Physical Quantities and Units

Additional Materials:

1 Five energies are listed.

5 kJ

5 mJ

5 MJ

5 nJ

Starting with the smallest first, what is the order of increasing magnitude of these energies?

A 5 kJ → 5 mJ → 5 MJ → 5 nJ

B 5 nJ → 5 kJ → 5 MJ → 5 mJ

C 5 nJ → 5 mJ → 5 kJ → 5 MJ

D 5 mJ → 5 nJ → 5 kJ → 5 MJ

2 Which of the following correctly expresses the volt in terms of SI base units?

A $\mathrm{A\,\Omega}$

B $\mathrm{W\,A^{-1}}$

C $\mathrm{kg\,m^2\,s^{-1}\,A^{-1}}$

D $\mathrm{kg\,m^2\,s^{-3}\,A^{-1}}$

3 What is a reasonable estimate of the average kinetic energy of an athlete during a 100 m race that takes 10 s?

A 40 J **B** 400 J **C** 4000 J **D** 40 000 J

4 The resistance R of a resistor is determined by measuring the potential difference V across it and the current I in it. The value of R is then calculated using the equation

$$R = \frac{V}{I}.$$

The values measured are $V = 1.00 \pm 0.05$ V and $I = 0.50 \pm 0.01$ A.

What is the percentage uncertainty in the value of R?

A 2.5 % **B** 3.0 % **C** 7.0 % **D** 10.0 %

5 Four students each made a series of measurements of the acceleration of free fall g. The table shows the results obtained.

Which set of results could be described as precise but **not** accurate?

	g / m s^{-2}			
A	9.81	9.79	9.84	9.83
B	9.81	10.12	9.89	8.94
C	9.45	9.21	8.99	8.76
D	8.45	8.46	8.50	8.41

1 Which statement, involving multiples and sub-multiples of the base unit metre (m), is correct?

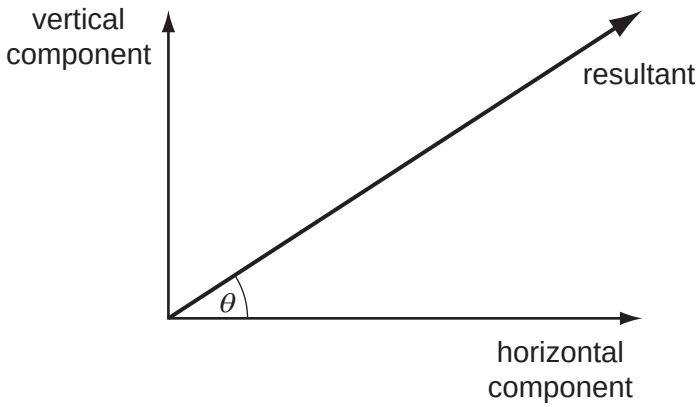
A $1\,\text{pm} = 10^{-9}\,\text{m}$

B $1\,\text{nm} = 10^{-6}\,\text{m}$

C $1\,\text{mm} = 10^{6}\,\mu\text{m}$

D $1\,\text{km} = 10^{6}\,\text{mm}$

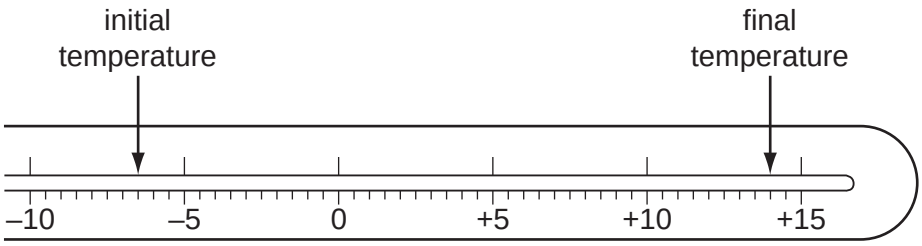
2 The diagram shows a resultant force and its horizontal and vertical components.



The horizontal component is 20.0 N and $\theta = 30°$. What is the vertical component?

A 8.7 N **B** 10.0 N **C** 11.5 N **D** 17.3 N

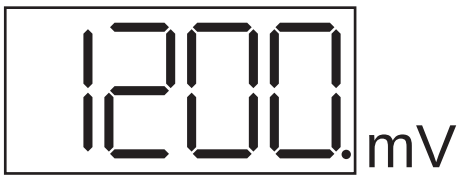
3 The diagram shows the stem of a Celsius thermometer marked to show initial and final temperature values.

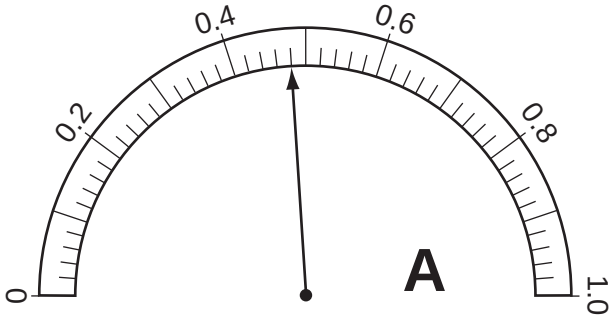


What is the temperature change expressed to an appropriate number of significant figures?

A 14 °C **B** 20.5 °C **C** 21 °C **D** 22.0 °C

4 The diagrams show digital voltmeter and analogue ammeter readings from a circuit in which electrical heating is occurring.





What is the electrical power of the heater?

A 0.53 W **B** 0.58 W **C** 530 W **D** 580 W

Space for working

1 The drag force F acting on a moving sphere obeys an equation of the form $F = kAv^2$, where A represents the sphere's frontal area and v represents its speed.

What are the base units of the constant k?

A $\mathrm{kg\,m^5\,s^{-4}}$ **B** $\mathrm{kg\,m^{-2}\,s^{-1}}$ **C** $\mathrm{kg\,m^{-3}}$ **D** $\mathrm{kg\,m^{-4}\,s^2}$

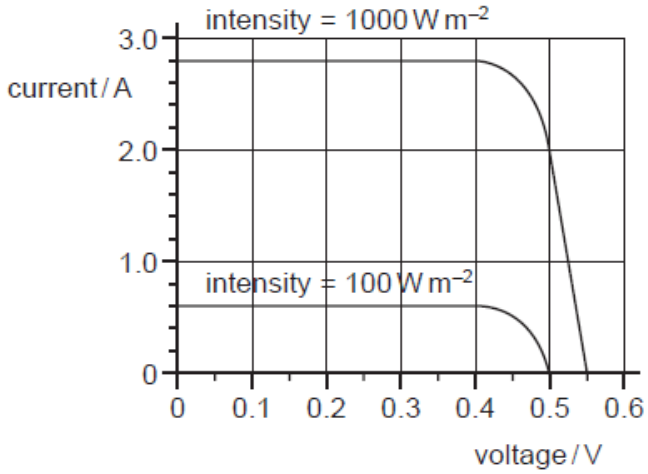
2 The table contains some quantities, together with their symbols and units.

quantity	symbol	unit
gravitational field strength	g	$\mathrm{N\,kg^{-1}}$
density of liquid	ρ	$\mathrm{kg\,m^{-3}}$
vertical height	h	m
volume of part of liquid	V	$\mathrm{m^3}$

Which expression has the units of energy?

A $g\rho hV$ **B** $\dfrac{\rho hV}{g}$ **C** $\dfrac{\rho g}{hV}$ **D** $\rho g^2 h$

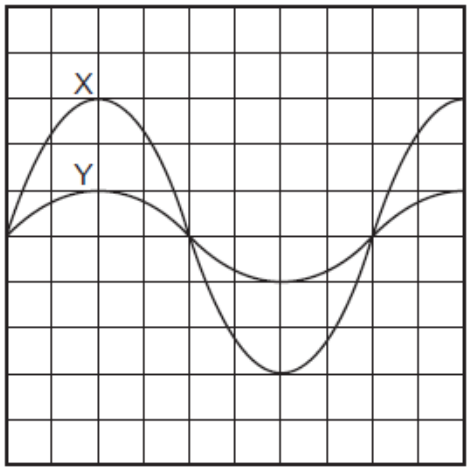
3 The graph shows two current-voltage calibration curves for a solar cell exposed to different light intensities.



At zero voltage, what is the ratio $\dfrac{\text{current at } 1000\,\mathrm{W\,m^{-2}}}{\text{current at } 100\,\mathrm{W\,m^{-2}}}$?

A 1.1 **B** 4.7 **C** 8.0 **D** 10

4 The diagram shows an oscilloscope screen displaying two signals.



Signal X has a frequency of 50 Hz and peak voltage of 12 V.

What is the period and peak voltage of signal Y?

	period / ms	peak voltage / V
A	20	4
B	20	12
C	50	4
D	50	12

PHYSICS **9702/11**

Paper 1 Multiple Choice **May/June 2010**

1 hour

Additional Materials:

1 The SI unit for potential difference (the volt) is given, in base units, by

A $\text{kg m A}^{-1}\text{ s}^{-3}$.

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2 The product of pressure and volume has the same SI base units as

A energy.

B force.

C $\frac{\text{force}}{\text{area}}$.

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3 An ion is accelerated by a series of electrodes in a vacuum. A graph of the power supplied to the ion is plotted against time.

What is represented by the area under the graph between two times?

A the change in kinetic energy of the ion

B the average force on the ion

C the change in momentum of the ion

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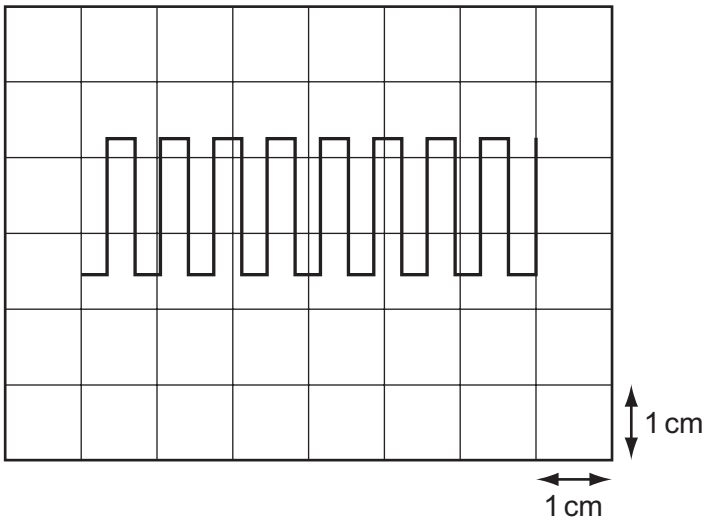
Space for working

4 The diagram shows a square-wave trace on the screen of a cathode-ray oscilloscope. A grid of 1 cm squares covers the screen. The time-base setting is 10 ms cm^{-1}.



What is the approximate frequency of the square wave?

A 70 Hz **B** 140 Hz **C** 280 Hz **D** 1400 Hz

Space for working

6 A student finds the density of a liquid by measuring its mass and its volume. The following is a summary of his measurements.

mass of empty beaker = (20 ± 1) g mass of beaker + liquid = (70 ± 1) g

volume of liquid = $(10.0 \pm 0.6)\,cm^3$

He correctly calculates the density of the liquid as $5.0\,g\,cm^{-3}$. What is the uncertainty in this value?

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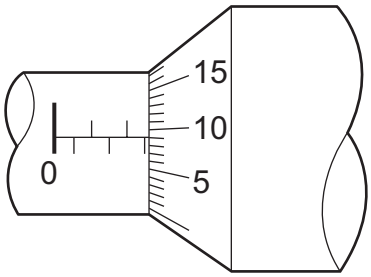
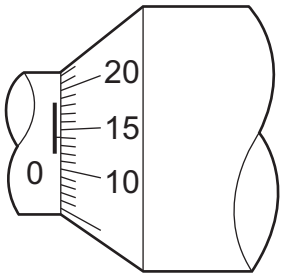


diagram 1



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What is the diameter of the wire?

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1 hour

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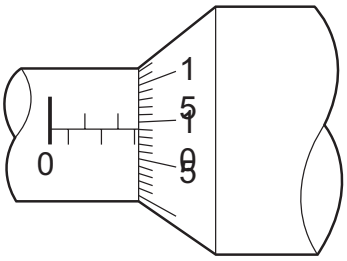

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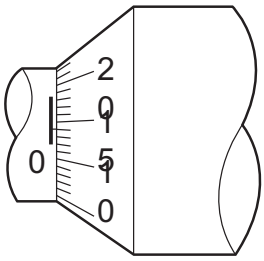

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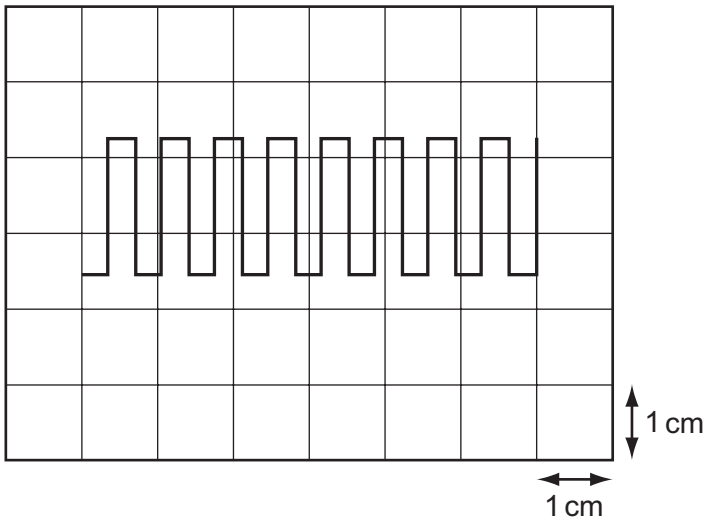
Space for working

5 The diagram shows a square-wave trace on the screen of a cathode-ray oscilloscope. A grid of 1 cm squares covers the screen. The time-base setting is 10 ms cm^{-1}.



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Space for working

1 The product of pressure and volume has the same SI base units as

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C $\frac{\text{force}}{\text{area}}$.

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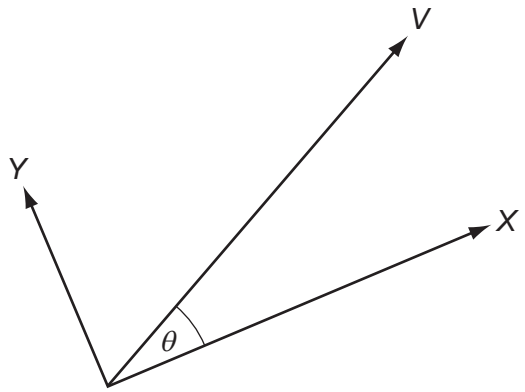
2 A vector quantity V is resolved into two perpendicular components X and Y. The angle between V and component X is θ.



The angle between component X and the vector V is increased from 0° to 90°.

How do the magnitudes of X and Y change as the angle θ is increased in this way?

	X	Y
A	increase	increase
B	increase	decrease
C	decrease	increase
D	decrease	decrease

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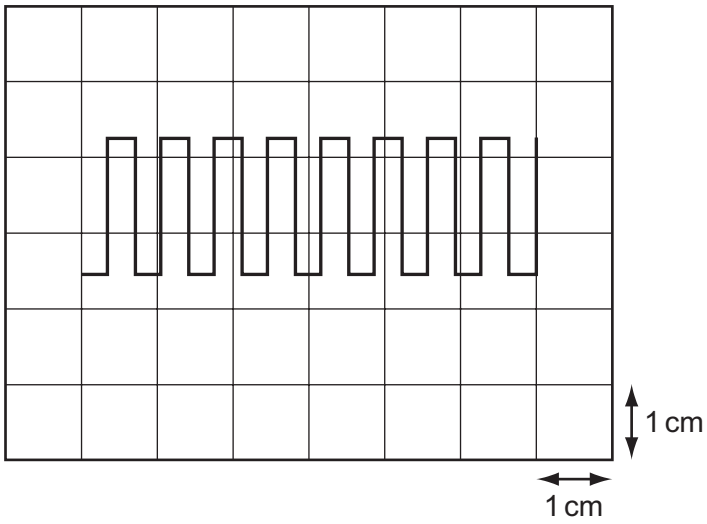

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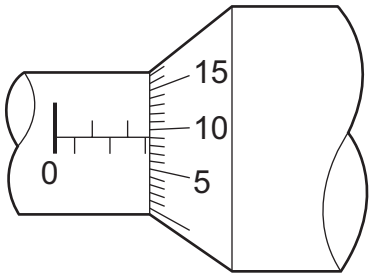

diagram 1

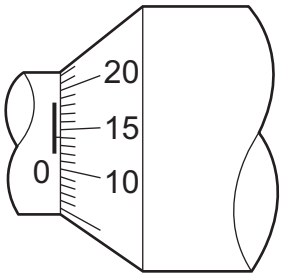

diagram 2

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A 1.90 mm **B** 2.45 mm **C** 2.59 mm **D** 2.73 mm

Space for working

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B $\mathrm{m^2\,A^{-1}\,s^{-2}}$.

C $\mathrm{kg\,m^2\,s^{-2}}$.

D $\mathrm{kg\,m^2\,A^{-1}\,s^{-3}}$.

Additional Materials:

2 A metal sphere of radius r is dropped into a tank of water. As it sinks at speed v, it experiences a drag force F given by $F = krv$, where k is a constant.

What are the SI base units of k?

A $kg\,m^2\,s^{-1}$ **B** $kg\,m^{-2}\,s^{-2}$ **C** $kg\,m^{-1}\,s^{-1}$ **D** $kg\,m\,s^{-2}$

3 Which physical quantity would result from a calculation in which a potential difference is multiplied by an electric charge?

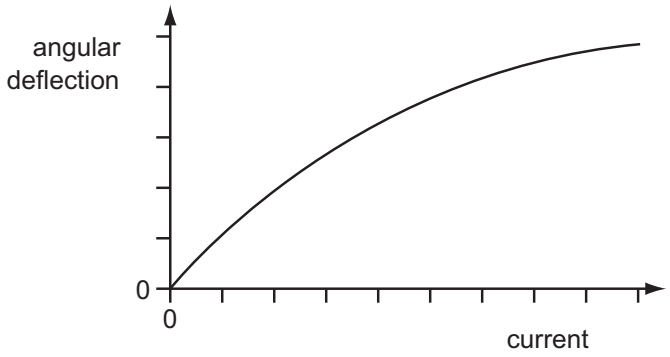
A electric current

B electric energy

C electric field strength

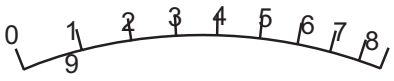
D electric power

4 The angular deflection of the needle of an ammeter varies with the current passing through the ammeter as shown in the graph.

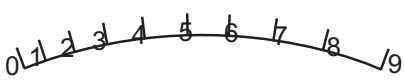


Which diagram could represent the appearance of the scale on this meter?

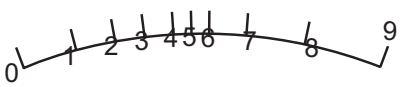
A



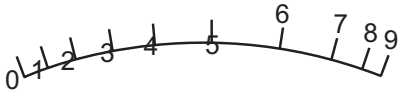
B



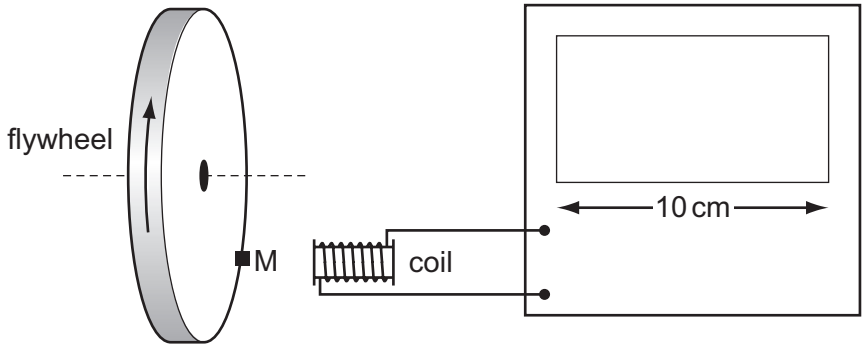
C



D



5 The diagram shows a cathode-ray oscilloscope (c.r.o.) being used to measure the rate of rotation of a flywheel.



The flywheel has a small magnet M mounted on it. Each time the magnet passes the coil, a voltage pulse is generated, which is passed to the c.r.o. The display of the c.r.o. is 10 cm wide. The flywheel is rotating at a rate of about 3000 revolutions per minute.

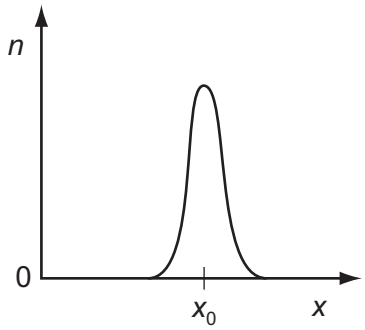
Which time-base setting will display clearly separate pulses on the screen?

A $1\,\text{s cm}^{-1}$ **B** $10\,\text{ms cm}^{-1}$ **C** $100\,\mu\text{s cm}^{-1}$ **D** $1\,\mu\text{s cm}^{-1}$

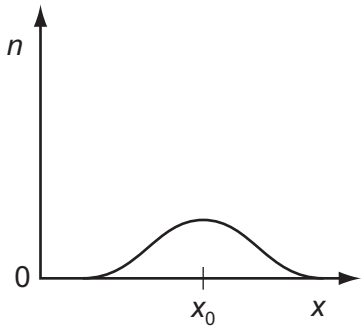
6 A fixed quantity x_0 is measured many times in an experiment that has experimental uncertainty. A graph is plotted to show the number n of times that a particular value x is obtained.

