Uncertainties *[49 marks]*

1. How many significant figures are there in the number 0.0450? *[1 mark]*

   A. 2

   B. 3

   C. 4

   D. 5

2. An object is positioned in a gravitational field. The measurement of gravitational force acting on the object has an uncertainty of 3 % and the uncertainty in the mass of the object is 9 %. What is the uncertainty in the gravitational field strength of the field? *[1 mark]*

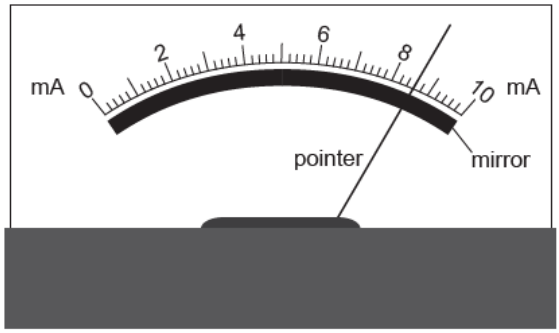
   A. 3 %

   B. 6 %

   C. 12 %

   D. 27 %

3. The diagram shows an analogue meter with a mirror behind the pointer. *[1 mark]*



   What is the main purpose of the mirror?

   A. To provide extra light when reading the scale

   B. To reduce the risk of parallax error when reading the scale

   C. To enable the pointer to be seen from different angles

   D. To magnify the image of the pointer

4. What is a correct value for the charge on an electron? *[1 mark]*

   A. 1.60×10^{-12} µC

   B. 1.60×10^{-15} mC

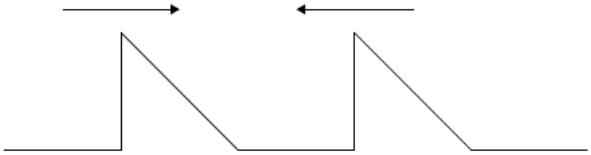
   C. 1.60×10^{-22} kC

   D. 1.60×10^{-24} MC

5. What is the unit of electrical energy in fundamental SI units? *[1 mark]*

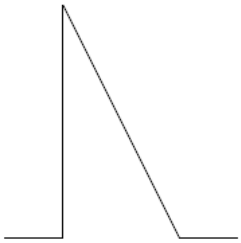
   A. kg m^2 C^{-1} s
   B. kg m s^{-2}
   C. kg m^2 s^{-2}
   D. kg m^2 s^{-1} A

6. Two pulses are travelling towards each other. *[1 mark]*

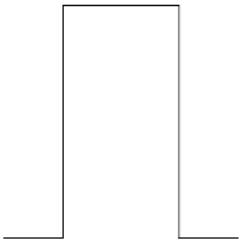


What is a possible pulse shape when the pulses overlap?

A.

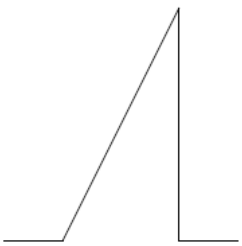


B.



C.

D.



7. Which of the following is a scalar quantity? *[1 mark]*

A. Velocity
B. Momentum
C. Kinetic energy
D. Acceleration

8. A stone falls from rest to the bottom of a water well of depth *d*. The time t taken to fall is 2.0 ±0.2 s. The depth of the well is calculated to be 20 m using $d = \frac{1}{2}at^2$. The uncertainty in a is negligible. *[1 mark]*

What is the absolute uncertainty in *d*?

