
b	i	$\text{Log}\left(\frac{M}{M_{\odot}}\right)=1.62$ ✓		[1]
b	ii	$\text{Log}\left(\frac{L}{L_{\odot}}\right)=5.68$ ✓		[1]
b	iii	$\text{Log}(44)=1.64\ \textit{and}\ \log40=1.60$ ✓ So, uncertainty = $\frac{1.64-1.60}{2}=0.02$ ✓	Accept BCA	[2]
c	i	The hypothesis $\frac{L}{L\odot}=\left(\frac{M}{M_{\odot}}\right)^{n}$ leads to $\log\frac{L}{L\odot}=n\log\left(\frac{M}{M_{\odot}}\right)$ ✓ Which is the equation of a straight line through the origin with gradient *n* which is what the **drawn** line of best fit is, so yes ✓		[2]
c	ii	Large triangle ✓ Two points on the line of best fit chosen ✓ Gradient = 3.5 ✓	Accept range 3.3 to 3.7 for gradient	[3]
c	iii	$\frac{L}{L_{\odot}}=\left(\frac{M}{M_{\odot}}\right)^{n}\ \Rightarrow\ 8.0\times10^{7}=\left(\frac{M}{M_{\odot}}\right)^{3.5}$ ✓ $M=181M_{\odot}\approx180M_{\odot}$ ✓		[2]