Which graph could be obtained if the measurement of x_0 has a large systematic error but a small random error?

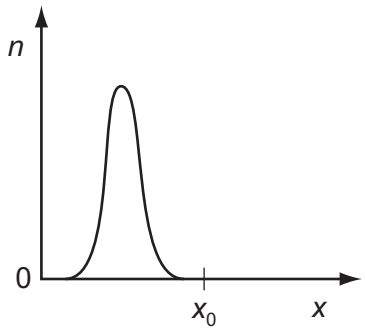
A



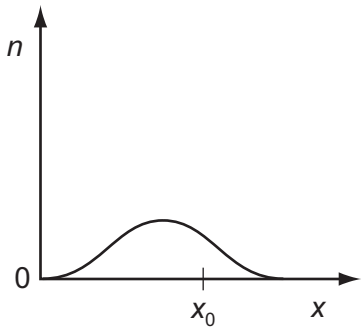
B



C



D



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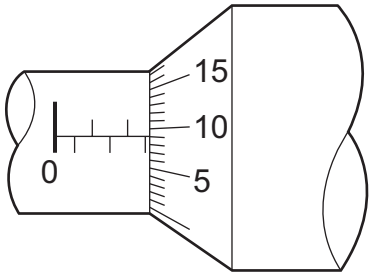

diagram 1

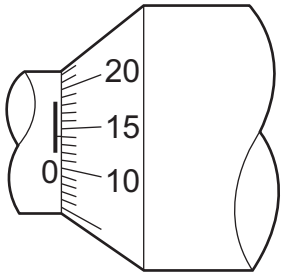

diagram 2

What is the diameter of the wire?

A 1.90 mm **B** 2.45 mm **C** 2.59 mm **D** 2.73 mm

2 The SI unit for potential difference (the volt) is given, in base units, by

A $kg\,m\,A^{-1}\,s^{-3}$.

B $m^2\,A^{-1}\,s^{-2}$.

C $kg\,m^2\,s^{-2}$.

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Space for working

Additional Materials:

1 Decimal sub-multiples and multiples of units are indicated using a prefix to the unit. For example, the prefix milli (m) represents 10^{-3}.

Which row gives the sub-multiples or multiples represented by pico (p) and giga (G)?

	pico (p)	giga (G)
A	10^{-9}	10^{9}
B	10^{-9}	10^{12}
C	10^{-12}	10^{9}
D	10^{-12}	10^{12}

2 Which definition is correct and uses only quantities rather than units?

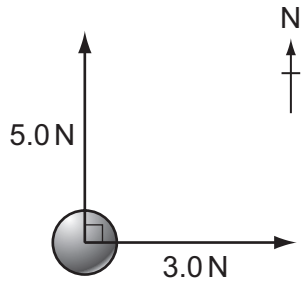
A Density is mass per cubic metre.

B Potential difference is energy per unit current.

C Pressure is force per unit area.

D Speed is distance travelled per second.

3 A force of 5.0 N pushes a ball due north and another force of 3.0 N pushes it due east.

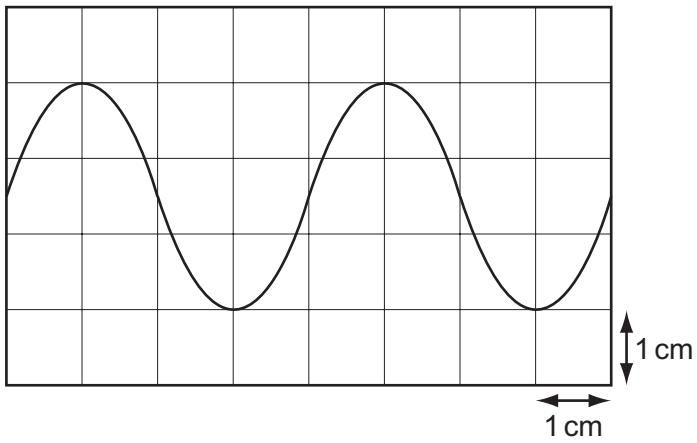


What is the magnitude of the net force acting on the ball?

A 2.8 N **B** 4.0 N **C** 5.8 N **D** 8.0 N

4 The diagram shows a trace of a wave on a cathode-ray oscilloscope.

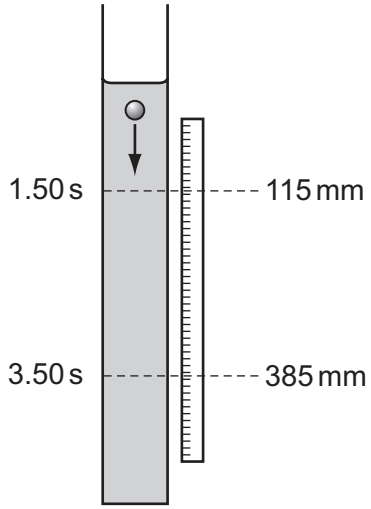
The vertical and horizontal gridlines have a spacing of 1.0 cm. The voltage scaling is 4 V cm^{-1} and the time scaling is 5 ms cm^{-1}.



What are the amplitude and period of the wave?

	amplitude / V	perio / ms
A	1.5	
B	5.0	
C	6.0	
D	12.0	

5 The diagram shows an experiment to measure the speed of a small ball falling at constant speed through a clear liquid in a glass tube.



There are two marks on the tube. The top mark is positioned at 115 ± 1 mm on the adjacent rule and the lower mark at 385 ± 1 mm. The ball passes the top mark at 1.50 ± 0.02 s and passes the lower mark at 3.50 ± 0.02 s.

The constant speed of the ball is calculated by $\frac{385 - 115}{3.50 - 1.50} = \frac{270}{2.00} = 135\,\text{mm}\,\text{s}^{-1}$.

Which expression calculates the fractional uncertainty in the value of this speed?

A $\frac{2}{270} + \frac{0.04}{2.00}$

B $\frac{2}{270} - \frac{0.04}{2.00}$

C $\frac{1}{270} \times \frac{0.02}{2.00}$

D $\frac{1}{270} \div \frac{0.02}{2.00}$

Additional Materials:

1 Stress has the same SI base units as

A $\frac{\text{force}}{\text{mass}}$.

B $\frac{\text{force}}{\text{length}}$.

C $\frac{\text{force}}{\text{area}}$.

D energy.

2 To check calculations, the units are put into the following equations together with the numbers.

Which equation must be **incorrect**?

A force = 300 J / 6 m

B power = 6000 J × 20 s

C time = 6 m / 30 m s^{-1}

D velocity = 4 m s^{-2} × 30 s

3 In making reasonable estimates of physical quantities, which statement is **not** correct?

A The frequency of sound can be of the order of GHz.

B The wavelength of light can be of the order of 600 nm.

C The Young modulus can be of the order of 10^{11} Pa.

D Beta radiation is associated with one unit of negative charge.

4 The uncertainty in the value of the momentum of a trolley passing between two points X and Y varies with the choice of measuring devices.

Measurements for the same trolley made by different instruments were recorded.

1 distance between X and Y using a metre rule with cm divisions = 0.55 m

2 distance between X and Y using a metre rule with mm divisions = 0.547 m

3 timings using a wristwatch measuring to the nearest 0.5 s at X = 0.0 s and at Y = 4.5 s

4 timings using light gates measuring to the nearest 0.1 s at X = 0.0 s and at Y = 4.3 s

5 mass of trolley using a balance measuring to the nearest g = 6.4 × 10^{-2} kg

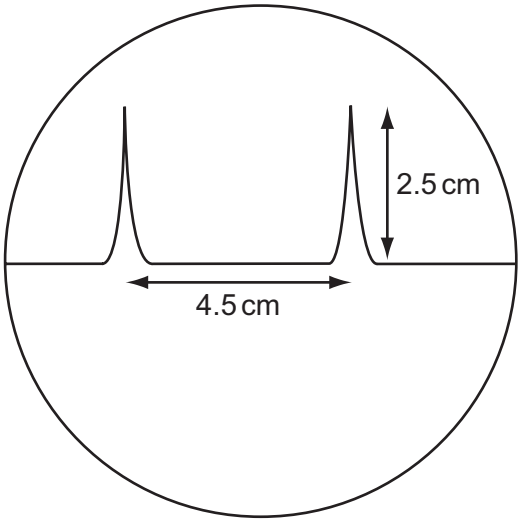
6 mass of trolley using a balance measuring to the nearest 10 g = 6 × 10^{-2} kg

Which measurements, one for each quantity measured, lead to the least uncertainty in the value of the momentum of the trolley?

A 1, 3 and 6 **B** 1, 4 and 6 **C** 2, 3 and 6 **D** 2, 4 and 5

5 The time-base on a cathode-ray oscilloscope is set at 6 ms / cm.

A trace consisting of two pulses is recorded as shown in the diagram.



What is the time interval between the two pulses?

A 0.42 ms **B** 0.75 ms **C** 1.33 ms **D** 27 ms

2 Decimal sub-multiples and multiples of units are indicated using a prefix to the unit. For example, the prefix milli (m) represents 10^{-3}.

Which row gives the sub-multiples or multiples represented by pico (p) and giga (G)?

	pico (p)	giga (G)
A	10^{-9}	10^{9}
B	10^{-9}	10^{12}
C	10^{-12}	10^{9}
D	10^{-12}	10^{12}

3 Which definition is correct and uses only quantities rather than units?

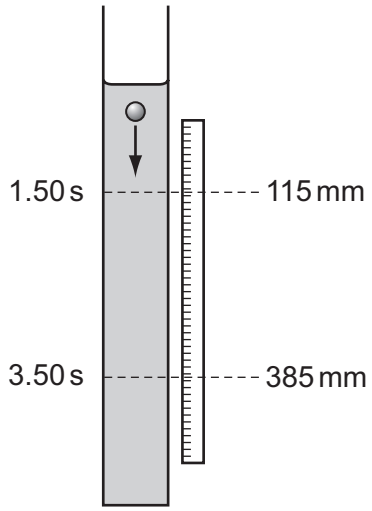
A Density is mass per cubic metre.

B Potential difference is energy per unit current.

C Pressure is force per unit area.

D Speed is distance travelled per second.

4 The diagram shows an experiment to measure the speed of a small ball falling at constant speed through a clear liquid in a glass tube.



There are two marks on the tube. The top mark is positioned at 115 ± 1 mm on the adjacent rule and the lower mark at 385 ± 1 mm. The ball passes the top mark at 1.50 ± 0.02 s and passes the lower mark at 3.50 ± 0.02 s.

The constant speed of the ball is calculated by $\frac{385-115}{3.50-1.50} = \frac{270}{2.00} = 135\,\text{mm}\,\text{s}^{-1}$.

Which expression calculates the fractional uncertainty in the value of this speed?

A $\frac{2}{270} + \frac{0.04}{2.00}$

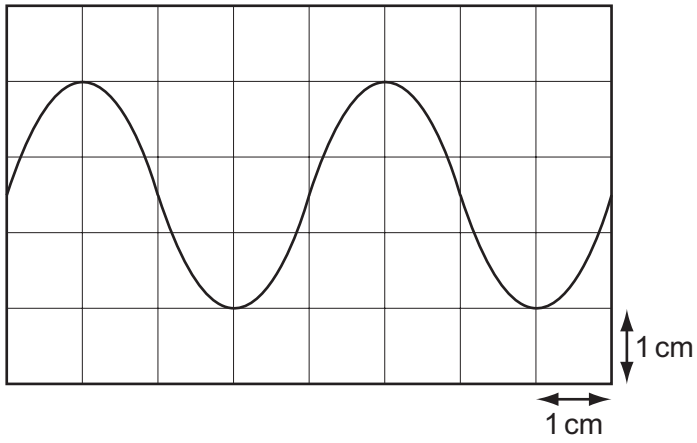
B $\frac{2}{270} - \frac{0.04}{2.00}$

C $\frac{1}{270} \times \frac{0.02}{2.00}$

D $\frac{1}{270} \div \frac{0.02}{2.00}$

5 The diagram shows a trace of a wave on a cathode-ray oscilloscope.

The vertical and horizontal gridlines have a spacing of 1.0 cm. The voltage scaling is 4 V cm^{-1} and the time scaling is 5 ms cm^{-1}.



What are the amplitude and period of the wave?

	amplitude / V	period / ms
A	1.5	4
B	5.0	10
C	6.0	20
D	12.0	20

PHYSICS **9702/11**

Paper 1 Multiple Choice **October/November 2011**

1 hour

Additional Materials:

1 Which statement using prefixes of the base unit metre (m) is **not** correct?

A $1\,\text{pm} = 10^{-12}\,\text{m}$

B $1\,\text{nm} = 10^{-9}\,\text{m}$

C $1\,\text{Mm} = 10^{6}\,\text{m}$

D $1\,\text{Gm} = 10^{12}\,\text{m}$

2 An Olympic athlete of mass 80 kg competes in a 100 m race.

What is the best estimate of his mean kinetic energy during the race?

A $4 \times 10^{2}\,\text{J}$ **B** $4 \times 10^{3}\,\text{J}$ **C** $4 \times 10^{4}\,\text{J}$ **D** $4 \times 10^{5}\,\text{J}$

3 Which group of quantities contains only vectors?

A acceleration, displacement, speed

B acceleration, work, electric field strength

C displacement, force, velocity

D power, electric field strength, force

4 A cylindrical tube rolling down a slope of inclination θ moves a distance L in time T. The equation relating these quantities is

$$L\left(3+\frac{a^2}{P}\right) = QT^2 \sin\theta$$

Where a is the internal radius of the tube and P and Q are constants.

Which line gives the correct units for P and Q?

	P	Q
A	m^2	$\text{m}^2\,\text{s}^{-2}$
B	m^2	$\text{m}\,\text{s}^{-2}$
C	m^2	$\text{m}^3\,\text{s}^{-2}$
D	m^3	$\text{m}\,\text{s}^{-2}$

Additional Materials:

1 Which quantity can be measured in electronvolts (eV)?

A electric charge

B electric potential

C energy

D power

2 What is the ratio $\frac{10^{-3}\ \text{THz}}{10^{3}\ \text{kHz}}$?

A 10^{-9} **B** 10^{-6} **C** 10^{0} **D** 10^{3}

3 The following physical quantities can be either positive or negative.

s : displacement of a particle along a straight line

θ : temperature on the Celsius scale

q : electric charge

V : readings on a digital voltmeter

Which of these quantities are vectors?

A s, θ, q, V **B** s, q, V only **C** θ, V only **D** s only

4 A micrometer is used to measure the diameters of two cylinders.

diameter of first cylinder = 12.78 ± 0.02 mm

diameter of second cylinder = 16.24 ± 0.03 mm

The difference in the diameters is calculated.

What is the uncertainty in this difference?

A ± 0.01 mm **B** ± 0.02 mm **C** ± 0.03 mm **D** ± 0.05 mm

5 The speedometer in a car consists of a pointer which rotates. The pointer is situated several millimetres from a calibrated scale.

What could cause a random error in the driver's measurement of the car's speed?

A The car's speed is affected by the wind direction.

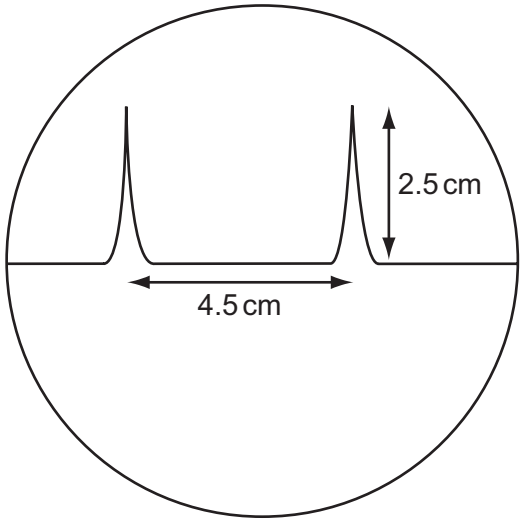
B The driver's eye is not always in the same position in relation to the pointer.

C The speedometer does not read zero when the car is at rest.

D The speedometer reads 10 % higher than the car's actual speed.

5 The time-base on a cathode-ray oscilloscope is set at 6 ms / cm.

A trace consisting of two pulses is recorded as shown in the diagram.



What is the time interval between the two pulses?

A 0.42 ms **B** 0.75 ms **C** 1.33 ms **D** 27 ms

6 A bullet is fired horizontally with speed v from a rifle. For a short time t after leaving the rifle, the only force affecting its motion is gravity. The acceleration of free fall is g.

Which expression gives the value of $\frac{\text{the horizontal distance travelled in time } t}{\text{the vertical distance travelled in time } t}$?

A $\frac{vt}{g}$ **B** $\frac{v}{gt}$ **C** $\frac{2vt}{g}$ **D** $\frac{2v}{gt}$

PHYSICS **9702/12**

Paper 1 Multiple Choice **May/June 2012**

1 hour

Additional Materials:

1 What is the unit watt in terms of SI base units?

A $J\,s^{-1}$ **B** $m^2\,kg\,s^{-1}$ **C** $m^2\,kg\,s^{-3}$ **D** $N\,m\,s^{-1}$

2 For which quantity is the magnitude a reasonable estimate?

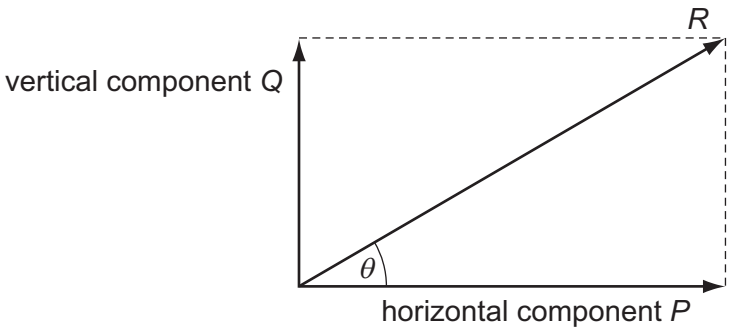
A frequency of a radio wave 500 pHz

B mass of an atom 500 μg

C the Young modulus of a metal 500 kPa

D wavelength of green light 500 nm

3 A vector has magnitude *R* and perpendicular components *P* and *Q*, as shown in the diagram.

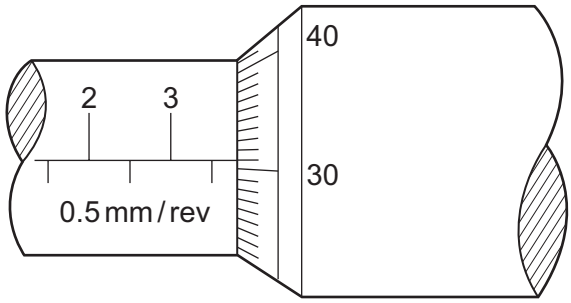


Which row correctly describes the perpendicular components?

	vertical component	horizontal component
A	Q	$R\sin\theta$
B	$R\cos\theta$	P
C	$R\cos\theta$	$R\sin\theta$
D	$R\sin\theta$	$R\cos\theta$

4 The diameter of a cylindrical metal rod is measured using a micrometer screw gauge.

The diagram below shows an enlargement of the scale on the micrometer screw gauge when taking the measurement.



What is the cross-sectional area of the rod?

A $3.81\,mm^2$ **B** $11.4\,mm^2$ **C** $22.8\,mm^2$ **D** $45.6\,mm^2$

5 A mass is dropped from rest, and falls through a distance of 2.0 m in a vacuum. An observer records the time taken for the mass to fall through this distance using a manually operated stopwatch and repeats the measurements a further two times. The average result of these measured times, displayed in the table below, was used to determine a value for the acceleration of free fall. This was calculated to be $9.8\,m\,s^{-2}$.

	first measurement	second measurement	third measurement	average
time / s	0.6	0.73	0.59	0.64

Which statement best relates to the experiment?

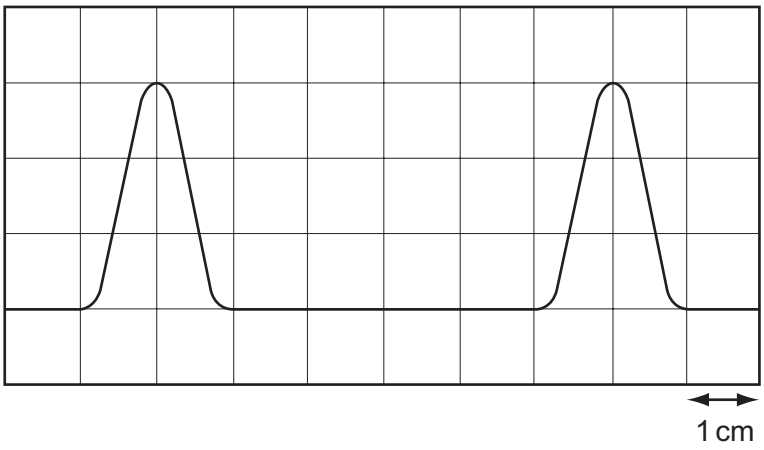
A The measurements are precise and accurate with no evidence of random errors.

B The measurements are not accurate and not always recorded to the degree of precision of the measuring device but the calculated experimental result is accurate.

C The measurements are not always recorded to the degree of precision of the measuring device but are accurate. Systematic errors may be present.

D The range of results shows that there were random errors made but the calculated value is correct so the experiment was successful.