A. ± 0.2 m

B. ± 1 m

C. ± 2 m

D. ± 4 m

9. Which is a vector quantity? *[1 mark]*

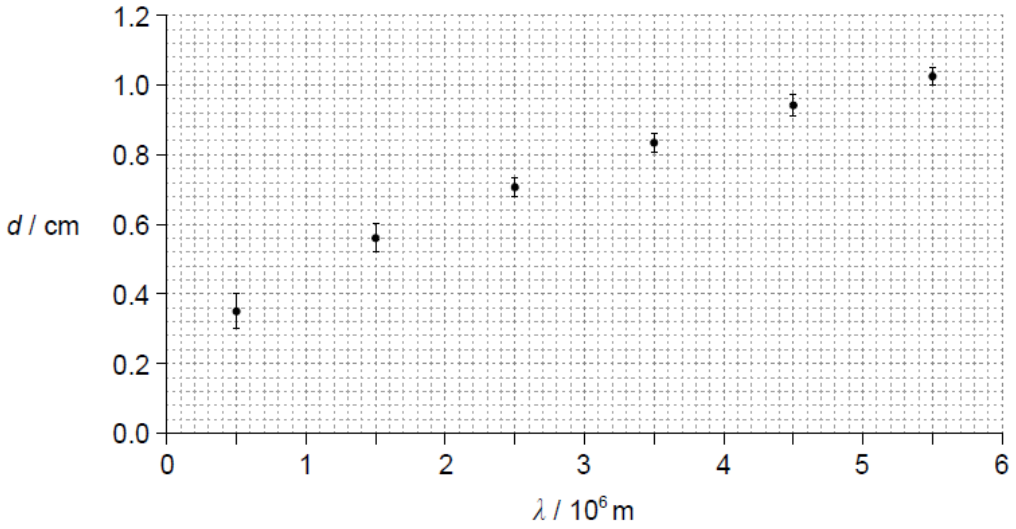
A. Pressure

B. Electric current

C. Temperature

D. Magnetic field

A radio wave of wavelength λ is incident on a conductor. The graph shows the variation with wavelength λ of the maximum distance d travelled inside the conductor.



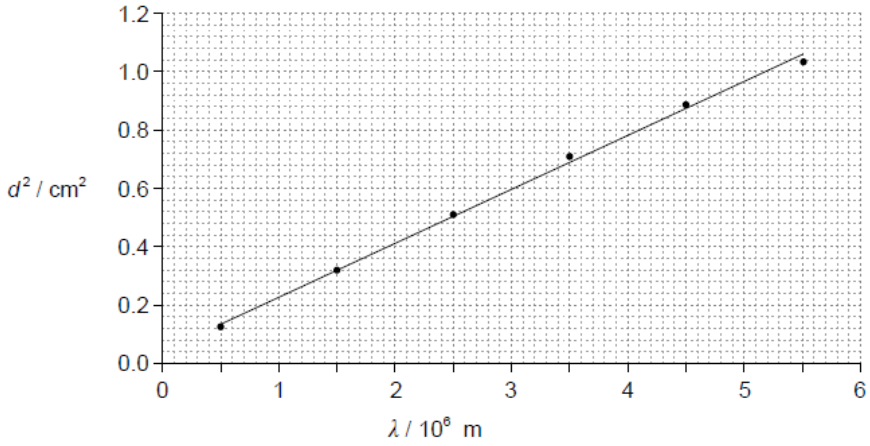
10a. Suggest why it is unlikely that the relation between d and λ is linear. *[1 mark]*

For $\lambda = 5.0 \times 10^{5}$ m, calculate the

10b. fractional uncertainty in d. *[2 marks]*

10c. percentage uncertainty in d^2. *[1 mark]*

The graph shows the variation with wavelength λ of d^2. Error bars are not shown and the line of best-fit has been drawn.



A student states that the equation of the line of best-fit is $d^2 = a + b\lambda$. When d^2 and λ are expressed in terms of fundamental SI units, the student finds that $a = 0.040 \times 10^{-4}$ and $b = 1.8 \times 10^{-11}$.

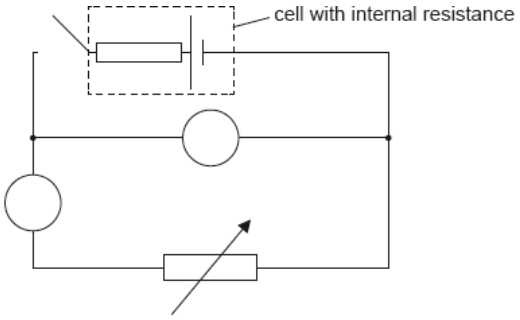
10d. State the fundamental SI unit of the constant a and of the constant b. *[2 marks]*

a: . . . . . .

b: . . . . . .