6 The diagram shows two complete pulses on the screen of a cathode-ray oscilloscope. A grid of 1 cm squares covers the screen. The time-base setting is 1 μs cm^{-1}.



How long does each pulse last?

A 2 μs **B** 3 μs **C** 4 μs **D** 6 μs

Additional Materials:

1 What is a reasonable estimate of the average kinetic energy of an athlete during a 100 m race that takes 10 s?

A 40 J **B** 400 J **C** 4000 J **D** 40 000 J

2 When a force F moves its point of application through a displacement s in the direction of the force, the work W done by the force is given by

$$W = Fs.$$

How many vector quantities and scalar quantities does this equation contain?

A one scalar quantity and two vector quantities

B one vector quantity and two scalar quantities

C three scalar quantities

D three vector quantities

3 What is a possible unit for the product VI, where V is the potential difference across a resistor and I is the current through the same resistor?

A newton per second ($\mathrm{N\,s^{-1}}$)

B newton second (N s)

C newton metre (N m)

D newton metre per second ($\mathrm{N\,m\,s^{-1}}$)

4 In an experiment, a radio-controlled car takes 2.50 ± 0.05 s to travel 40.0 ± 0.1 m.

What is the car's average speed and the uncertainty in this value?

A $16 \pm 1\,\mathrm{m\,s^{-1}}$

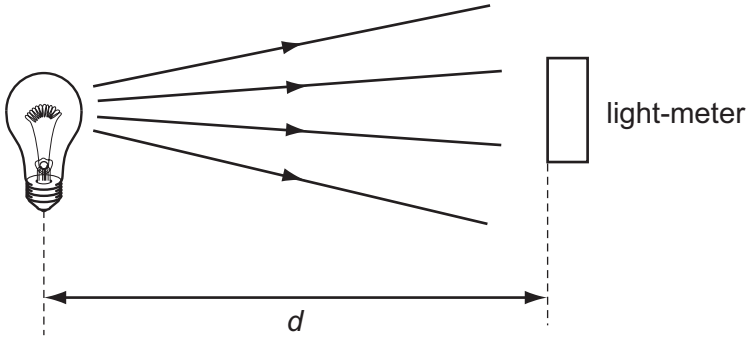
B $16.0 \pm 0.2\,\mathrm{m\,s^{-1}}$

C $16.0 \pm 0.4\,\mathrm{m\,s^{-1}}$

D $16.00 \pm 0.36\,\mathrm{m\,s^{-1}}$

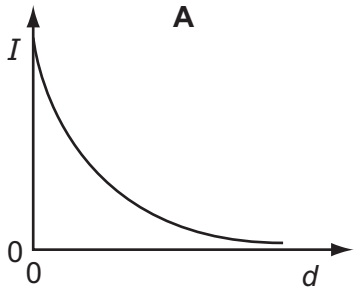
Space for working

5 A light-meter measures the intensity I of the light falling on it. Theory suggests that I varies inversely as the square of the distance d.

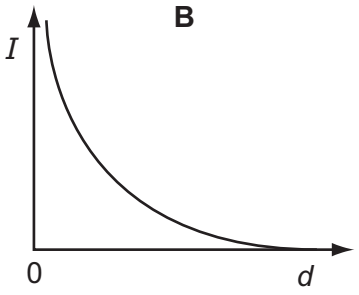


Which graph of the results supports this theory?

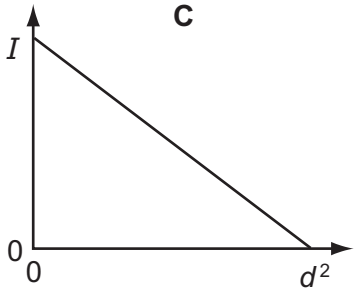
A



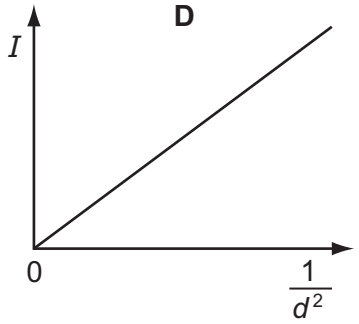
B



C



D



PHYSICS **9702/11**

Paper 1 Multiple Choice **October/November 2012**

1 hour

Additional Materials:

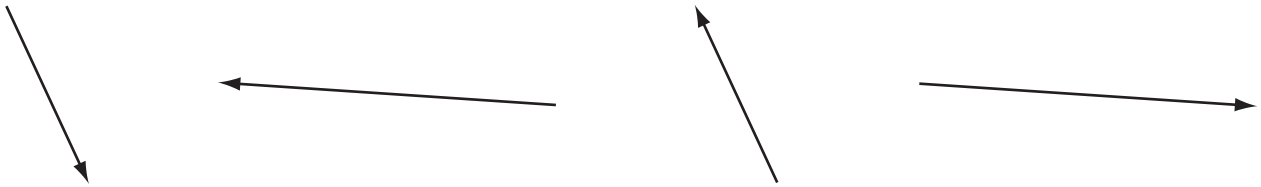
1 What is the unit of weight in terms of SI base unit(s)?

A $kg\,m\,s^{-1}$ **B** $kg\,m\,s^{-2}$ **C** N **D** $J\,m^{-1}$

2 Vectors P and Q are drawn to scale.

Which diagram represents the vector (P – Q)?

A **B**



3 What is the approximate temperature of a red-hot ring on an electric cooker?

A 100 °C **B** 200 °C **C** 400 °C **D** 800 °C

4 Which list contains only scalar quantities?

A area, length, displacement

B kinetic energy, speed, power

C potential energy, momentum, time

D velocity, distance, temperature

5 The density of the material of a coil of thin wire is to be found.

Which set of instruments could be used to do this most accurately?

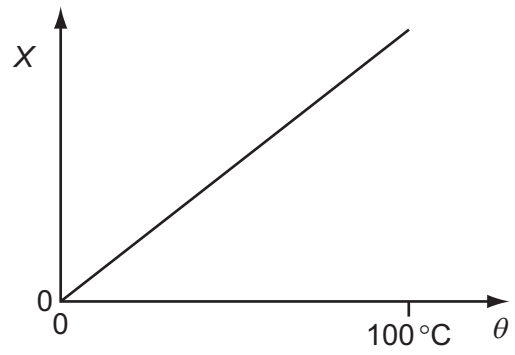
A metre rule, protractor, spring balance

B micrometer, metre rule, top-pan balance

C stopwatch, newton-meter, vernier calipers

D tape measure, vernier calipers, lever balance

6 A quantity X varies with temperature θ as shown.



θ is determined from the corresponding values of X by using this graph.
X is measured with a percentage uncertainty of ± 1 % of its value at all temperatures.

Which statement about the uncertainty in θ is correct?

A The percentage uncertainty in θ is least near 0 °C.

B The percentage uncertainty in θ is least near 100 °C.

C The actual uncertainty in θ is least near 0 °C.

D The actual uncertainty in θ is least near 100 °C.

PHYSICS **9702/12**

Paper 1 Multiple Choice **October/November 2012**

1 hour

Additional Materials:

1 Which quantity has the same base units as momentum?

A density × energy

B density × volume × velocity

C pressure × area

D weight ÷ area

2 Vectors P and Q are drawn to scale.

Which diagram represents the vector (P + Q)?

A

B

C

D

3 What is the approximate kinetic energy of an Olympic athlete when running at maximum speed during a 100 m race?

A 400 J **B** 4000 J **C** 40 000 J **D** 400 000 J

4 Physical quantities can be classed as vectors or as scalars.

Which pair of quantities are both vectors?

A kinetic energy and elastic force

B momentum and time

C velocity and electric field strength

D weight and temperature

5 A student is given a reel of wire of diameter less than 0.2 mm and is asked to find the density of the metal.

Which pair of instruments would be most suitable for finding the **volume** of the wire?

A balance and micrometer

B metre rule and micrometer

C metre rule and vernier calipers

D micrometer and vernier calipers

Additional Materials:

1 The units of all physical quantities can be expressed in terms of SI base units.

Which pair contains quantities with the same base units?

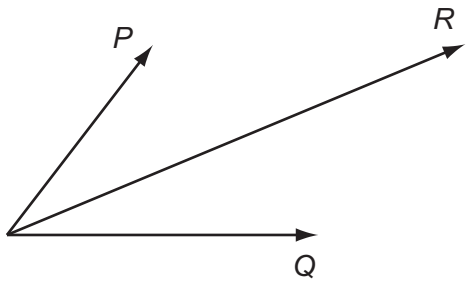
A force and momentum

B pressure and Young modulus

C power and kinetic energy

D mass and weight

2 Two physical quantities *P* and *Q* are added. The sum of *P* and *Q* is *R*, as shown.



Which quantity could be represented by *P* and by *Q*?

A kinetic energy

B power

C speed

D velocity

3 A 1.5 V cell supplies 0.20 A to a lamp for seven hours before the lamp goes out.

What is a sensible estimate for the initial chemical energy content of the cell?

A 1×10^2 J **B** 1×10^4 J **C** 1×10^6 J **D** 1×10^8 J

4 Three of these quantities have the same unit.

Which quantity has a different unit?

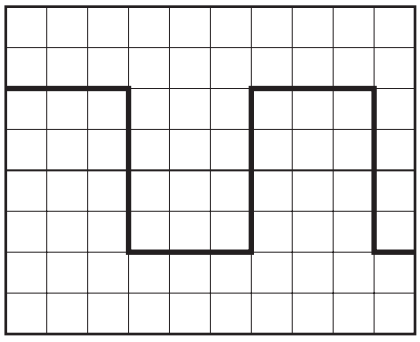
A $\frac{\text{energy}}{\text{distance}}$

B force

C power × time

D rate of change of momentum

5 A cathode-ray oscilloscope displays a square wave, as shown in the diagram.



The time-base setting is 0.20 ms per division.

What is the frequency of the square wave?

A 8.3 Hz **B** 830 Hz **C** 1300 Hz **D** 1700 Hz

PHYSICS **9702/11**

Paper 1 Multiple Choice **May/June 2013**

1 hour

Additional Materials:

1 Which pair of quantities contains one vector and one scalar quantity?

A displacement; force

B kinetic energy; power

C acceleration; momentum

D velocity; distance

2 One property Q of a material is used to describe the behaviour of sound waves in the material. Q is defined as the pressure P of the sound wave divided by the speed v of the wave and the surface area A of the material through which the wave travels:

$$Q = \frac{P}{vA}.$$

What are the SI base units of Q?

A $\text{kg m}^2\text{ s}^{-3}$ **B** $\text{kg m}^{-3}\text{ s}^{-1}$ **C** $\text{kg m}^{-4}\text{ s}^{-1}$ **D** $\text{kg m}^{-2}\text{ s}^{-2}$

4 A wave has a frequency of 5 GHz.

What is the period of the wave?

A 20 000 μs

B 20 ns

C 2 ns

D 200 ps

5 In an experiment to determine the acceleration of free fall g, the period of oscillation T and length l of a simple pendulum were measured. The uncertainty in the measurement of l is estimated to be 4%, and the uncertainty in the measurement of T is estimated to be 1%.

The value of g is determined using the formula

$$g = \frac{4\pi^2 l}{T^2}.$$

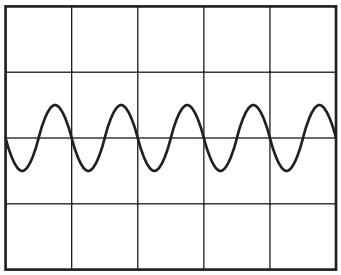
What is the uncertainty in the calculated value for g?

A 2% **B** 3% **C** 5% **D** 6%

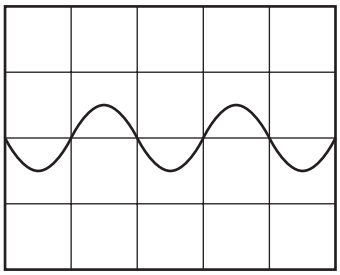
6 The Y-input terminals of a cathode-ray oscilloscope (c.r.o.) are connected to a supply of amplitude 5.0 V and frequency 50 Hz. The time-base is set at 10 ms per division and the Y-gain at 5.0 V per division.

Which trace is obtained?

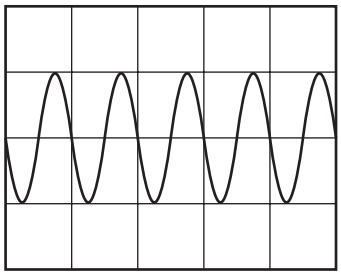
A



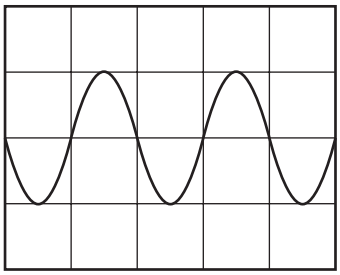
B



C



D



PHYSICS **9702/12**

Paper 1 Multiple Choice **May/June 2013**

1 hour

Additional Materials:

1 Which pair includes a vector quantity and a scalar quantity?

A displacement; acceleration

B force; kinetic energy

C power; speed

D work; potential energy

2 The unit of resistivity, expressed in terms of base units, is given by

$$\text{kg}\, x^3 y^{-2} z^{-3}.$$

Which base units are x, y and z?

	x	y	z
A	ampere	metre	second
B	metre	ampere	second
C	metre	second	ampere
D	second	ampere	metre

4 A student carried out an experiment in which an electric current was known to decrease with time. The readings he found, from first to last, were 3.62 mA, 2.81 mA, 1.13 mA, 1.76 mA and 0.90 mA.

Which statement could **not** explain the anomalous 1.13 mA reading?

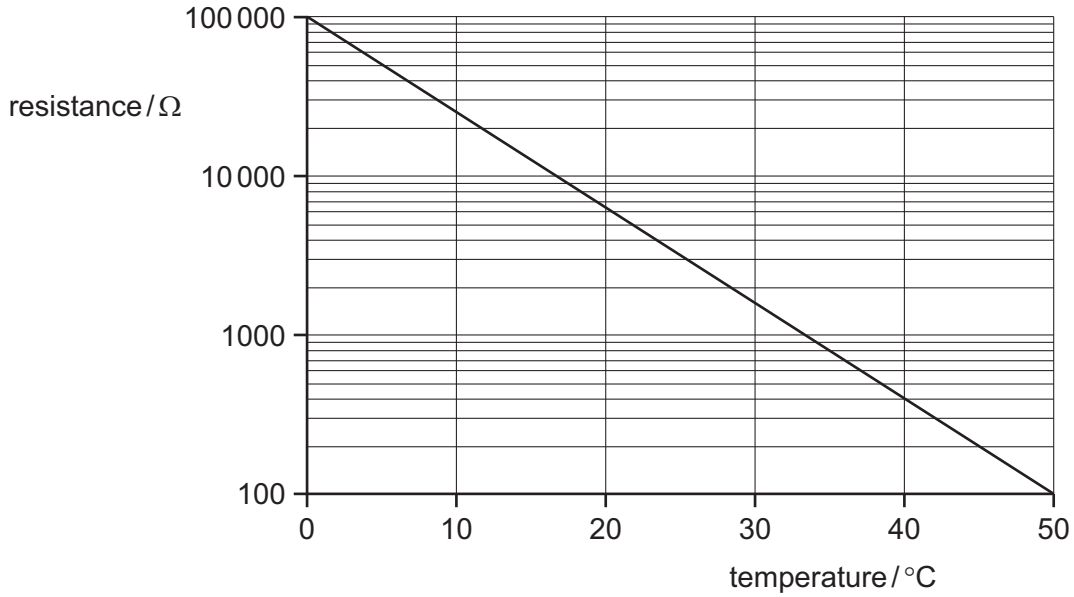
A He has reversed the third and fourth readings in the results table.

B He read the ammeter incorrectly; the reading should have been 2.13 mA.

C He took the current reading at the wrong time.

D There was a systematic error in the readings from the ammeter.

5 The diagram shows a calibration curve for a thermistor, drawn with an unusual scale on the vertical axis.



What is the thermistor resistance corresponding to a temperature of 40 °C?

A 130 Ω **B** 150 Ω **C** 400 Ω **D** 940 Ω

Additional Materials:

2 What is the unit of power, expressed in SI base units?

A $kg\,m^2\,s^{-3}$ **B** $kg\,m\,s^{-3}$ **C** $kg\,m\,s^{-2}$ **D** $kg\,m^2\,s^{-1}$

3 Which statement is **incorrect** by a factor of 100 or more?

A Atmospheric pressure is about 1×10^5 Pa.

B Light takes 5×10^2 s to reach us from the Sun.

C The frequency of ultra-violet light is 3×10^{12} Hz.

D The life-span of a man is about 2×10^9 s.

5 A student takes measurements of the current in a resistor of constant resistance and the potential difference (p.d.) across it. The readings are then used to plot a graph of current against p.d.

There is a systematic error in the current readings.

How could this be identified from the graph?

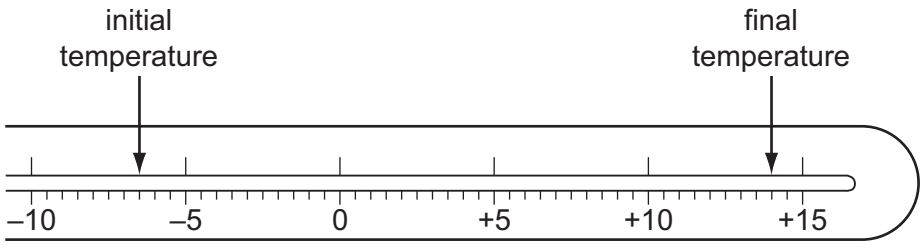
A At least one anomalous data point can be identified.

B The data points are scattered about the straight line of best fit.

C The graph is a curve, not a straight line.

D The straight line graph does not pass through the origin.

6 The diagram shows the stem of a Celsius thermometer, marked to show initial and final temperature values.



What is the temperature change expressed to an appropriate number of significant figures?

A 14 °C **B** 20.5 °C **C** 21 °C **D** 22.0 °C

PHYSICS **9702/11**

Paper 1 Multiple Choice **October/November 2013**

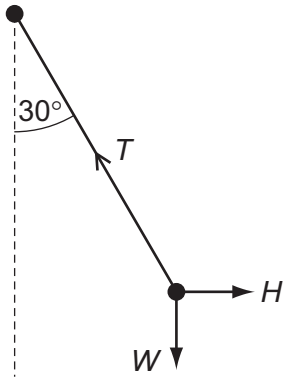
1 hour

Additional Materials:

1 Which row shows an SI base quantity with its correct unit?

	SI base quantity	unit
A	charge	c
B	current	
C	potential difference	volt
D	temperature	Celsius

2 A pendulum bob is held stationary by a horizontal force *H*. The three forces acting on the bob are shown in the diagram.



The tension in the string of the pendulum is *T*. The weight of the pendulum bob is *W*.

Which statement is correct?

A $H = T \cos 30°$

B $T = H \sin 30°$

C $W = T \cos 30°$

D $W = T \sin 30°$

3 The drag coefficient C_d is a number with no units. It is used to compare the drag on different cars at different speeds. It is given by the equation

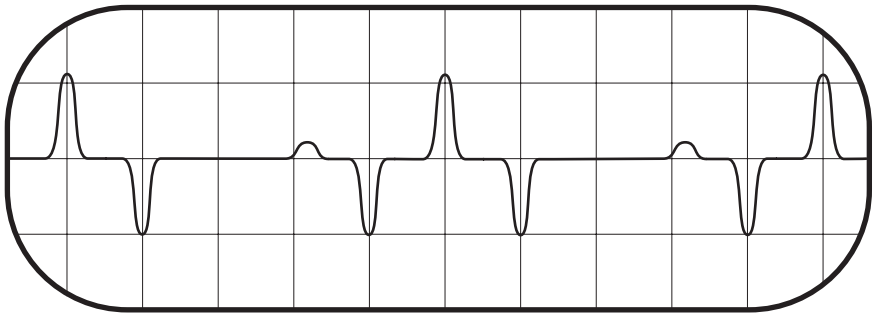
$$C_d = \frac{2F}{\rho v^n A}$$

where F is the drag force on the car, ρ is the density of the air, A is the cross-sectional area of the car and v is the speed of the car.

What is the value of n?

A 1 **B** 2 **C** 3 **D** 4

4 A signal that repeats periodically is displayed on the screen of a cathode-ray oscilloscope.



The screen has 1 cm squares and the time base is set at 2.00 ms cm^{-1}.

What is the frequency of this periodic signal?

A 50 Hz **B** 100 Hz **C** 125 Hz **D** 200 Hz

5 A micrometer screw gauge is used to measure the diameter of a small uniform steel sphere. The micrometer reading is 5.00 mm $\pm$ 0.01 mm.

What will be the percentage uncertainty in a calculation of the volume of the sphere, using these values?

A 0.2% **B** 0.4% **C** 0.6% **D** 1.2%

Additional Materials:

1 Which estimate is realistic?

A The kinetic energy of a bus travelling on an expressway is 30 000 J.

B The power of a domestic light is 300 W.

C The temperature of a hot oven is 300 K.

D The volume of air in a car tyre is 0.03 m^3.

2 Which unit is equivalent to the coulomb?

A ampere per second

B joule per volt

C watt per ampere

D watt per volt

3 Two forces of equal magnitude are represented by two coplanar vectors. One is directed eastwards and the other is directed northwards.

What is the direction of a single force that will balance these two forces?