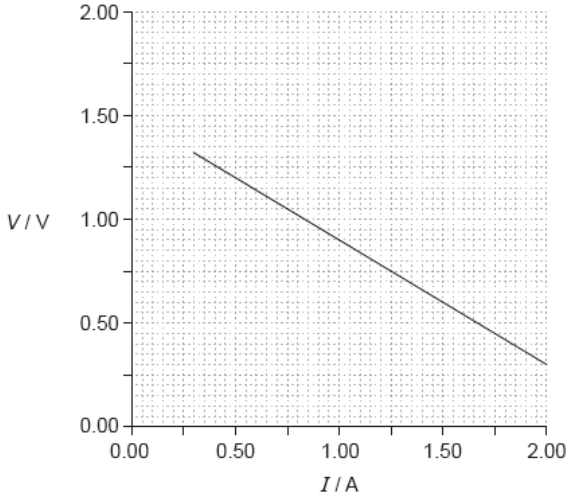
10e. Determine the distance travelled inside the conductor by very high frequency electromagnetic waves. *[2 marks]*

The circuit shown may be used to measure the internal resistance of a cell.



11a. An ammeter and a voltmeter are connected in the circuit. Label the ammeter with the letter A and the voltmeter with the letter V. *[1 mark]*

11b. In one experiment a student obtains the following graph showing the variation with current *I* of the potential difference *V* across the cell. *[3 marks]*



Using the graph, determine the best estimate of the internal resistance of the cell.

The ammeter used in the experiment in (b) is an analogue meter. The student takes measurements without checking for a "zero error" on the ammeter.

11c. State what is meant by a zero error. *[1 mark]*

11d. After taking measurements the student observes that the ammeter has a positive zero error. Explain what effect, if any, this zero error will have on the calculated value of the internal resistance in (b). *[2 marks]*

12. A boy jumps from a wall 3m high. What is an estimate of the change in momentum of the boy when he lands without rebounding? *[1 mark]*

A. 5×10^{0} kg m s^{-1}

B. 5×10^{1} kg m s^{-1}

C. 5×10^{2} kg m s^{-1}

D. 5×10^{3} kg m s^{-1}

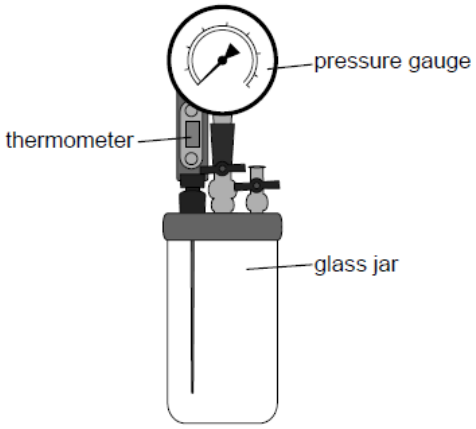
13. Light of wavelength 400nm is incident on two slits separated by 1000μm. The interference pattern from the slits is observed from a satellite orbiting 0.4Mm above the Earth. The distance between interference maxima as detected at the satellite is *[1 mark]*

A. 0.16Mm.
B. 0.16km.
C. 0.16m.
D. 0.16mm.

14. A car moves north at a constant speed of 3m s^{-1} for 20s and then east at a constant speed of 4m s^{-1} for 20s. What is the average speed of the car during this motion? *[1 mark]*

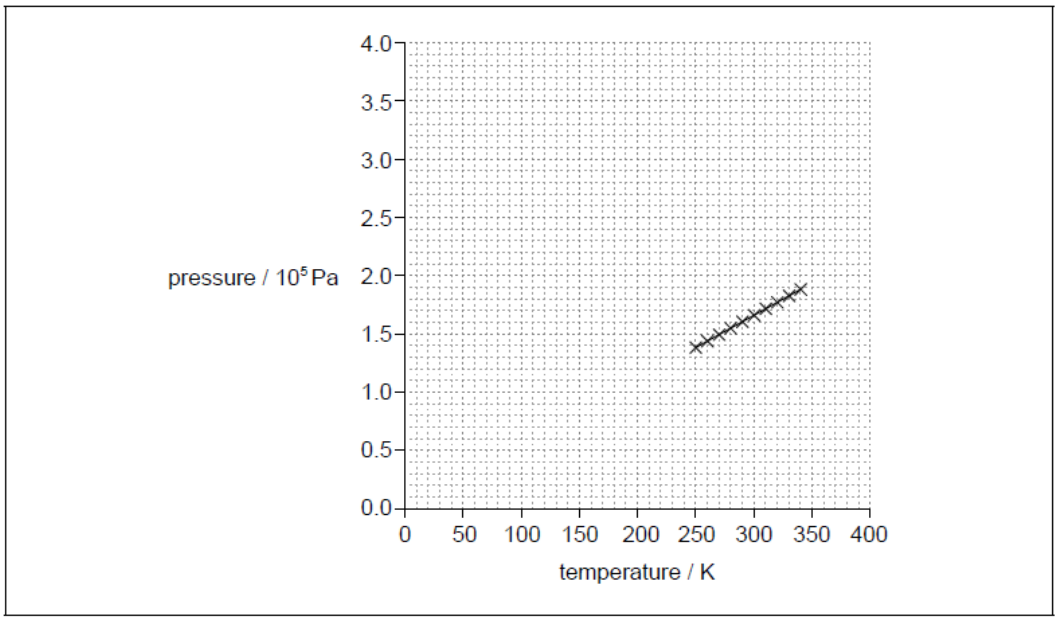
A. 7.0m s^{-1}
B. 5.0m s^{-1}
C. 3.5m s^{-1}
D. 2.5m s^{-1}

An apparatus is used to verify a gas law. The glass jar contains a fixed volume of air. Measurements can be taken using the thermometer and the pressure gauge.



The apparatus is cooled in a freezer and then placed in a water bath so that the temperature of the gas increases slowly. The pressure and temperature of the gas are recorded.

15a. The graph shows the data recorded. *[1 mark]*



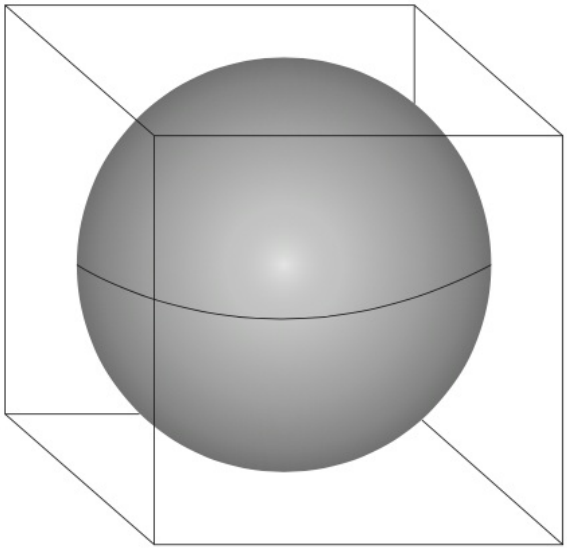
Identify the fundamental SI unit for the gradient of the pressure–temperature graph.

15b. The experiment is repeated using a different gas in the glass jar. The pressure for both experiments is low and both gases can be considered to be ideal. *[3 marks]*

(i) Using the axes provided in (a), draw the expected graph for this second experiment.

(ii) Explain the shape and intercept of the graph you drew in (b)(i).

16. A sphere fits inside a cube. *[1 mark]*



The length of the cube and the diameter of the sphere are 10.0±0.2cm.

What is the ratio $\frac{\text{percentageuncertaintyofthevolumeofthesphere}}{\text{percentageuncertaintyofthevolumeofthecube}}$?