A towards the north-east

B towards the north-west

C towards the south-east

D towards the south-west

4 The spring constant k of a coiled wire spring is given by the equation

$$k = \frac{Gr^4}{4nR^3}$$

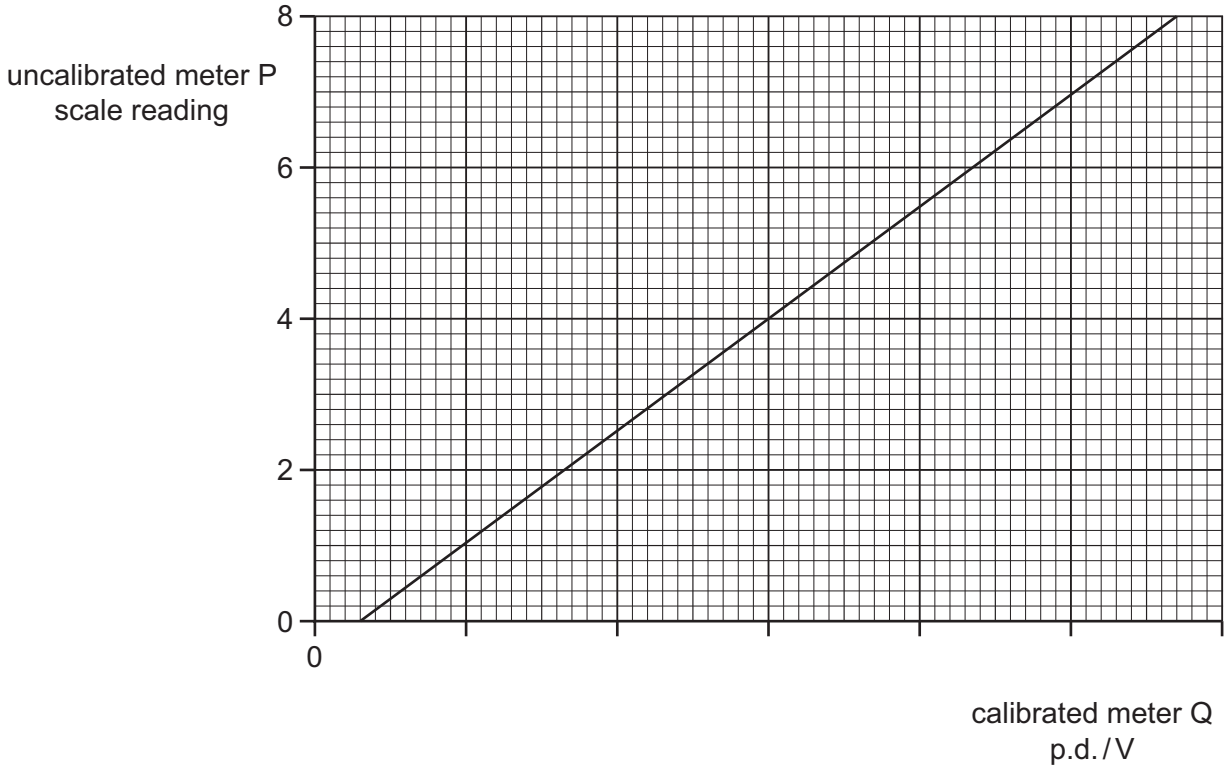
where r is the radius of the wire, n is the number of turns of wire and R is the radius of each of the turns of wire. The quantity G depends on the material from which the wire is made.

What is a suitable unit for G?

A $N m^{-2}$ **B** $N m^{-1}$ **C** $N m$ **D** $N m^2$

5 An uncalibrated analogue voltmeter P is connected in parallel with another voltmeter Q which is known to be accurately calibrated. For a range of values of potential difference (p.d.), readings are taken from the two meters.

The diagram shows the calibration graph obtained.



The graph shows that meter P has a zero error. This meter is now adjusted to remove this zero error. When the meter is recalibrated, the gradient of the calibration graph is found to be unchanged.

What is the new scale reading on meter P when it is used to measure a p.d. of 5.0 V?

A 6.6 **B** 6.7 **C** 7.2 **D** 7.4

6 A student wishes to determine the density ρ of lead. She measures the mass and diameter of a small sphere of lead:

$$\text{mass} = (0.506 \pm 0.005)\,\text{g}$$

$$\text{diameter} = (2.20 \pm 0.02)\,\text{mm}.$$

What is the best estimate of the percentage uncertainty in her value of ρ?

A 1.9% **B** 2.0% **C** 2.8% **D** 3.7%

PHYSICS **9702/11**

Paper 1 Multiple Choice **May/June 2014**

1 hour

Additional Materials:

1 Which pair of units contains one derived unit and one SI base unit?

A ampere coulomb

B kilogram kelvin

C metre second

D newton pascal

2 What is equivalent to 2000 microvolts?

A $2\,\mu J\,C^{-1}$ **B** $2\,mV$ **C** $2\,pV$ **D** $2000\,mV$

3 The speed v of a liquid leaving a tube depends on the change in pressure ΔP and the density ρ of the liquid. The speed is given by the equation

$$v = k\left(\frac{\Delta P}{\rho}\right)^n$$

where k is a constant that has no units.

What is the value of n?

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

4 An experiment is carried out to measure the resistance of a wire.

The current in the wire is $(1.0 \pm 0.2)\,A$ and the potential difference across the wire is $(8.0 \pm 0.4)\,V$.

What is the resistance of the wire and its uncertainty?

A $(8.0 \pm 0.2)\,\Omega$

B $(8.0 \pm 0.6)\,\Omega$

C $(8 \pm 1)\,\Omega$

D $(8 \pm 2)\,\Omega$

5 The Young modulus of the material of a wire is to be found. The Young modulus E is given by the equation below.

$$E = \frac{4Fl}{\pi d^2 x}$$

The wire is extended by a known force and the following measurements are made.

Which measurement has the largest effect on the uncertainty in the value of the calculated Young modulus?

	measurement	symbol	value
A	length of wire before force applied	l	2.043 ± 0.002 m
B	diameter of wire	d	0.54 ± 0.02 mm
C	force applied	F	19.62 ± 0.01 N
D	extension of wire with force applied	x	5.2 ± 0.2 mm

Additional Materials:

1 The maximum theoretical power P of a wind turbine is given by the equation

$$P = k\rho A v^n$$

where ρ is the density of air, A is the area swept by the turbine blades, v is the speed of the air and k is a constant with no units.

What is the value of n?

A 1 **B** 2 **C** 3 **D** 4

2 What is the unit of resistance when expressed in SI base units?

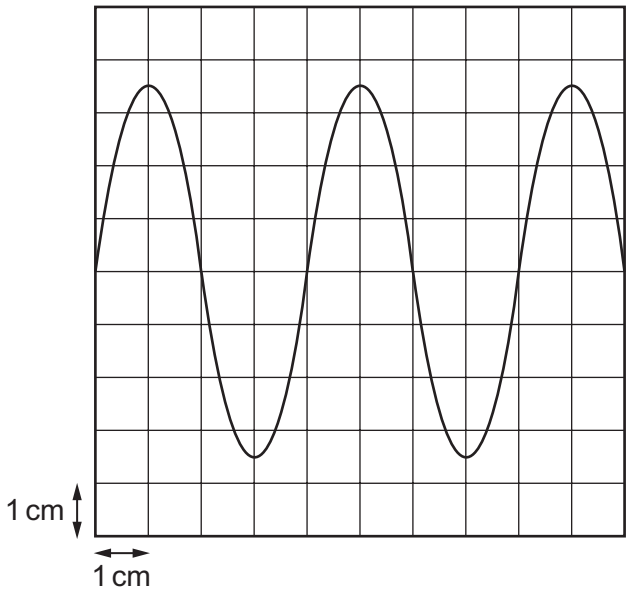
A $\text{kg m}^2\text{ s}^{-2}\text{ A}^{-1}$

B $\text{kg m}^2\text{ s}^{-3}\text{ A}^{-2}$

C $\text{kg m s}^{-2}\text{ A}^{-1}$

D $\text{kg m s}^{-3}\text{ A}^{-1}$

3 A cathode-ray oscilloscope (c.r.o.) is connected to an alternating voltage. The following trace is produced on the screen.



The oscilloscope time-base setting is 0.5 ms cm^{-1} and the Y-plate sensitivity is 2 V cm^{-1}.

Which statement about the alternating voltage is correct?

A The amplitude is 3.5 cm.

B The frequency is 0.5 kHz.

C The period is 1 ms.

D The wavelength is 4 cm.

4 A quantity y is to be determined from the equation shown.

$$y = \frac{px}{q^2}$$

The percentage uncertainties in p, x and q are shown.

	percentage uncertainty
p	6%
x	2%
q	4%

What is the percentage uncertainty in y?

A 0.5 % **B** 1 % **C** 16 % **D** 192 %

5 A thermometer can be read to an accuracy of ± 0.5 °C. This thermometer is used to measure a temperature rise from 40 °C to 100 °C.

What is the percentage uncertainty in the measurement of the temperature rise?

A 0.5 % **B** 0.8 % **C** 1.3 % **D** 1.7 %

Additional Materials:

1 Which quantity can be measured in electronvolts (eV)?

A electric charge

B electric potential

C energy

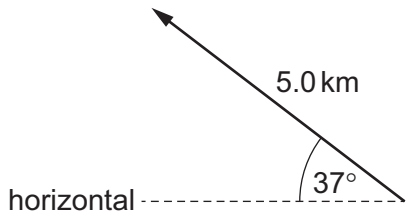
D power

2 The unit of specific heat capacity is $J\,kg^{-1}\,K^{-1}$.

What is its equivalent in terms of SI base units?

A $kg^{-1}\,m^2\,K^{-1}$ **B** $m\,s^{-1}\,K^{-1}$ **C** $m\,s^{-2}\,K^{-1}$ **D** $m^2\,s^{-2}\,K^{-1}$

3 What is the vertical component of this displacement vector?



A 3.0 km **B** 3.8 km **C** 4.0 km **D** 5.0 km

4 The resistance of a lamp is calculated from the value of the potential difference (p.d.) across it and the value of the current passing through it.

Which statement correctly describes how to combine the uncertainties in the p.d. and in the current?

A Add together the actual uncertainty in the p.d. and the actual uncertainty in the current.

B Add together the percentage uncertainty in the p.d. and the percentage uncertainty in the current.

C Subtract the actual uncertainty in the current from the actual uncertainty in the p.d.

D Subtract the percentage uncertainty in the current from the percentage uncertainty in the p.d.

6 A digital caliper is used to measure the 28.50 mm width of a plastic ruler. The digital caliper reads to the nearest 0.01 mm.

What is the correct way to record this reading?

A $0.02850 \pm 0.01\,\text{m}$

B $0.0285 \pm 0.001\,\text{m}$

C $(2.850 \pm 0.001) \times 10^{-2}\,\text{m}$

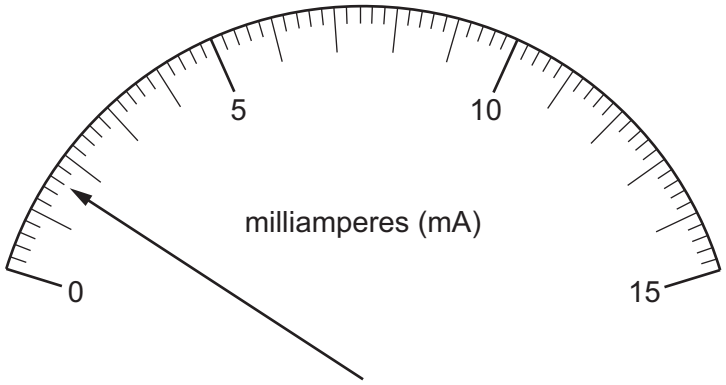
D $(2.85 \pm 0.001) \times 10^{-3}\,\text{m}$

Additional Materials:

2 What is equivalent to the unit of electric field strength?

A JCm^{-1} **B** NsA^{-1} **C** $kgms^{-3}A^{-1}$ **D** $kgm^3s^{-3}A^{-1}$

3 The diagram shows the reading on an analogue ammeter.



Which digital ammeter reading is the same as the reading on the analogue ammeter?

	display units	display reading
A	μA	1600
B	μA	160
C	mA	16.0
D	A	1.60

Additional Materials:

1 When the brakes are applied on a vehicle moving at speed v, the distance d moved by the vehicle in coming to rest is given by the expression

$$d = kv^2$$

where k is a constant.

What is the unit of k expressed in SI base units?

A $m^{-1}s^2$ **B** ms^{-2} **C** m^2s^{-2} **D** $m^{-1}s$

2 Which list contains one vector quantity and two scalar quantities?

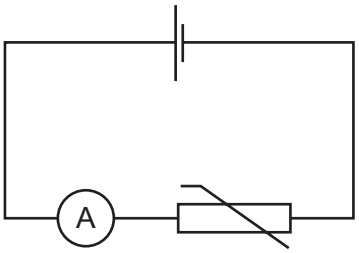
A displacement, weight, velocity

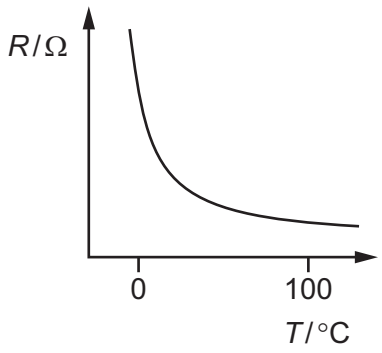
B force, acceleration, time

C momentum, mass, speed

D work, density, energy

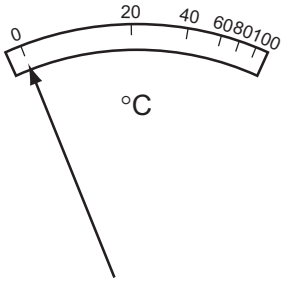
3 In the circuit shown, an analogue ammeter is to be recalibrated as a thermometer. The graph shows how the resistance R of the thermistor changes with temperature T.



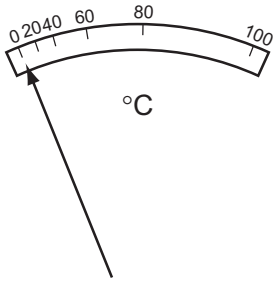


Which diagram could represent the temperature scale on the ammeter?

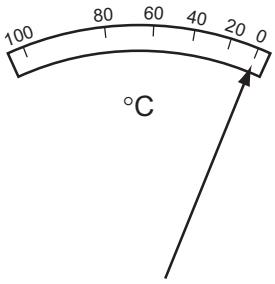
A



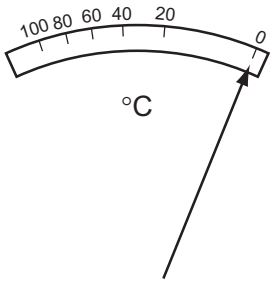
B



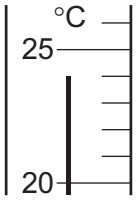
C



D



4 The diagram shows part of a thermometer.



What is the correct reading on the thermometer and the uncertainty in this reading?

	reading / °C	uncertainty in reading / °C
A	24	±1
B	24	±0.5
C	24	±0.2
D	24.0	±0.5

5 The resistance R of a resistor is to be determined. The current I in the resistor and the potential difference V across it are measured.

The results, with their uncertainties, are

$$I = (2.0 \pm 0.2)\,\text{A} \qquad V = (15.0 \pm 0.5)\,\text{V}.$$

The value of R is calculated to be $7.5\,\Omega$.

What is the uncertainty in this value for R?

A $\pm 0.3\,\Omega$ **B** $\pm 0.5\,\Omega$ **C** $\pm 0.7\,\Omega$ **D** $\pm 1\,\Omega$

Additional Materials:

1 Which is an SI base unit?

A current

B gram

C kelvin

D volt

2 Which pair contains one vector and one scalar quantity?

A	displacement	acceleration
B	force	kinetic energy
C	momentum	velocity
D	power	speed

3 When a constant braking force is applied to a vehicle moving at speed v, the distance d moved by the vehicle in coming to rest is given by the expression

$$d = kv^2$$

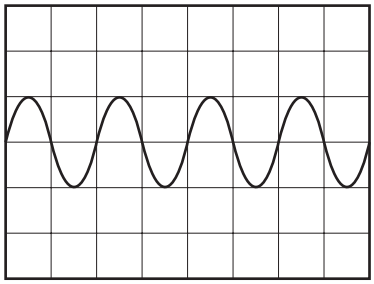
where k is a constant.

When d is measured in metres and v is measured in metres per second, the constant has a value of k_1.

What is the value of the constant when the distance is measured in metres, and the speed is measured in kilometres per hour?

A $0.0772\,k_1$ **B** $0.278\,k_1$ **C** $3.60\,k_1$ **D** $13.0\,k_1$

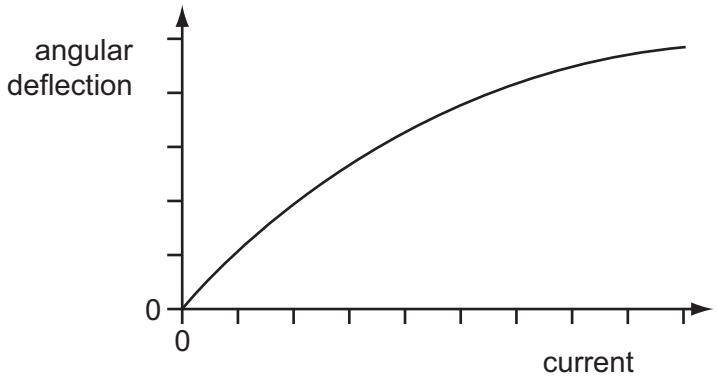
4 A whale produces sound waves of frequency 5 Hz. The waves are detected by a microphone and displayed on an oscilloscope.



What is the time-base setting on the oscilloscope?

A $0.1\,\text{ms div}^{-1}$ **B** $1\,\text{ms div}^{-1}$ **C** $10\,\text{ms div}^{-1}$ **D** $100\,\text{ms div}^{-1}$

5 The angular deflection of the needle of an ammeter varies with the current in the ammeter as shown in the graph.



Which diagram could represent the appearance of the scale on this meter?

A

B

C

D

6 The strain energy W of a spring is determined from its spring constant k and extension x. The spring obeys Hooke's law and the value of W is calculated using the equation shown.

$$W = \tfrac{1}{2} kx^2$$

The spring constant is $100 \pm 2\,\text{N m}^{-1}$ and the extension is $0.050 \pm 0.002\,\text{m}$.

What is the percentage uncertainty in the calculated value of W?

A 6% **B** 10% **C** 16% **D** 32%

Additional Materials:

1 Which definition is correct and uses only quantities rather than units?

A Density is mass per cubic metre.

B Potential difference is energy per unit current.

C Pressure is force per unit area.

D Speed is distance travelled per second.

2 The average kinetic energy E of a gas molecule is given by the equation

$$E = \tfrac{3}{2} kT$$

where T is the absolute (kelvin) temperature.

What are the SI base units of k?

A $\mathrm{kg^{-1}\,m^{-1}\,s^{2}\,K}$

B $\mathrm{kg^{-1}\,m^{-2}\,s^{2}\,K}$

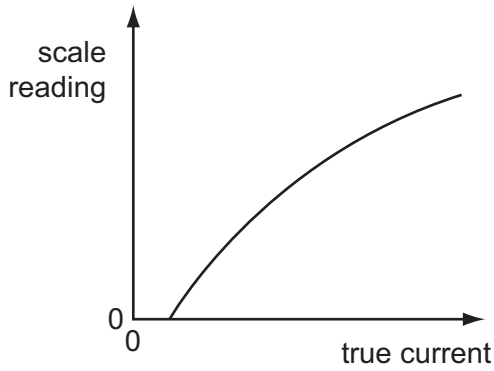
C $\mathrm{kg\,m\,s^{-2}\,K^{-1}}$

D $\mathrm{kg\,m^{2}\,s^{-2}\,K^{-1}}$

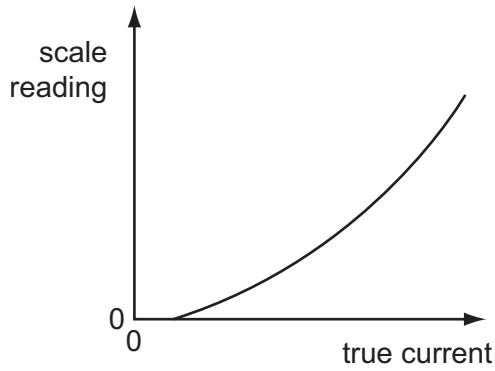
3 An analogue ammeter has a pointer which moves over a scale. Following prolonged use, the pointer does not return fully to zero when the current is turned off and the meter has become less sensitive at higher currents than it is at lower currents.

Which diagram best represents the calibration graph needed to obtain an accurate current reading?