A. $\frac{3}{4\pi}$

B. 1

C. 2

D. 8

17. A swimming pool contains 18×10^{6} kg of pure water. The molar mass of water is 18gmol^{-1}. What is the correct estimate of the number of water molecules in the swimming pool? *[1 mark]*

A. 10^{4}
B. 10^{24}
C. 10^{25}
D. 10^{33}

18. Which of the following is a derived unit? *[1 mark]*

A. Mole

B. Kelvin

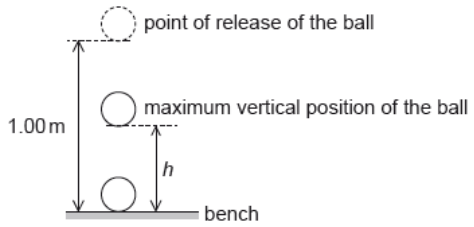
C. Coulomb

D. Ampere

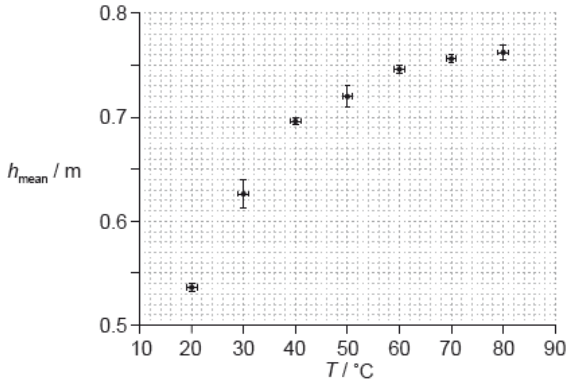
Data analysis question.

An experiment is undertaken to investigate the relationship between the temperature of a ball and the height of its first bounce.

A ball is placed in a beaker of water until the ball and the water are at the same temperature. The ball is released from a height of 1.00 m above a bench. The maximum vertical height h from the bottom of the ball above the bench is measured for the first bounce. This procedure is repeated twice and an average h_{mean} is calculated from the three measurements.



The procedure is repeated for a range of temperatures. The graph shows the variation of h_{mean} with temperature T.



19a. Draw the line of best-fit for the data. *[1 mark]*

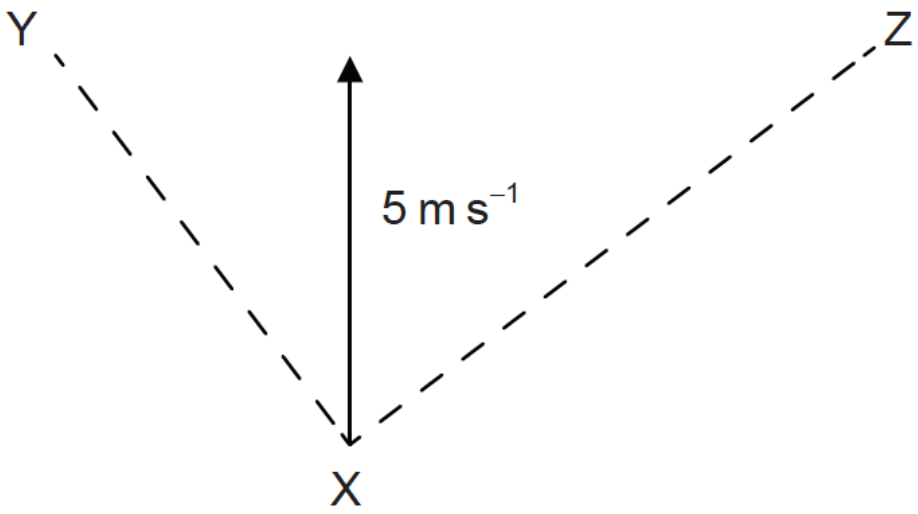
19b. State why the line of best-fit suggests that h_{mean} is not proportional to T. *[1 mark]*

19c. State the uncertainty in each value of T. *[1 mark]*

19d. The temperature is measured using a liquid in glass thermometer. State what physical characteristic of the thermometer suggests that the change in the liquid's length is proportional to the change in temperature. *[1 mark]*

19e. Another hypothesis is that $h_{\text{mean}} = KT^3$ where K is a constant. Using the graph on page 2, calculate the absolute uncertainty in K corresponding to $T = 50^{\circ}\text{C}$. *[4 marks]*

20. A velocity of 5 m s^{-1} can be resolved along perpendicular directions XY and XZ. *[1 mark]*



The component of the velocity in the direction XY is of magnitude 4 m s^{-1}. What is the magnitude of the component in the direction XZ?

A. 4 m s^{-1}

B. 3 m s^{-1}

C. 2 m s^{-1}

D. 1 m s^{-1}

21. What is the unit of energy density? *[1 mark]*

A. J kg^{-1}

B. J kg^{-1} m^3

C. J mol^{-1}

D. J K^{-1}

22. Which of the following expresses the watt in terms of fundamental units? *[1 mark]*

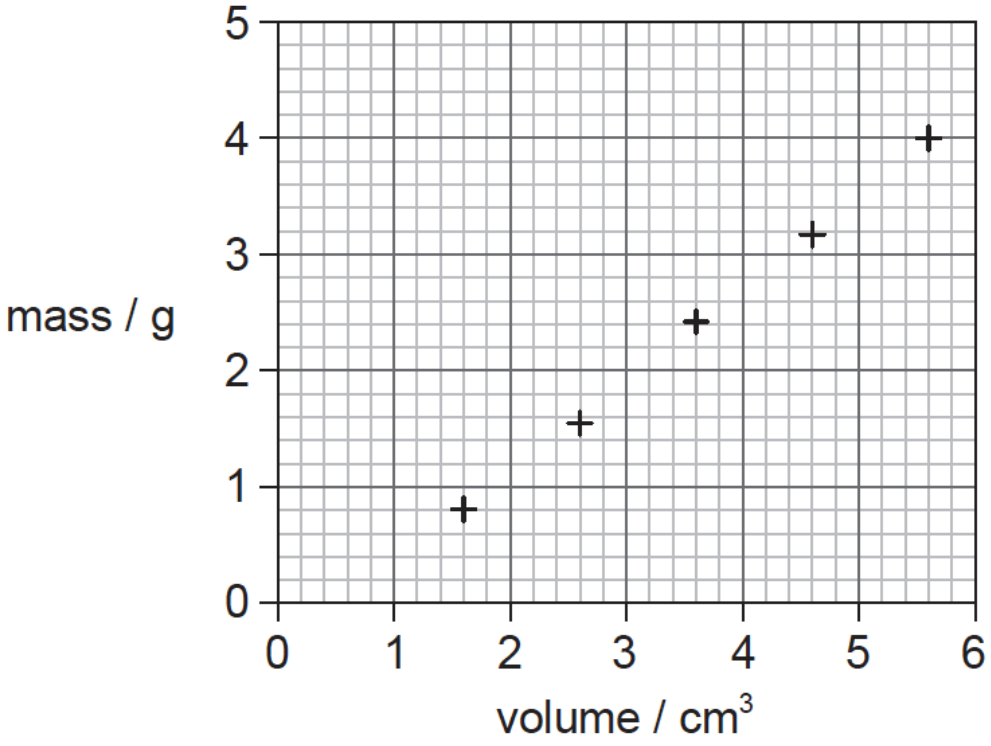
A. kg m^2 s

B. kg m^2 s^{-1}

C. kg m^2 s^{-2}

D. kg m^2 s^{-3}

23. The graph shows a set of experimental results to determine the density of oil. The results have systematic errors and random errors. *[1 mark]*



Using the information on the graph, what can be said about the measurements used to find the density of oil?

	Systematic errors	Random errors
A.	small	small
B.	small	large
C.	large	small
D.	large	large

24. Which of the following expresses the units of capacitance in terms of fundamental units? *[1 mark]*

A. $s^4A^2m^{-2}kg^{-1}$

B. $s^2Am^{-2}kg^{-1}$

C. $s^4A^2m^{-2}$

D. s^2Am^{-2}

25. Which of the following is a fundamental unit? *[1 mark]*

A. Ampere

B. Coulomb

C. Ohm

D. Volt

26. The maximum acceleration a_{max} of an oscillator undergoing simple harmonic motion (SHM) has a percentage uncertainty of 12%. *[1 mark]* The amplitude x_0 of the oscillation has a percentage uncertainty of 20%. If $k = \sqrt{\frac{a_{max}}{x_0}}$ what is the percentage uncertainty in the constant k?

A. 4%

B. 8%

C. 16%

D. 32%