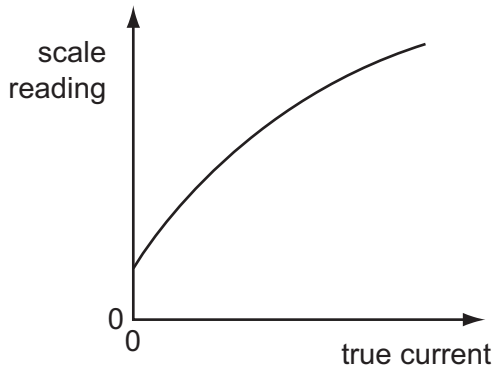
A



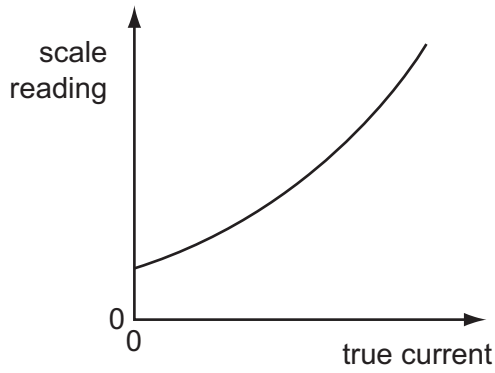
B



C



D



PHYSICS **9702/13**

Paper 1 Multiple Choice **May/June 2015**

1 hour

Additional Materials:

1 Which statement includes a correct unit?

A energy = 7.8 N s

B force = 3.8 N s

C momentum = 6.2 N s

D torque = 4.7 N s

2 What is the joule (J) in SI base units?

A $kg\,m\,s^{-1}$ **B** $kg\,m^2\,s^{-1}$ **C** $kg\,m\,s^{-2}$ **D** $kg\,m^2\,s^{-2}$

3 The speed of an aeroplane in still air is $200\,km\,h^{-1}$. The wind blows from the west at a speed of $85.0\,km\,h^{-1}$.

In which direction must the pilot steer the aeroplane in order to fly due north?

A 23.0° east of north

B 23.0° west of north

C 25.2° east of north

D 25.2° west of north

4 A student is given a reel of wire of diameter less than 0.2 mm and is asked to find the density of the metal.

Which pair of instruments would be most suitable for finding the **volume** of the wire?

A balance and micrometer

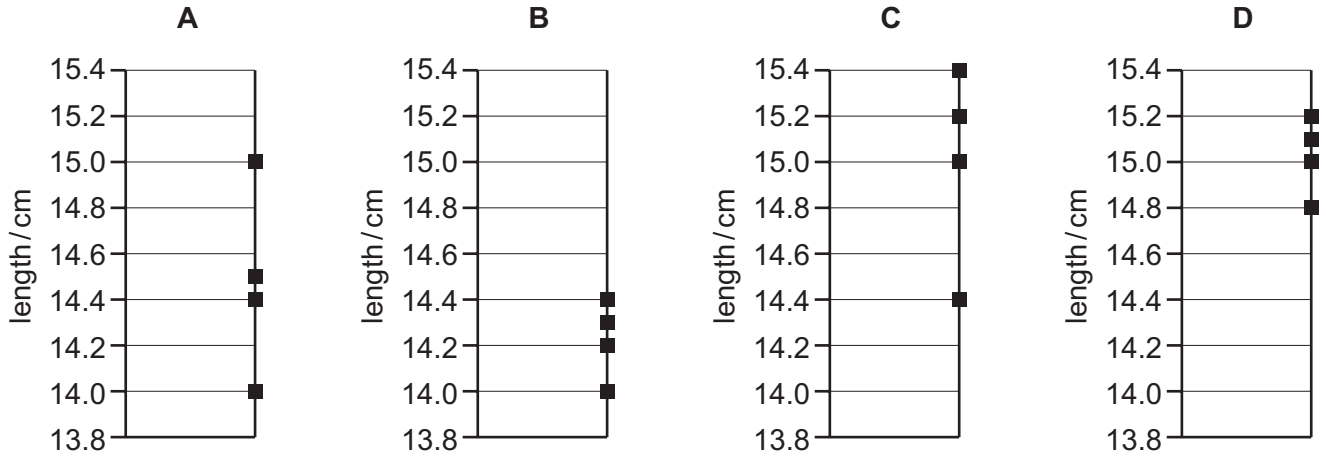
B metre rule and micrometer

C metre rule and vernier calipers

D micrometer and vernier calipers

5 Four different students use a ruler to measure the length of a 15.0 cm pencil. Their measurements are recorded on four different charts.

Which chart shows measurements that are precise but **not** accurate?



6 In a simple electrical circuit, the current in a resistor is measured as (2.50 ± 0.05) mA. The resistor is marked as having a value of 4.7 Ω ± 2 %.

If these values were used to calculate the power dissipated in the resistor, what would be the percentage uncertainty in the value obtained?

A 2 % **B** 4 % **C** 6 % **D** 8 %

Additional Materials:

1 What is the unit of weight in terms of SI base unit(s)?

A $\mathrm{kg\,m\,s^{-1}}$ **B** $\mathrm{kg\,m\,s^{-2}}$ **C** N **D** $\mathrm{J\,m^{-1}}$

2 At temperatures close to 0 K, the specific heat capacity c of a particular solid is given by $c = bT^3$, where T is the thermodynamic temperature and b is a constant characteristic of the solid.
The SI unit of specific heat capacity is $\mathrm{J\,kg^{-1}\,K^{-1}}$.

What is the unit of constant b, expressed in SI base units?

A $\mathrm{m^2\,s^{-2}\,K^{-3}}$

B $\mathrm{m^2\,s^{-2}\,K^{-4}}$

C $\mathrm{kg\,m^2\,s^{-2}\,K^{-3}}$

D $\mathrm{kg\,m^2\,s^{-2}\,K^{-4}}$

3 In making reasonable estimates of physical quantities, which statement is **not** correct?

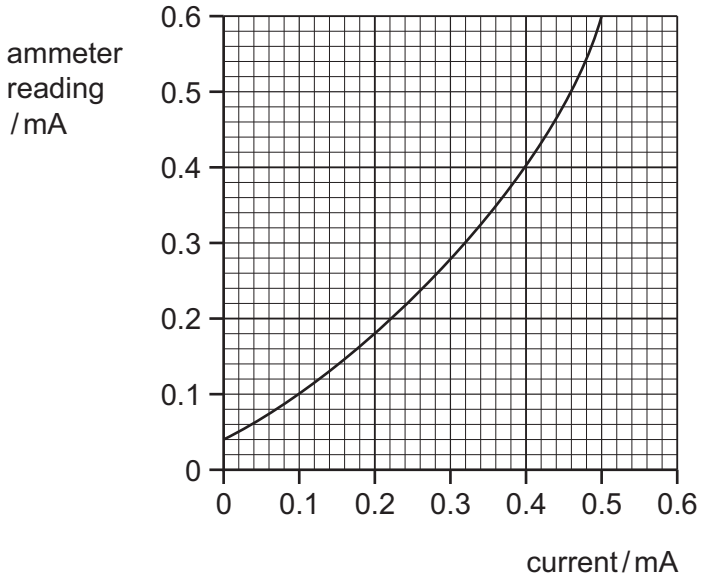
A The frequency of sound can be of the order of GHz.

B The wavelength of light can be of the order of 600 nm.

C The Young modulus of a metal can be of the order of 10^{11} Pa.

D Beta particles are associated with one unit of negative charge.

4 A calibration graph is shown for an ammeter whose scale is inaccurate.

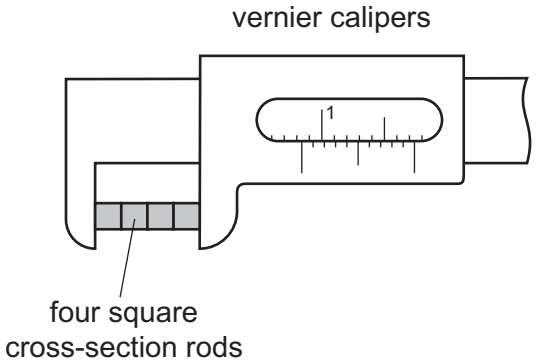


Two readings taken on the meter at different times during an experiment are 0.13 mA and 0.47 mA.

By how much did the current really increase between taking the two readings?

A 0.30 mA **B** 0.35 mA **C** 0.40 mA **D** 0.44 mA

5 Four identical rods have a square cross-section. The rods are placed side by side and their total width is measured with vernier calipers, as shown.



The measurement is (8.4 ± 0.1) mm and the zero reading on the calipers is (0.0 ± 0.1) mm.

What is the width of one rod?

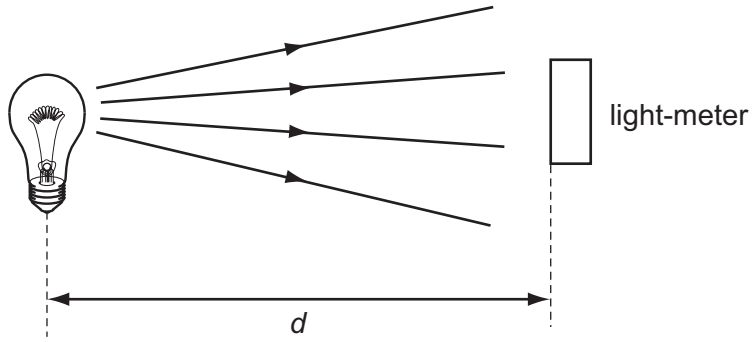
A (2.10 ± 0.025) mm

B (2.10 ± 0.05) mm

C (2.1 ± 0.1) mm

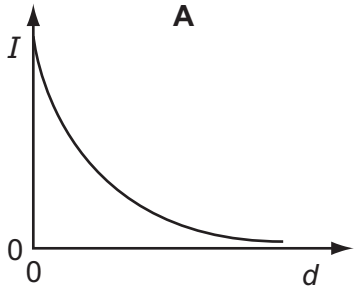
D (2.1 ± 0.2) mm

6 A light-meter measures the intensity I of the light incident on it. Theory suggests that I varies inversely as the square of the distance d.

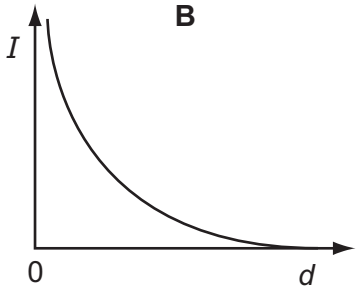


Which graph of the results supports this theory?

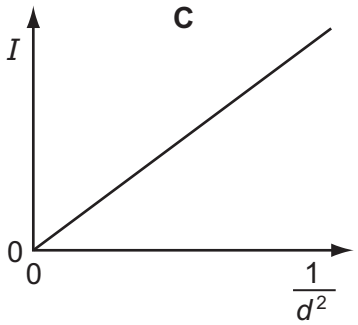
A



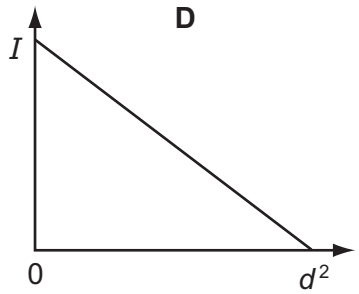
B



C



D



Additional Materials:

1 Which list shows increasing lengths from beginning to end?

A 1 cm 1 nm 1 mm μm

B 1 μm mm 1 nm cm

C 1 nm μm 1 mm cm

D 1 mm cm 1 μm nm

2 Which equation contains only scalar quantities?

A $\text{acceleration} = \dfrac{\text{force}}{\text{mass}}$

B $\text{power} = \dfrac{\text{work}}{\text{time}}$

C $\text{pressure} = \dfrac{\text{force}}{\text{area}}$

D $\text{velocity} = \dfrac{\text{displacement}}{\text{time}}$

3 The time T taken for a satellite to orbit the Earth on a circular path is given by the equation

$$T^2 = \frac{kr^3}{M}$$

where r is the radius of the orbit, M is the mass of the Earth and k is a constant.

What are the SI base units of k?

A $\text{kg}^{-1}\,\text{m}^{-3}\,\text{s}^2$ **B** $\text{kg}^{-1}\,\text{m}^3\,\text{s}^2$ **C** $\text{kg}\,\text{m}^{-3}\,\text{s}^2$ **D** $\text{kg}\,\text{m}^3\,\text{s}^2$

4 Which row gives reasonable estimates for the mass and the speed of an adult running?

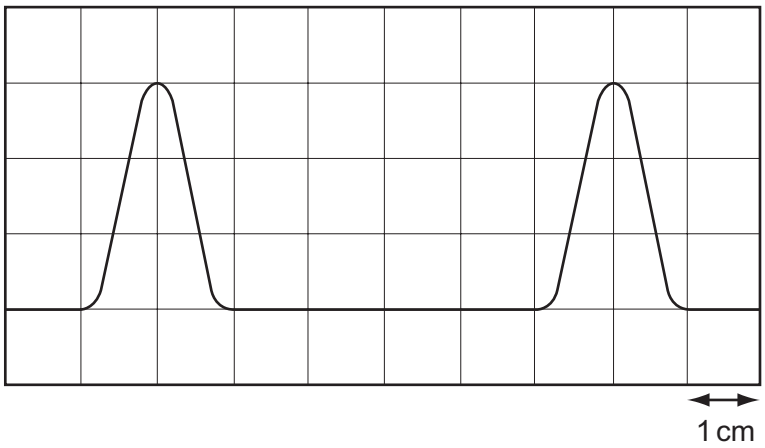
	mass / kg	spe / m s^{-1}
A	6×10^0	5×10^1
B	6×10^1	5×10^0
C	6×10^1	5×10^1
D	6×10^2	5×10^0

to calculate the acceleration of free fall *g*.

What is the best estimate of the percentage uncertainty in the value of *g*?

A 0.02% **B** 4% **C** 8% **D** 16%

6 The diagram shows two complete pulses on the screen of a cathode-ray oscilloscope. A grid of 1 cm squares covers the screen. The time-base setting is 1 μs cm^{-1}.



How long does each pulse last?

A 2 μs **B** 3 μs **C** 4 μs **D** 6 μs

PHYSICS **9702/13**

Paper 1 Multiple Choice **October/November 2015**

1 hour

Additional Materials:

1 What is the unit of the Young modulus when expressed in SI base units?

A $\mathrm{kg\,m^{-1}\,s^{-2}}$

B $\mathrm{kg\,m^{3}\,s^{-2}}$

C $\mathrm{kg\,m^{-2}}$

D $\mathrm{kg\,m^{-1}\,s^{-1}}$

2 The Reynolds number R is a constant used in the study of liquids flowing through pipes. R is a pure number with no unit.

$$R = \frac{\rho v D}{\mu}$$

where ρ is the density of the liquid, v is the speed of the liquid and D is the diameter of the pipe through which the liquid flows.

What are the SI base units of μ?

A $\mathrm{kg\,m\,s}$ **B** $\mathrm{kg\,m^{-1}\,s}$ **C** $\mathrm{kg\,m\,s^{-1}}$ **D** $\mathrm{kg\,m^{-1}\,s^{-1}}$

3 When a force F moves its point of application through a displacement s in the direction of the force, the work W done by the force is given by

$$W = Fs.$$

How many vector quantities and scalar quantities does this equation contain?

A one scalar quantity and two vector quantities

B one vector quantity and two scalar quantities

C three scalar quantities

D three vector quantities

4 Measurements are subject to systematic error and random error.

Which measurements have high accuracy and low precision?

A high random error and high systematic error

B high random error and low systematic error

C low random error and high systematic error

D low random error and low systematic error

5 The density of the material of a coil of thin wire is to be found.

Which set of instruments could be used to do this most accurately?

A metre rule, protractor, spring balance

B micrometer, metre rule, top-pan balance

C stopwatch, newton-meter, vernier calipers

D tape measure, vernier calipers, lever balance

6 A cylindrical tube rolling down a slope of inclination θ moves a distance L in time T. The equation relating these quantities is

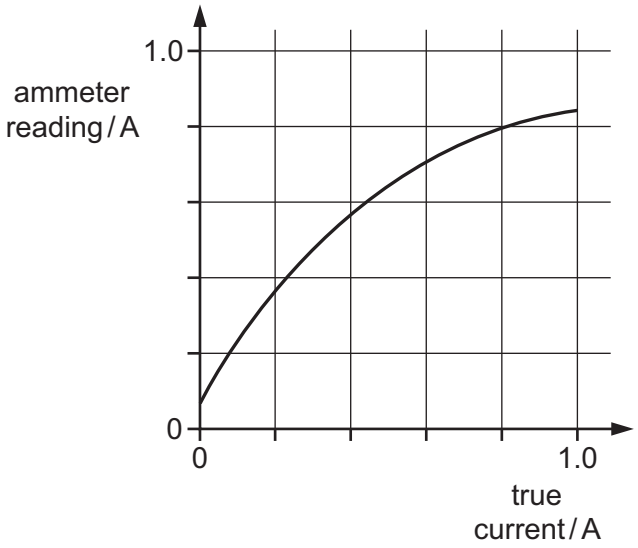
$$L\left(3+\frac{a^2}{P}\right) = QT^2 \sin\theta$$

where a is the internal radius of the tube and P and Q are constants.

Which row gives the correct units for P and for Q?

	P	Q
A	m^2	$m^2 s^{-2}$
B	m^2	$m s^{-2}$
C	m^2	$m^3 s^{-2}$
D	m^3	$m s^{-2}$

5 A calibration graph is produced for a faulty ammeter.



Which ammeter reading will be nearest to the true current?

A 0.2 A **B** 0.4 A **C** 0.6 A **D** 0.8 A

2 Which pair of quantities do **not** have the same SI base units?

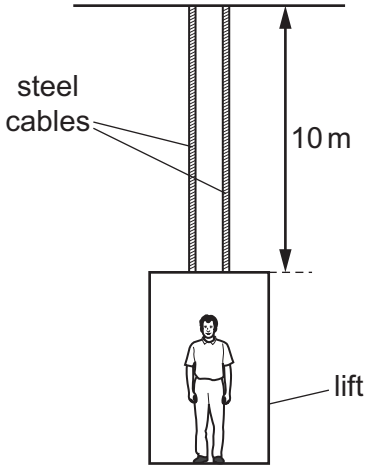
A electromotive force and electric potential difference

B pressure and stress

C spring constant and moment of a force

D torque and work

3 A lift is supported by two steel cables, each of length 10 m and diameter 0.5 cm.



NOT TO SCALE

The cables extend by 1 mm when a man of mass 80 kg steps into the lift.

What is the best estimate of the value of the Young modulus of the steel?

A $2 \times 10^{10}\,\text{N m}^{-2}$

B $4 \times 10^{10}\,\text{N m}^{-2}$

C $2 \times 10^{11}\,\text{N m}^{-2}$

D $4 \times 10^{11}\,\text{N m}^{-2}$

4 When performing an experiment, a student should minimise the uncertainty of any measurement.

In which case is the student reducing the systematic error in a measurement?

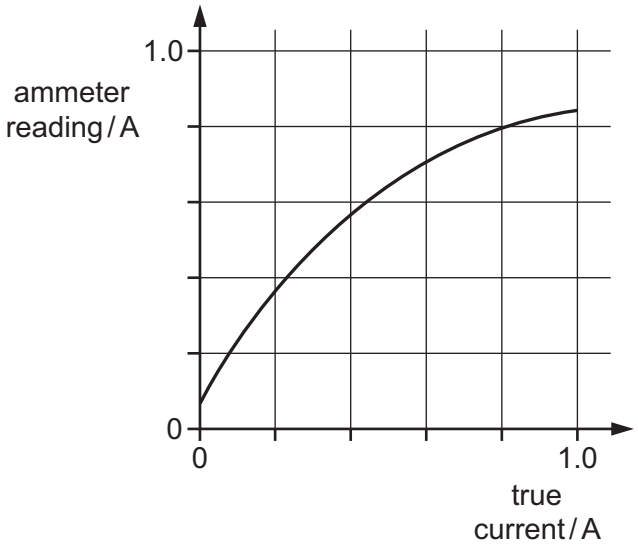
A adjusting a voltmeter needle pointer to the zero position before using it to measure a potential difference

B measuring the diameter of a wire at several points and orientations

C measuring the mass of 100 paperclips to determine the mass of one paperclip

D timing 20 oscillations of a mass on a spring to determine the period of one oscillation

5 A calibration graph is produced for a faulty ammeter.



Which ammeter reading will be nearest to the true current?

A 0.2 A **B** 0.4 A **C** 0.6 A **D** 0.8 A

Additional Materials:

1 Which quantity with its unit is correct?

A acceleration of a bicycle = $1.4\,\text{m s}^{-1}$

B electric current in a lamp = $0.25\,\text{A s}^{-1}$

C electric potential difference across a battery = $8.0\,\text{J C}^{-1}$

D kinetic energy of a car = $4500\,\text{N m}^{-1}$

2 The luminosity L of a star is given by

$$L = 4\pi r^2 \sigma T^4$$

where

r is the radius of the star,

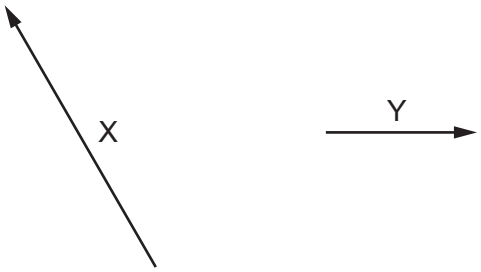
T is the temperature of the star,

σ is a constant with units $\text{W m}^{-2}\,\text{K}^{-4}$.

What are the SI base units of L?

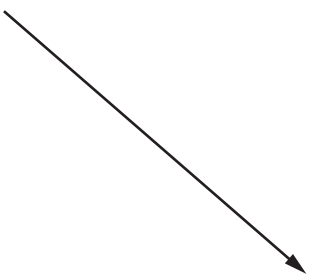
A $\text{kg m}^2\,\text{s}^{-1}$ **B** $\text{kg m}^2\,\text{s}^{-2}$ **C** $\text{kg m}^2\,\text{s}^{-3}$ **D** $\text{kg m}^2\,\text{s}^{-4}$

3 The diagram shows two vectors X and Y, drawn to scale.

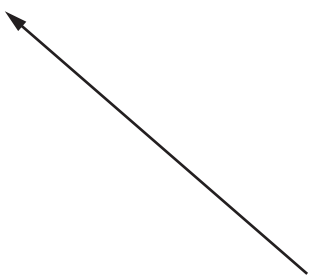


If X = Y – Z, which diagram best represents the vector Z?

A



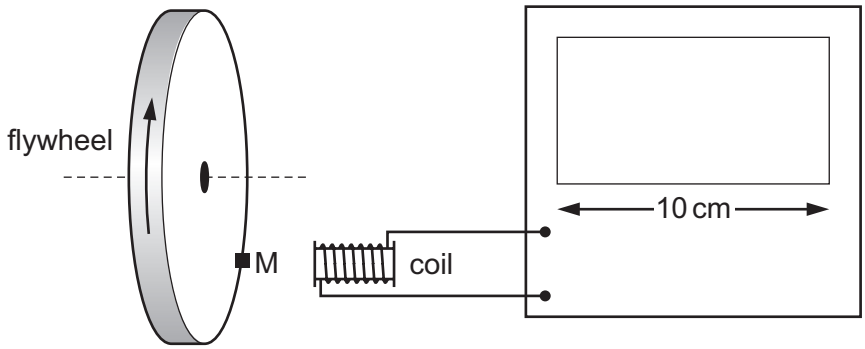
B



C

D

4 The diagram shows a cathode-ray oscilloscope (c.r.o.) being used to measure the rate of rotation of a flywheel.



The flywheel has a small magnet M mounted on it. Each time the magnet passes the coil, a voltage pulse is generated, which is passed to the c.r.o. The display of the c.r.o. is 10 cm wide. The flywheel is rotating at 3000 revolutions per minute.

Which time-base setting will display clearly separate pulses on the screen?

A $1\,\text{s cm}^{-1}$ **B** $10\,\text{ms cm}^{-1}$ **C** $100\,\mu\text{s cm}^{-1}$ **D** $1\,\mu\text{s cm}^{-1}$

Additional Materials:

1 What is the order of magnitude of the Young modulus for a metal such as copper?

A 10^{-11} Pa **B** 10^{-4} Pa **C** 10^{4} Pa **D** 10^{11} Pa

2 The force F between two point charges q_1 and q_2, a distance r apart, is given by the equation

$$F = \frac{kq_1q_2}{r^2}$$

where k is a constant.

What are the SI base units of k?

A $\text{kg m}^3\text{ s}^{-4}\text{ A}^2$ **B** $\text{kg m}^3\text{ s}^{-4}\text{ A}^{-2}$ **C** $\text{kg m}^3\text{ A}^2$ **D** $\text{kg m}^3\text{ A}^{-2}$

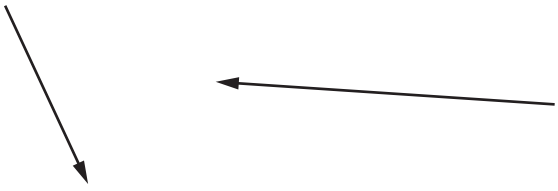
What are the SI base units of γ?

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

3 Vectors P and Q are drawn to scale.

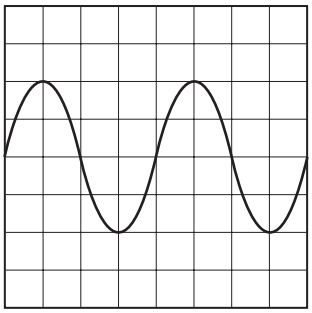
Which diagram represents the vector (P – Q)?

A



B

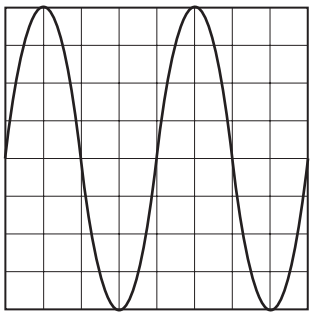
5 The following trace is seen on the screen of a cathode-ray oscilloscope.



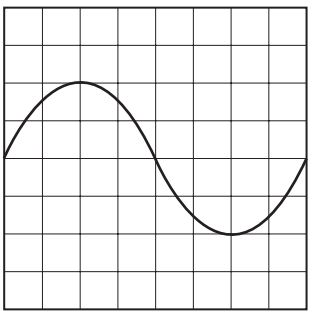
The setting of the time-base is then changed from $10\,\text{ms}\,\text{cm}^{-1}$ to $20\,\text{ms}\,\text{cm}^{-1}$ and the Y-plate sensitivity remains constant.

Which trace is now seen on the screen?

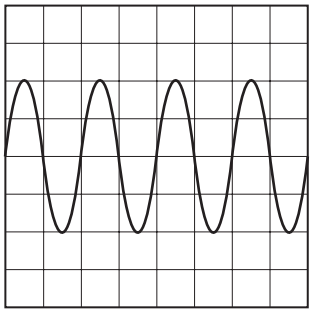
A



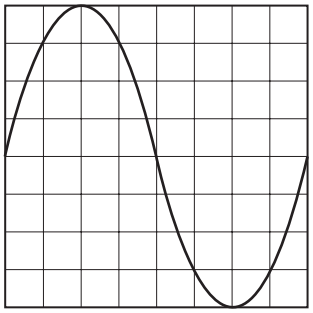
B



C



D



2 The force F between two point charges q_1 and q_2, a distance r apart, is given by the equation

$$F = \frac{kq_1q_2}{r^2}$$

where k is a constant.

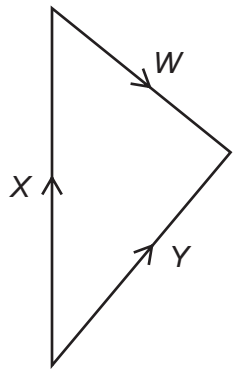
What are the SI base units of k?

A $\text{kg m}^3\text{ s}^{-4}\text{ A}^2$ **B** $\text{kg m}^3\text{ s}^{-4}\text{ A}^{-2}$ **C** $\text{kg m}^3\text{ A}^2$ **D** $\text{kg m}^3\text{ A}^{-2}$

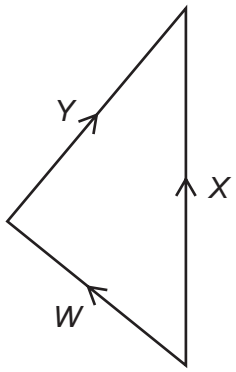
3 An aeroplane can fly at a velocity X when moving through still air. When flying in wind the aeroplane's velocity relative to the ground is Y.

Which vector diagram shows the magnitude and direction of the wind velocity W?

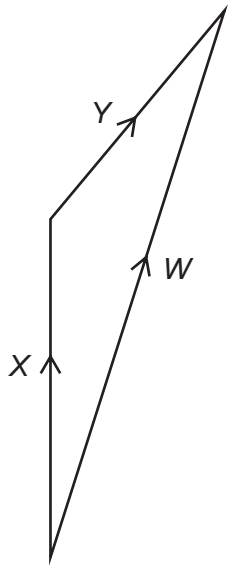
A



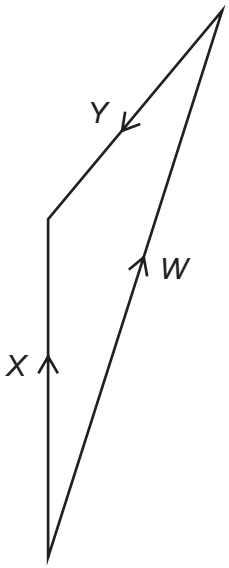
B



C



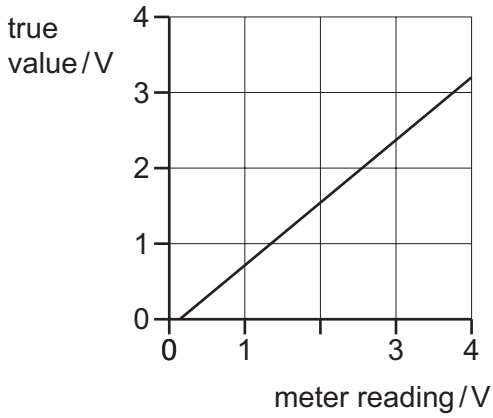
D



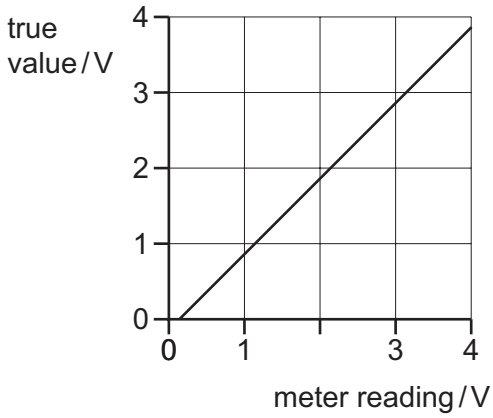
4 A voltmeter gives readings that are larger than the true values and has a systematic error that varies with voltage.

Which graph shows the calibration curve for the voltmeter?

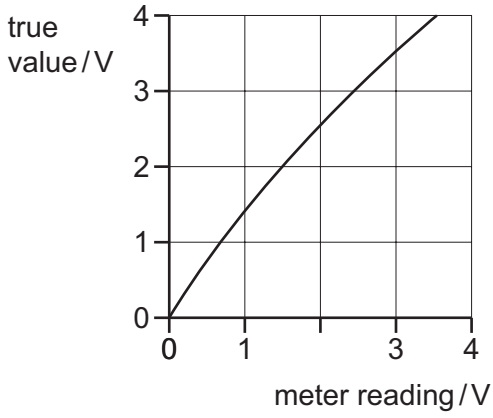
A



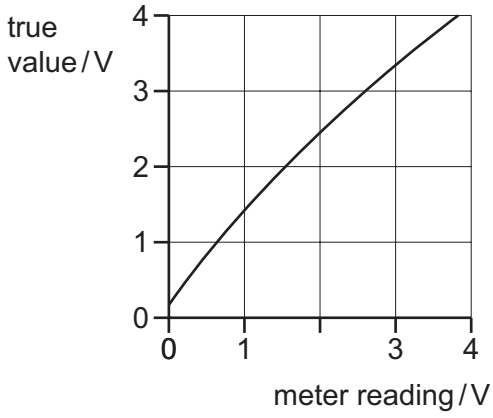
B



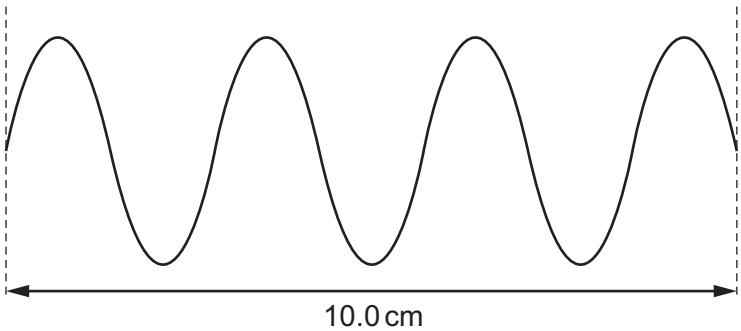
C



D



5 A student uses a cathode-ray oscilloscope (c.r.o.) to measure the period of a signal. She sets the time-base of the c.r.o. to $5\,\text{ms}\,\text{cm}^{-1}$ and observes the trace illustrated below. The trace has a length of 10.0 cm.



What is the period of the signal?

A $7.1 \times 10^{-6}\,\text{s}$ **B** $1.4 \times 10^{-5}\,\text{s}$ **C** $7.1 \times 10^{-3}\,\text{s}$ **D** $1.4 \times 10^{-2}\,\text{s}$

PHYSICS **9702/12**

Paper 1 Multiple Choice **October/November 2016**

1 hour 15 minutes

Additional Materials:

1 Concrete has a density of 2400 kg m^{-3}.

Which mass of concrete fills a rectangular space of dimensions 8.0 cm × 90 cm × 110 cm?

A 79 kg **B** 190 kg **C** 790 kg **D** 1900 kg

2 The speed v of sound in a gas is given by the equation

$$v = \sqrt{\frac{\gamma P}{\rho}}$$

where P is the pressure of the gas, ρ is its density and γ is a constant.

What are the SI base units of γ?

A m^{-1} s **B** m^{3} s^{-3} **C** m^{-4} s^{-4} **D** no units

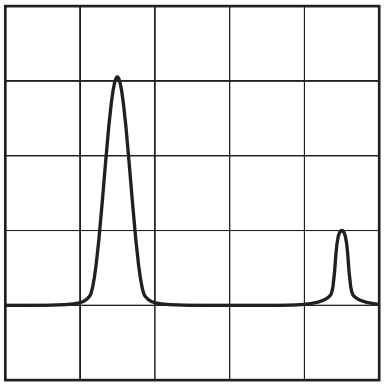
3 The motion of an object moving from rest with a constant acceleration a may be represented by the equation shown.

$$v^2 = 2as$$

Which row describes the quantities represented by the symbols v and s?

	v	s
A	scalar	scalar
B	scalar	vector
C	vector	scalar
D	vector	vector

4 A cathode-ray oscilloscope (c.r.o.) displays a waveform as shown.



The time interval between two adjacent peaks of the waveform is 0.006 s.

What is the time-base setting of the c.r.o.?

A 2 μs / division

B 20 μs / division

C 2 ms / division

D 3 ms / division

5 A value for the acceleration of free fall on Earth is given as $(10 \pm 2)\,\text{m s}^{-2}$.

Which statement is correct?

A The value is accurate but not precise.

B The value is both precise and accurate.

C The value is neither precise nor accurate.

D The value is precise but not accurate.

6 An experiment to determine atmospheric pressure P uses the equation $P = \rho gh$ where

$\rho = (13\,600 \pm 100)\,\text{kg m}^{-3}$,

$g = (9.81 \pm 0.02)\,\text{m s}^{-2}$,

$h = (0.762 \pm 0.005)\,\text{m}$.

What is the value of P, with its uncertainty, when stated to an appropriate number of significant figures?

A $(1.0166 \pm 0.0162) \times 10^5\,\text{Pa}$

B $(1.017 \pm 0.016) \times 10^5\,\text{Pa}$

C $(1.017 \pm 1.6\%) \times 10^5\,\text{Pa}$

D $(1.02 \pm 0.02) \times 10^5\,\text{Pa}$

1 A student creates a table to show reasonable estimates of some physical quantities.

Which row is **not** a reasonable estimate?

	quantity	
A	current in a fan heater	12 A
B	mass of an adult person	70 kg
C	speed of an Olympic sprint runner	$10\,m\,s^{-1}$
D	water pressure at the bottom of a garden pond	10^6 Pa

2 A particle travels in a straight line with speed v.

The particle slows down and changes direction. The new speed of the particle is $\frac{v}{2}$.

The new velocity has a component of $\frac{v}{4}$ in the same direction as the initial path of the particle.

Through which angle has the particle turned?

A 27° **B** 30° **C** 45° **D** 60°

3 The speed v of a liquid leaving a tube depends on the change in pressure ΔP and the density ρ of the liquid. The speed is given by the equation

$$v = k\left(\frac{\Delta P}{\rho}\right)^n$$

where k is a constant that has no units.

What is the value of n?

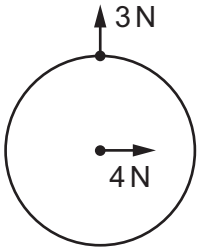
A $\frac{1}{2}$ **B** 1 **C** $\frac{3}{2}$ **D** 2

Additional Materials:

1 What is the approximate average speed of a winning female Olympic athlete running a 100 m race?

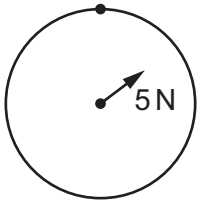
A $6\,m\,s^{-1}$ **B** $9\,m\,s^{-1}$ **C** $12\,m\,s^{-1}$ **D** $15\,m\,s^{-1}$

2 Two forces act on a circular disc as shown.

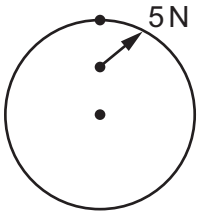


Which diagram shows the line of action of the resultant force?

A

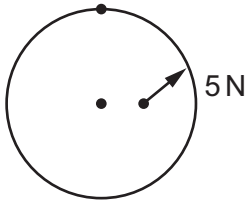


B



C

D



3 What correctly expresses the volt in terms of SI base units?

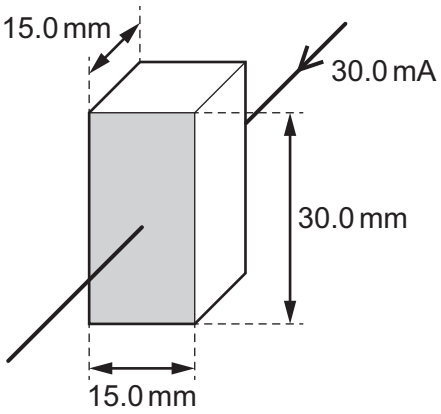
A $A\Omega$

B WA^{-1}

C $kg\,m^2\,s^{-1}\,A^{-1}$

D $kg\,m^2\,s^{-3}\,A^{-1}$

4 The current in a block of semiconductor is 30.0 mA when there is a potential difference (p.d.) of 10.0 V across it. The dimensions of the block and the direction of the current in it are as shown.



The electrical meters used are accurate to ± 0.1 mA and ± 0.1 V. The dimensions of the block are accurate to ± 0.2 mm.

What is the resistivity of the semiconductor?

A 10.0 ± 0.2 Ω m

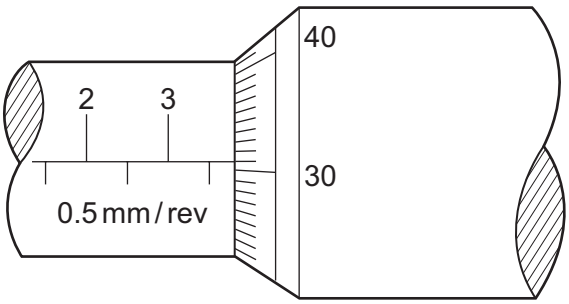
B 10.0 ± 0.3 Ω m

C 10.0 ± 0.5 Ω m

D 10.0 ± 0.8 Ω m

5 The diameter of a cylindrical metal rod is measured using a micrometer screw gauge.

The diagram below shows an enlargement of the scale on the micrometer screw gauge when taking the measurement.



What is the cross-sectional area of the rod?

A 3.81 mm^2 **B** 11.4 mm^2 **C** 22.8 mm^2 **D** 45.6 mm^2

PHYSICS **9702/13**

Paper 1 Multiple Choice **May/June 2017**

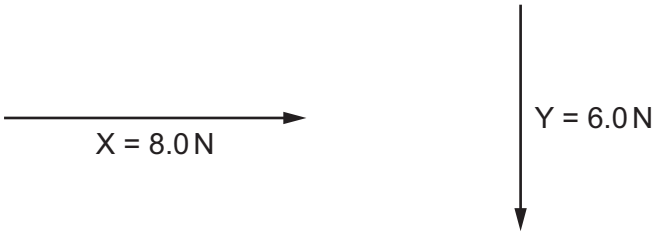
1 hour 15 minutes

Additional Materials:

1 What is the best estimate of the kinetic energy of a family car travelling at $50\,km\,h^{-1}$?

A $1.5 \times 10^3\,J$ **B** $1.5 \times 10^5\,J$ **C** $1.5 \times 10^7\,J$ **D** $1.5 \times 10^9\,J$

2 The diagram shows two vectors X and Y. The vectors are perpendicular to one another.



What is the magnitude and direction of vector (X – Y)?

A 10.0 N at an angle of 37° downwards from the direction of X

B 10.0 N at an angle of 37° upwards from the direction of X

C 14.0 N at an angle of 53° downwards from the direction of X

D 14.0 N at an angle of 53° upwards from the direction of X

3 Which expression using SI base units is equivalent to the volt?

A $kg\,m^2\,s^{-1}\,A^{-1}$

B $kg\,m\,s^{-2}\,A$

C $kg\,m^2\,s^{-1}\,A$

D $kg\,m^2\,s^{-3}\,A^{-1}$

4 A voltage is carefully measured with a high-quality instrument and found to be 2.321 V.

Two students, using two different methods, conclude that the voltage is 2.33 V and 2.344 V respectively.

Which statement is correct?

A 2.33 V is less accurate and less precise than 2.344 V.

B 2.33 V is less accurate and more precise than 2.344 V.

C 2.33 V is more accurate and less precise than 2.344 V.

D 2.33 V is more accurate and more precise than 2.344 V.

Additional Materials:

1 Which SI unit, expressed in base units, is **not** correct?

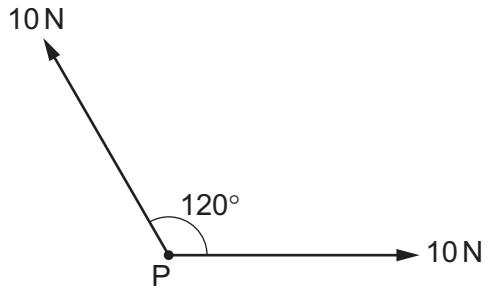
A unit of force, kg m s^{-2}

B unit of momentum, kg m s^{-1}

C unit of pressure, $\text{kg m}^{-2}\text{ s}^{-2}$

D unit of work, $\text{kg m}^{2}\text{ s}^{-2}$

2 Two forces, each of 10 N, act at a point P as shown. The angle between the directions of the forces is 120°.



What is the magnitude of the resultant force?

A 5 N **B** 10 N **C** 17 N **D** 20 N

3 An ion is accelerated in a vacuum by a series of electrodes. A graph of the power supplied to the ion is plotted against time.

What is represented by the area under the graph between two times?

A the average force on the ion

B the change in kinetic energy of the ion

C the change in momentum of the ion

D the change in velocity of the ion

4 What is a typical value of the wavelength of a microwave travelling in a vacuum?

A 3 000 000 pm

B 30 nm

C 30 000 μm

D 3000 mm

5 A double-slit interference experiment is used to determine the wavelength of light from a monochromatic source.

The following measurements are used.

slit separation $a = 0.50 \pm 0.02$ mm

fringe separation $x = 1.7 \pm 0.1$ mm

distance between slits and screen $D = 2.000 \pm 0.002$ m

What is the percentage uncertainty in the calculated wavelength?

A 0.1% **B** 1% **C** 6% **D** 10%

Additional Materials:

1 Which pair of units are **not** the same when expressed in SI base units?

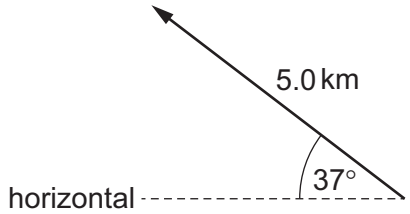
A $m\,s^{-2}$ and $N\,kg^{-1}$

B $N\,s$ and $kg\,m\,s^{-1}$

C Pa and $N\,m^{-2}$

D $V\,m^{-2}$ and $N\,C^{-1}$

2 What is the vertical component of this displacement vector?



A 3.0 km **B** 3.8 km **C** 4.0 km **D** 5.0 km

3 The units of specific heat capacity are $J\,kg^{-1}\,K^{-1}$.

What are the SI base units of specific heat capacity?

A $m\,s^{-2}\,K^{-1}$ **B** $m\,s^{-1}\,K^{-1}$ **C** $m^2\,s^{-2}\,K^{-1}$ **D** $m^2\,s^{-1}\,K^{-1}$

4 A quantity y is to be determined from the equation shown.

$$y = \frac{px}{q^2}$$

The percentage uncertainties in p, x and q are shown.

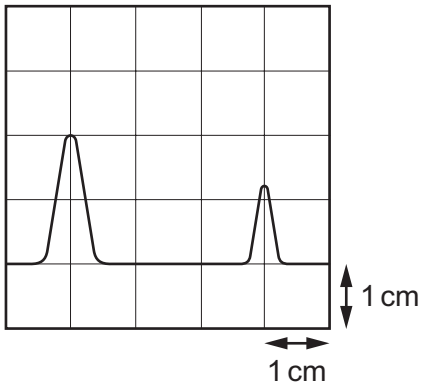
	percentage uncertainty
p	6%
x	2%
q	4%

What is the percentage uncertainty in y?

A 0.5% **B** 0.75% **C** 12% **D** 16%

5 A transmitter emits a pulse of electromagnetic waves towards a reflector. The pulse is reflected and returns to the transmitter.

A detector is located at the transmitter. The emitted pulse and the reflected pulse are displayed on a cathode-ray oscilloscope (c.r.o.) as shown.



The pulse takes 6.3 μs to travel from the transmitter to the reflector.

What is the time-base setting of the c.r.o.?

A 2.1 $\mu s\,cm^{-1}$ **B** 3.2 $\mu s\,cm^{-1}$ **C** 4.2 $\mu s\,cm^{-1}$ **D** 6.3 $\mu s\,cm^{-1}$

Additional Materials:

1 How many cubic nanometres, nm^3, are in a cubic micrometre, μm^3?

A 10^3 **B** 10^6 **C** 10^9 **D** 10^{12}

2 The maximum theoretical power P of a wind turbine is given by the equation

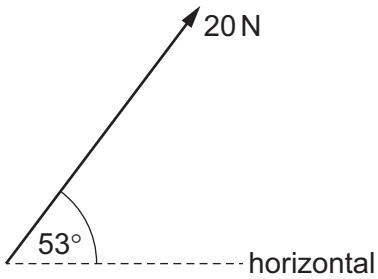
$$P = k\rho A v^n$$

where ρ is the density of air, A is the area swept by the turbine blades, v is the speed of the air and k is a constant with no units.

What is the value of n?

A 1 **B** 2 **C** 3 **D** 4

3 What is the horizontal component of the force shown?



A 12 N **B** 16 N **C** 20 N **D** 27 N

4 A school has a piece of aluminium that it uses for radioactivity experiments. Its thickness is marked as 3.2 mm. A student decides to check this value. He has vernier calipers which give measurements to 0.1 mm and a micrometer which gives measurements to 0.01 mm.

Which statement **must** be correct?

A The micrometer gives a more accurate measurement.

B The micrometer gives a more precise measurement.

C The vernier calipers give a more accurate measurement.

D The vernier calipers give a more precise measurement.

5 Four possible sources of error in a series of measurements are listed.

1 an analogue meter whose scale is read from different angles

2 a meter which always measures 5% too high

3 a meter with a needle that is not frictionless, so the needle sometimes sticks slightly

4 a meter with a zero error

Which errors are random and which are systematic?

	random error	systematic error
A	1 and 2	3 and 4
B	1 and 3	2 and 4
C	2 and 4	1 and 3
D	3 and 4	1 and 2

PHYSICS **9702/11**

Paper 1 Multiple Choice **May/June 2018**

1 hour 15 minutes

Additional Materials:

1 What is a unit for stress?

A $kg\,m^{-1}\,s^{-2}$ **B** $kg\,m^{-2}\,s^{-2}$ **C** $N\,m^{-1}$ **D** $N\,m$

2 Physical quantities can be classed as vectors or as scalars.

Which pair of quantities consists of two vectors?

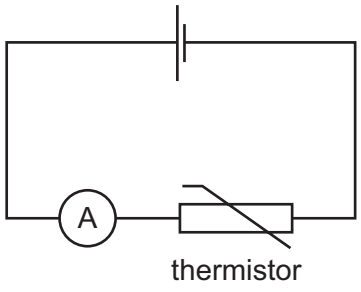
A kinetic energy and force

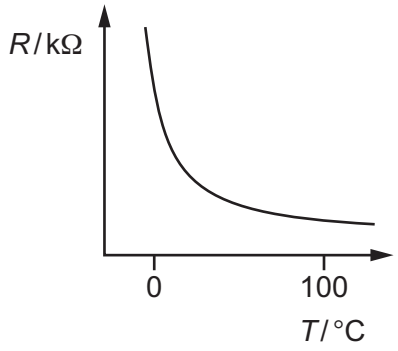
B momentum and time

C velocity and electric field strength

D weight and temperature

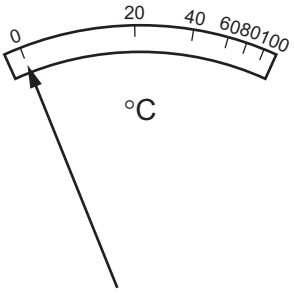
4 In the circuit shown, an analogue ammeter is to be recalibrated as a thermometer. The ammeter is connected in series with a thermistor. The thermistor is a component with a resistance that varies with temperature. The graph shows how the resistance R of the thermistor changes with temperature T.



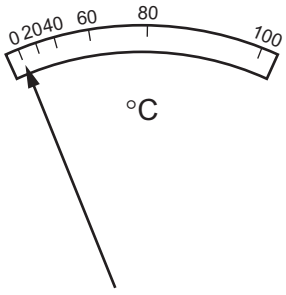


Which diagram could represent the temperature scale on the ammeter?

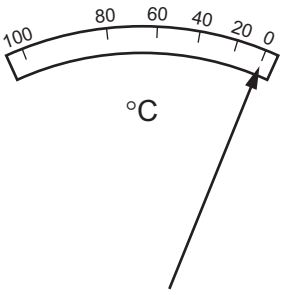
A



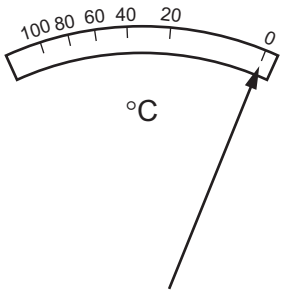
B



C



D



5 The sides of a cube are measured with calipers.

The measured length of each side is (30.0 ± 0.1) mm.

The measurements are used to calculate the volume of the cube.

What is the percentage uncertainty in the calculated value of the volume?

A 0.01% **B** 0.3% **C** 1% **D** 3%

Additional Materials:

1 A sheet of gold leaf has a thickness of 0.125 μm. A gold atom has a radius of 174 pm.

Approximately how many layers of atoms are there in the sheet?

A 4 **B** 7 **C** 400 **D** 700

2 The drag coefficient C_d is a number with no units. It is used to compare the drag on different cars at different speeds. C_d is given by the equation

$$C_d = \frac{2F}{v^n \rho A}$$

where F is the drag force on the car, ρ is the density of the air, A is the cross-sectional area of the car and v is the speed of the car.

What is the value of n?

A 1 **B** 2 **C** 3 **D** 4

3 A student measures the current through a resistor and the potential difference (p.d.) across it. There is a 4% uncertainty in the current reading and a 1% uncertainty in the p.d. reading. The student calculates the resistance of the resistor.

What is the percentage uncertainty in the calculated resistance?

A 0.25% **B** 3% **C** 4% **D** 5%

4 A student applies a potential difference V of (4.0 ± 0.1) V across a resistor of resistance R of $(10.0 \pm 0.3)\,\Omega$ for a time t of (50 ± 1) s.

The student calculates the energy E dissipated using the equation below.

$$E = \frac{V^2 t}{R} = \frac{4.0^2 \times 50}{10.0} = 80\,\text{J}$$

What is the absolute uncertainty in the calculated energy value?

A 1.5 J **B** 3 J **C** 6 J **D** 8 J

Additional Materials:

1 What is the best way of describing a physical quantity?

A a quantity with a magnitude and a direction but no unit

B a quantity with a magnitude and a unit

C a quantity with a magnitude but no direction

D a quantity with a unit but no magnitude

2 Which pair includes a vector quantity and a scalar quantity?

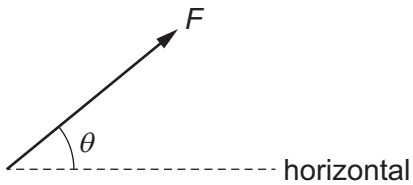
A displacement and acceleration

B force and kinetic energy

C power and speed

D work and potential energy

3 A force F acts at an angle θ to the horizontal.



What are the horizontal and the vertical components of the force?

	horizontal component	vertical component
A	$F\cos\theta$	$F\cos(90° - \theta)$
B	$F\cos\theta$	$F\sin(90° - \theta)$
C	$F\sin\theta$	$F\cos\theta$
D	$F\sin\theta$	$F\cos(90° - \theta)$

4 What will reduce the systematic errors when taking a measurement?

A adjusting the needle on a voltmeter so that it reads zero when there is no potential difference across it

B measuring the diameter of a wire at different points and taking the average

C reducing the parallax effects by using a marker and a mirror when measuring the amplitude of oscillation of a pendulum

D timing 20 oscillations, rather than a single oscillation, when finding the period of a pendulum

5 In an experiment to determine the Young modulus E of the material of a wire, the measurements taken are shown.

mass hung on end of wire	$m = 2.300 \pm 0.002\,\text{kg}$
original length of wire	$l = 2.864 \pm 0.005\,\text{m}$
diameter of wire	$d = 0.82 \pm 0.01\,\text{mm}$
extension of wire	$e = 7.6 \pm 0.2\,\text{mm}$

The Young modulus is calculated using

$$E = \frac{4mgl}{\pi d^2 e}$$

where g is the acceleration of free fall.

The calculated value of E is $1.61 \times 10^{10}\,\text{N m}^{-2}$.

How should the calculated value of E and its uncertainty be expressed?

A (1.61 ± × $10^{10}\,\text{N m}^{-2}$

B (1.61 ± × $10^{10}\,\text{N m}^{-2}$

C (1.61 ± × $10^{10}\,\text{N m}^{-2}$

D (1.61 ± × $10^{10}\,\text{N m}^{-2}$

6 A rock on the surface of Mars is projected vertically upwards with an initial speed of $9.4\,\text{m s}^{-1}$. The rock rises to a height of 12 m above the surface.

Assume there is no atmosphere on Mars.

What is the acceleration of free fall near the surface of Mars?

A $0.39\,\text{m s}^{-2}$ **B** $3.7\,\text{m s}^{-2}$ **C** $7.4\,\text{m s}^{-2}$ **D** $9.8\,\text{m s}^{-2}$

Additional Materials:

1 The radius of the Earth is approximately 6.4×10^6 m, and the radius of the Moon is approximately 1.7×10^6 m. A student wishes to build a scale model of the Solar System in the classroom, using a football of radius 0.12 m to represent the Earth.

Which object would best represent the Moon?

A basketball

B cherry

C golf ball

D tennis ball

2 When a beam of light is incident on a surface, it delivers energy to the surface. The intensity of the beam is defined as the energy delivered per unit area per unit time.

What is the unit of intensity, expressed in SI base units?

A $\text{kg m}^{-2}\text{ s}^{-1}$ **B** $\text{kg m}^{2}\text{ s}^{-3}$ **C** kg s^{-2} **D** kg s^{-3}

3 A ship is travelling with a velocity of 8.0 km h^{-1} in a direction 30° east of north.

What are the components of the ship's velocity in the east and north directions?

	component of velocity in east direction / km h^{-1}	component of velocity in north direction / km h^{-1}
A	4.0	4.0
B	4.0	6.9
C	4.6	6.9
D	6.9	4.0

4 A micrometer screw gauge is used to measure the diameter of a copper wire.

The reading with the wire in position is shown in diagram 1. The wire is removed and the jaws of the micrometer are closed. The new reading is shown in diagram 2.

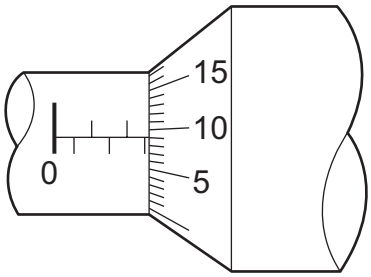


diagram 1

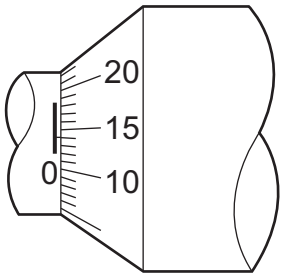


diagram 2

What is the diameter of the wire?

A 1.90 mm **B** 2.45 mm **C** 2.59 mm **D** 2.73 mm

5 A digital meter has an accuracy of ±1%.

The meter is used to measure the current in an electrical circuit.

The reading on the meter varies between 3.04 A and 3.08 A.

What is the value of the current, with its uncertainty?

A (3.06 ± 0.02) A

B (3.06 ± 0.04) A

C (3.06 ± 0.05) A

D (3.06 ± 0.07) A

6 A tennis ball is thrown horizontally in air from the top of a tall building.

The effect of air resistance is **not** negligible.

What happens to the horizontal and to the vertical components of the ball's velocity?

	horizontal component of velocity	vertical component of velocity
A	constant	constant
B	constant	increases at a constant rate
C	decreases to zero	increases at a constant rate
D	decreases to zero	increases to a maximum value

PHYSICS **9702/12**

Paper 1 Multiple Choice **October/November 2018**

1 hour 15 minutes

Additional Materials:

1 A car is travelling at a speed of $20\,m\,s^{-1}$. The table contains values for the kinetic energy and the momentum of the car.

Which values are reasonable estimates?

	kinetic energy / J	momentum / $kg\,m\,s^{-1}$
A	3×10^5	3×10^4
B	3×10^5	5×10^6
C	2×10^7	3×10^4
D	2×10^7	5×10^6

2 What is the unit of resistance when expressed in SI base units?

A $kg\,m^2\,s^{-2}\,A^{-1}$

B $kg\,m^2\,s^{-3}\,A^{-2}$

C $kg\,m\,s^{-2}\,A^{-1}$

D $kg\,m\,s^{-3}\,A^{-1}$

3 Which list contains both scalar and vector quantities?

A acceleration, momentum, velocity, weight

B area, current, force, work

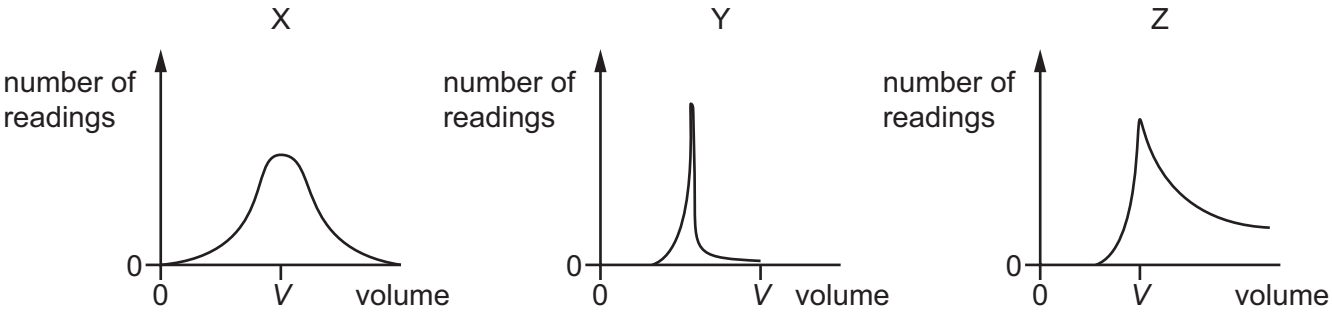
C distance, kinetic energy, power, pressure

D mass, temperature, time, speed

5 Students take readings of the volume of a liquid using three different pieces of measuring equipment X, Y and Z.

The true value of the volume of the liquid is *V*.

The students' results are shown.



How many pieces of equipment are precise and how many are accurate?

	number of precise pieces of equipment	number of accurate pieces of equipment
A	1	
B	1	
C	2	
D	2	

PHYSICS **9702/13**

Paper 1 Multiple Choice **October/November 2018**

1 hour 15 minutes

Additional Materials:

1 Which statement is **not** a reasonable estimate?

A Atmospheric pressure at sea level is about 1×10^5 Pa.

B Light takes 5×10^2 s to reach us from the Sun.

C The frequency of ultraviolet light is 3×10^{12} Hz.

D The lifespan of a man is about 2×10^9 s.

2 Three of these quantities have the same unit.

Which quantity has a different unit?

A $\frac{\text{energy}}{\text{distance}}$

B force

C power $\times$ time

D rate of change of momentum

3 Which group of quantities contains only vectors?

A acceleration, displacement, speed

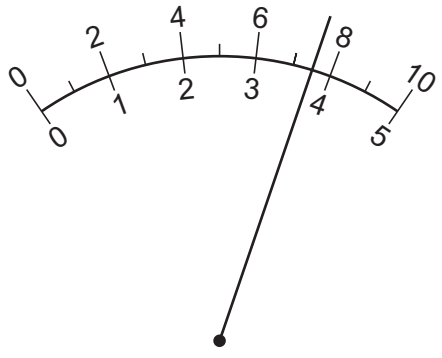
B acceleration, work, electric field strength

C displacement, force, velocity

D power, electric field strength, force

4 An ammeter is calibrated so that it shows a full-scale deflection when it measures a current of 2.0 A.

The diagram shows the display of this ammeter when it is measuring a current.



Which current is the ammeter measuring?

A 0.75 A **B** 1.5 A **C** 3.8 A **D** 7.5 A

5 The width of a table is measured as (50.3 ± 0.1) cm. Its length is measured as (1.40 ± 0.01) m.

What is the area of the table and its absolute uncertainty?

A $(0.7 \pm 0.1)\,m^2$

B $(0.704 \pm 0.006)\,m^2$

C $(0.704 \pm 0.011)\,m^2$

D $(70.4 \pm 0.6)\,m^2$

PHYSICAL QUANTITIES AND UNITS

1. ESTIMATIONS, CRO AND CALIBRATIONS
   9702/02/M/J/08/Q.1, 9702/02/M/J/09/Q.1, 9702/23/M/J/16/Q.1, 9702/21/O/N/09/Q.1, 9702/23/O/N/13/Q.1

2. UNITS AND CONVERSIONS
   9702/22/M/J/09/Q.1, 9702/21/M/J/10/Q.1, 9702/21/M/J/12/Q.1, 9702/22/M/J/13/Q.1, 9702/23/M/J/13/Q.1, 9702/22/M/J/14/Q.1, 9702/23/M/J/14/Q.1, 9702/21/M/J/15/Q.1, 9702/22/M/J/15/Q.1, 9702/23/M/J/15/Q.1, 9702/02/O/N/08/Q.1, 9702/21/O/N/10/Q.1, 9702/21/O/N/13/Q.1, 9702/21/O/N/14/Q.1, 9702/23/O/N/14/Q.1, 9702/21/O/N/15/Q.1, 9702/23/O/N/15/Q.1, 9702/22/O/N/16/Q.1, 9702/21/M/J/17/Q.1, 9702/22/M/J/17/Q.1, 9702/21/O/N/17/Q.1, 9702/23/O/N/17/Q.1, 9702/22/M/J/18/Q.1

3. ERROR AND UNCERTAINITIES
   9702/22/M/J/10/Q.1, 9702/23/M/J/10/Q.1, 9702/21/M/J/11/Q.1, 9702/23/M/J/11/Q.1, 9702/22/M/J/12/Q.1, 9702/21/M/J/13/Q.1, 9702/22/M/J/14/Q.1, 9702/21/M/J/16/Q.1, 9702/23/M/J/16/Q.1, 9702/22/O/N/09/Q.1, 9702/23/O/N/13/Q.1, 9702/21/O/N/14/Q.2, 9702/21/O/N/15/Q.1, 9702/23/O/N/16/Q.1, 9702/22/O/N/17/Q.1, 9702/21/M/J/18/Q.1

Answer **all** the questions in the spaces provided.

For Examiner's Use

1 Make reasonable estimates of the following quantities.

(a) the frequency of an audible sound wave

frequency = ... Hz [1]

(b) the wavelength, in nm, of ultraviolet radiation

wavelength = ... nm [1]

(c) the mass of a plastic 30 cm ruler

mass = ... g [1]

(d) the density of air at atmospheric pressure

density = ... kg m^{-3} [1]

Answer **all** the questions in the spaces provided.

For Examiner's Use

1 **(a)** State the most appropriate instrument, or instruments, for the measurement of the following.

(i) the diameter of a wire of diameter about 1 mm

..... [1]

(ii) the resistance of a filament lamp

..... [1]

(iii) the peak value of an alternating voltage

..... [1]

(b) The mass of a cube of aluminium is found to be 580 g with an uncertainty in the measurement of 10 g. Each side of the cube has a length of (6.0 ± 0.1) cm.

Calculate the density of aluminium with its uncertainty. Express your answer to an appropriate number of significant figures.

density = ... ± ..... $g\,cm^{-3}$ [5]

Answer **all** the questions in the spaces provided.

For Examiner's Use

1 **(a)** Two of the SI base quantities and their units are mass (kg) and length (m).

Name three other SI base quantities and their units.

1. quantity ..... unit .....

2. quantity ..... unit .....

3. quantity ..... unit .....

[3]

(b) The pressure p due to a liquid of density ρ is related to the depth h by the expression

$$p = \rho g h,$$

where g is the acceleration of free fall.

Use this expression to determine the derived units of pressure. Explain your working.

[5]

Answer **all** the questions in the spaces provided.

For Examiner's Use

1 A unit is often expressed with a prefix. For example, the gram may be written with the prefix 'kilo' as the kilogram. The prefix represents a power-of-ten. In this case, the power-of-ten is 10^3.

Complete Fig. 1.1 to show each prefix with its symbol and power-of-ten.

prefix	symbol	power-of-ten
kilo	k	10^3
nano	n	.....
centi	.....	10^{-2}
.....	M	10^6
.....	T	10^{12}

Fig. 1.1

[4]

Answer **all** the questions in the spaces provided.

For Examiner's Use

1 A metal wire has a cross-section of diameter approximately 0.8 mm.

(a) State what instrument should be used to measure the diameter of the wire.

.....[1]

(b) State how the instrument in **(a)** is

(i) checked so as to avoid a systematic error in the measurements,

.....

.....[1]

(ii) used so as to reduce random errors.

.....

.....

.....[2]

[Turn over

5

Answer **all** the questions in the spaces provided.

For Examiner's Use

1 A digital voltmeter with a three-digit display is used to measure the potential difference across a resistor. The manufacturers of the meter state that its accuracy is ±1% and ±1 digit. The reading on the voltmeter is 2.05 V.

(a) For this reading, calculate, to the nearest digit,

(i) a change of 1% in the voltmeter reading,

change = ...V [1]

(ii) the maximum possible value of the potential difference across the resistor.

maximum value = ...V [1]

(b) The reading on the voltmeter has high precision. State and explain why the reading may not be accurate.

.....

.....

.....[2]

4

Answer **all** the questions in the spaces provided.

For Examiner's Use

1 Measurements made for a sample of metal wire are shown in Fig. 1.1.

quantity	measurement	uncertainty
length	1750 mm	± 3 mm
diameter	0.38 mm	± 0.01 mm
resistance	7.5 Ω	± 0.2 Ω

Fig. 1.1

(a) State the appropriate instruments used to make each of these measurements.

(i) length

..... [1]

(ii) diameter

..... [1]

(iii) resistance

..... [1]

(b) (i) Show that the resistivity of the metal is calculated to be $4.86 \times 10^{-7}\,\Omega\,\text{m}$.

[2]

(ii) Calculate the uncertainty in the resistivity.

uncertainty = ± ..... Ω m [4]

5

(c) Use the answers in **(b)** to express the resistivity with its uncertainty to the appropriate number of significant figures.

For Examiner's Use

resistivity = ... ± ..... Ω m [1]

1 **(a)** For each of the following, tick [✓] one box to indicate whether the experimental technique would reduce random error, systematic error or neither. The first row has been completed as an example.

For Examiner's Use

	random error	systematic error	neither
keeping your eye in line with the scale and the liquid level for a single reading of a thermometer		✓	
averaging many readings of the time taken for a ball to roll down a slope			
using a linear scale on an ammeter			
correcting for a non-zero reading when a micrometer screw gauge is closed			

[2]

(b) The measurement of a particular time interval is repeated many times. The readings are found to vary. The results are shown in Fig. 1.1.

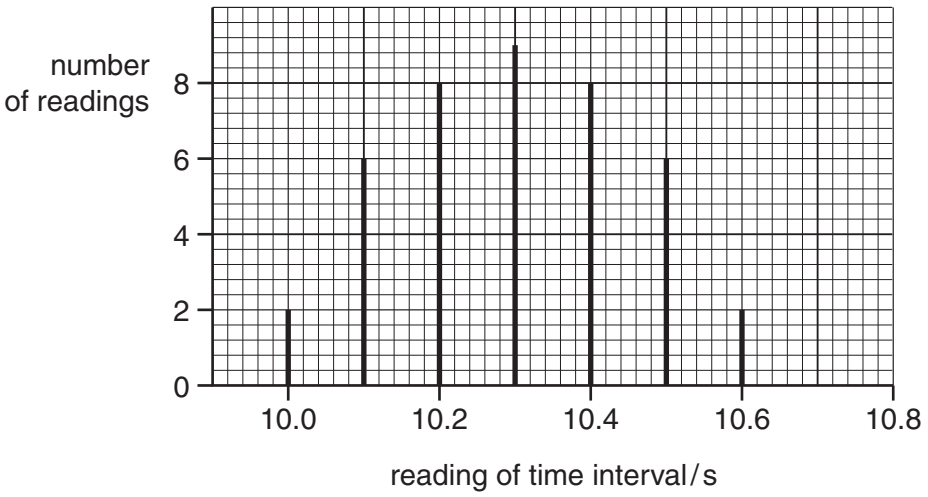


Fig. 1.1

The true value of the time interval is 10.1 s.

5

For Examiner's Use

(i) State how the readings on Fig. 1.1 show the presence of

1. a systematic error,

.....

.....[1]

2. a random error.

.....

.....[1]

(ii) State the expected changes to Fig. 1.1 for experimental measurements that are

1. more accurate,

.....

.....[1]

2. more precise.

.....

.....[1]

[Turn over

5

Answer **all** the questions in the spaces provided.

For Examiner's Use

1 (a) (i) State the SI base units of volume.

base units of volume ..... [1]

(ii) Show that the SI base units of pressure are $kg\,m^{-1}\,s^{-2}$.

[1]

(b) The volume V of liquid that flows through a pipe in time t is given by the equation

$$\frac{V}{t} = \frac{\pi P r^4}{8Cl}$$

where P is the pressure difference between the ends of the pipe of radius r and length l. The constant C depends on the frictional effects of the liquid.

Determine the base units of C.

base units of C ..... [3]

5

Answer **all** the questions in the spaces provided.

For Examiner's Use

1 The volume V of liquid flowing in time t through a pipe of radius r is given by the equation

$$\frac{V}{t} = \frac{\pi P r^4}{8Cl}$$

where P is the pressure difference between the ends of the pipe of length l, and C depends on the frictional effects of the liquid.

An experiment is performed to determine C. The measurements made are shown in Fig. 1.1.

$\frac{V}{t}$ / $10^{-6}\,m^3\,s^{-1}$	$P/10^3\,N\,m^{-2}$	r/mm	l/m
1.20 ± 0.01	2.50 ± 0.05	0.75 ± 0.01	0.250 ± 0.001

Fig. 1.1

(a) Calculate the value of C.

C = ... $N\,s\,m^{-2}$ [2]

(b) Calculate the uncertainty in C.

uncertainty = ... $N\,s\,m^{-2}$ [3]

(c) State the value of C and its uncertainty to the appropriate number of significant figures.

C = ... ± ..... $N\,s\,m^{-2}$ [1]

[Turn over

5

Answer **all** the questions in the spaces provided.

For Examiner's Use

1 Energy is stored in a metal wire that is extended elastically.

(a) Explain what is meant by *extended elastically*.

.....

..... [2]

(b) Show that the SI units of energy per unit volume are $kg\,m^{-1}\,s^{-2}$.

[2]

(c) For a wire extended elastically, the elastic energy per unit volume X is given by

$$X = C\varepsilon^2 E$$

where C is a constant,
ε is the strain of the wire,
and E is the Young modulus of the wire.

Show that C has no units.

[3]

4

Answer **all** the questions in the spaces provided.

For Examiner's Use

1 **(a)** Determine the SI base units of power.

SI base units of power ..... [3]

(b) Fig. 1.1 shows a turbine that is used to generate electrical power from the wind.

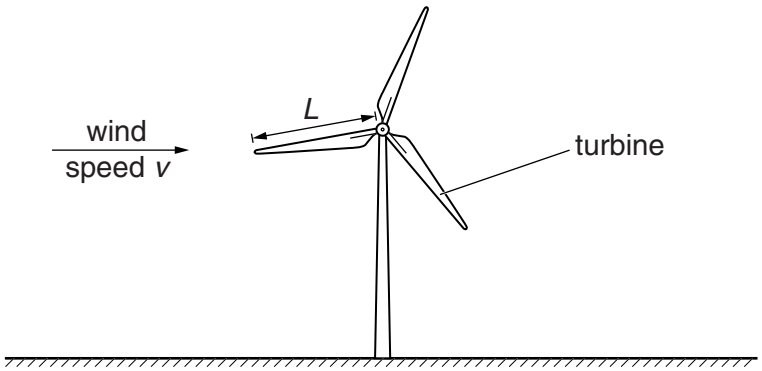


Fig. 1.1

The power P available from the wind is given by

$$P = CL^2\rho v^3$$

where L is the length of each blade of the turbine,
ρ is the density of air,
v is the wind speed,
C is a constant.

(i) Show that C has no units.

[3]

5

(ii) The length L of each blade of the turbine is 25.0 m and the density ρ of air is 1.30 in SI units. The constant C is 0.931.
The efficiency of the turbine is 55% and the electric power output P is 3.50×10^5 W.

For Examiner's Use

Calculate the wind speed.

wind speed = ... $m\,s^{-1}$ [3]

(iii) Suggest two reasons why the electrical power output of the turbine is less than the power available from the wind.

1. .....

.....

2. .....

.....
[2]

4

Answer **all** the questions in the spaces provided.

For Examiner's Use

1 **(a)** State the SI base units of force.

.....[1]

(b) Two wires each of length l are placed parallel to each other a distance x apart, as shown in Fig. 1.1.

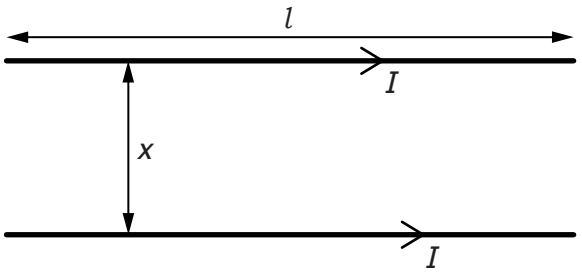


Fig. 1.1

Each wire carries a current I. The currents give rise to a force F on each wire given by

$$F = \frac{KI^2 l}{x}$$

where K is a constant.

(i) Determine the SI base units of K.

units of K ..... [2]

(ii) On Fig. 1.2, sketch the variation with x of F. The quantities I and l remain constant.

Fig. 1.2 [2]

5

(iii) The current I in both of the wires is varied.

On Fig. 1.3, sketch the variation with I of F. The quantities x and l remain constant.

For Examiner's Use

Fig. 1.3 [1]

4

Answer **all** the questions in the spaces provided.

1 **(a)** Show that the SI base units of power are $kg\,m^2\,s^{-3}$.

[3]

(b) The rate of flow of thermal energy $\frac{Q}{t}$ in a material is given by

$$\frac{Q}{t} = \frac{CAT}{x}$$

where A is the cross-sectional area of the material,
T is the temperature difference across the thickness of the material,
x is the thickness of the material,
C is a constant.

Determine the SI base units of C.

base units ..... [4]

2 A coin is made in the shape of a thin cylinder, as shown in Fig. 2.1.

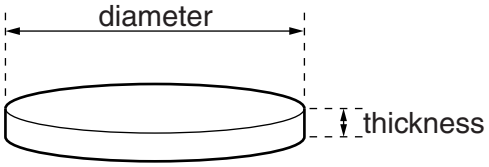


Fig. 2.1

Fig. 2.2 shows the measurements made in order to determine the density ρ of the material used to make the coin.

quantity	measurement	uncertainty
mass	9.6 g	± 0.5 g
thickness	2.00 mm	± 0.01 mm
diameter	22.1 mm	± 0.1 mm

Fig. 2.2

(a) Calculate the density ρ in kg m^{-3}.

ρ = ...kg m^{-3} [3]

(b) (i) Calculate the percentage uncertainty in ρ.

percentage uncertainty = ... [3]

(ii) State the value of ρ with its actual uncertainty.

ρ = ... ± ..... kg m^{-3} [1]

5

Answer **all** the questions in the spaces provided.

1 **(a)** Underline **all** the base quantities in the following list.

ampere charge current mass second temperature weight [2]

(b) The potential energy E_P stored in a stretched wire is given by

$$E_P = \tfrac{1}{2}C\sigma^2 V$$

where C is a constant,
σ is the strain,
V is the volume of the wire.

Determine the SI base units of C.

base units .....[3]

4

Answer **all** the questions in the spaces provided.

1 **(a)** Use the definition of power to show that the SI base units of power are $kg\,m^2\,s^{-3}$.

[2]

(b) Use an expression for electrical power to determine the SI base units of potential difference.

units .....[2]

5

Answer **all** the questions in the spaces provided.

1 **(a)** Use the definition of work done to show that the SI base units of energy are $kg\,m^2\,s^{-2}$.

[2]

(b) Define potential difference.

.....

..... [1]

(c) Determine the SI base units of resistance. Show your working.

units ..... [3]

4

Answer **all** the questions in the spaces provided.

1 **(a)** The distance between the Sun and the Earth is 1.5×10^{11} m. State this distance in Gm.

distance = ... Gm [1]

(b) The distance from the centre of the Earth to a satellite above the equator is 42.3 Mm. The radius of the Earth is 6380 km.
A microwave signal is sent from a point on the Earth directly below the satellite.

Calculate the time taken for the microwave signal to travel to the satellite and back.

time = ... s [2]

(c) The speed v of a sound wave through a gas of density ρ and pressure P is given by

$$v = \sqrt{\frac{CP}{\rho}}$$

where C is a constant.

Show that C has no unit.

[3]

(d) Underline all the scalar quantities in the list below.

acceleration energy momentum power weight [1]

5

(e) A boat travels across a river in which the water is moving at a speed of $1.8\,m\,s^{-1}$. The velocity vectors for the boat and the river water are shown to scale in Fig. 1.1.

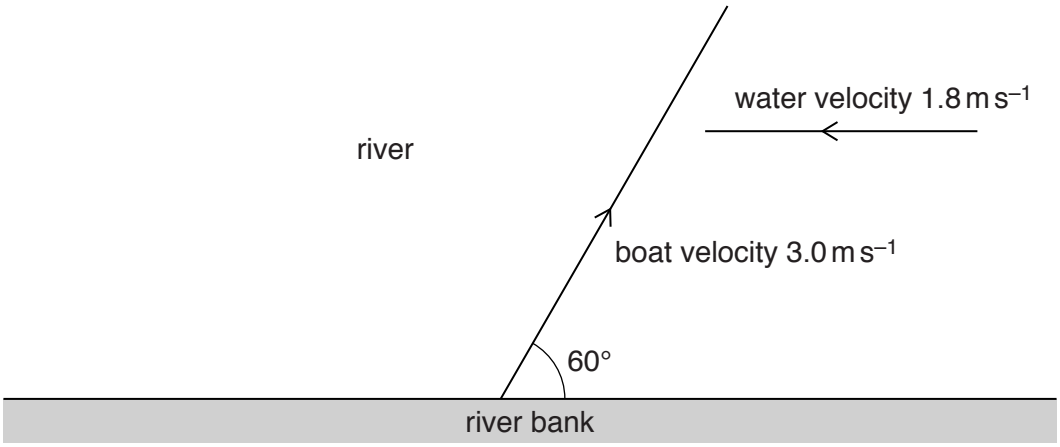


Fig. 1.1 (shown to scale)

In still water the speed of the boat is $3.0\,m\,s^{-1}$. The boat is directed at an angle of 60° to the river bank.

(i) On Fig. 1.1, draw a vector triangle or a scale diagram to show the resultant velocity of the boat. [2]

(ii) Determine the magnitude of the resultant velocity of the boat.

resultant velocity = ... $m\,s^{-1}$ [2]

[Turn over

4

Answer **all** the questions in the spaces provided.

1 **(a)** Make estimates of

(i) the mass, in kg, of a wooden metre rule,

mass = ... kg [1]

(ii) the volume, in cm^3, of a cricket ball or a tennis ball.

volume = ... cm^3 [1]

(b) A metal wire of length L has a circular cross-section of diameter d, as shown in Fig. 1.1.

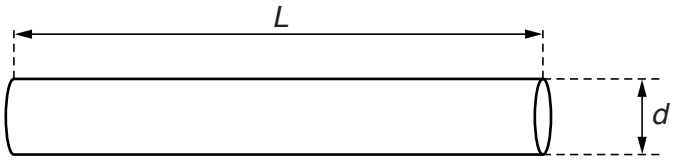


Fig. 1.1

The volume V of the wire is given by the expression

$$V = \frac{\pi d^2 L}{4}.$$

The diameter, length and mass M are measured to determine the density of the metal of the wire. The measured values are:

$d = 0.38 \pm 0.01$ mm,
$L = 25.0 \pm 0.1$ cm,
$M = 0.225 \pm 0.001$ g.

Calculate the density of the metal, with its absolute uncertainty. Give your answer to an appropriate number of significant figures.

density = ... ± ..... $kg\,m^{-3}$ [5]

[Total: 7]

4

Answer **all** the questions in the spaces provided.

1 **(a)** A list of quantities that are either scalars or vectors is shown in Fig. 1.1.

quantity	scalar	vector
distance	✓	
energy		
momentum		
power		
time		
weight		

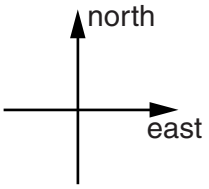
Fig. 1.1

Complete Fig. 1.1 to indicate whether each quantity is a scalar or a vector.

One line has been completed as an example. [2]

(b) A girl runs 120 m due north in 15 s. She then runs 80 m due east in 12 s.

(i) Sketch a vector diagram to show the path taken by the girl. Draw and label her resultant displacement R.



[1]

(ii) Calculate, for the girl,

1. the average speed,

average speed = ... $m\,s^{-1}$ [1]

2. the magnitude of the average velocity v and its angle with respect to the direction of the initial path.

magnitude of v = ... $m\,s^{-1}$

angle = ... °

[3]

[Total: 7]

2 **(a)** Describe the effects, one in each case, of systematic errors and random errors when using a micrometer screw gauge to take readings for the diameter of a wire.

systematic errors: .....

.....

random errors: .....

.....

[2]

(b) Distinguish between precision and accuracy when measuring the diameter of a wire.

precision: .....

.....

accuracy: .....

.....

[2]

[Total: 4]

5

Answer **all** the questions in the spaces provided.

For Examiner's Use

1 **(a)** The current in a wire is I. Charge Q passes one point in the wire in time t. State

(i) the relation between I, Q and t,

..... [1]

(ii) which of the quantities I, Q and t are base quantities.

.....

..... [2]

(b) The current in the wire is due to electrons, each with charge q, that move with speed v along the wire. There are n of these electrons per unit volume.
For a wire having a cross-sectional area S, the current I is given by the equation

$$I = nSqv^k,$$

where k is a constant.

(i) State the units of I, n, S, q and v in terms of the base units.

I .....

n .....

S .....

q .....

v .....
[3]

(ii) By considering the homogeneity of the equation, determine the value of k.

k = ... [2]

4

Answer **all** the questions in the spaces provided.

For Examiner's Use

1 The volume of fuel in the tank of a car is monitored using a meter as illustrated in Fig. 1.1.

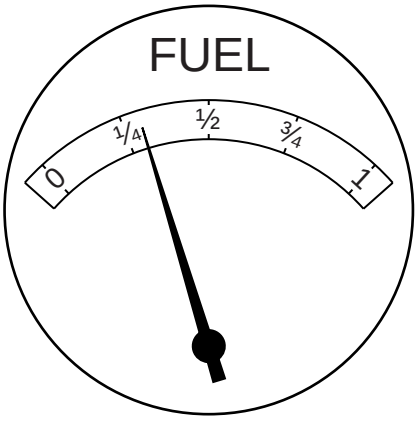


Fig. 1.1

The meter has an analogue scale. The meter reading for different volumes of fuel in the tank is shown in Fig. 1.2.

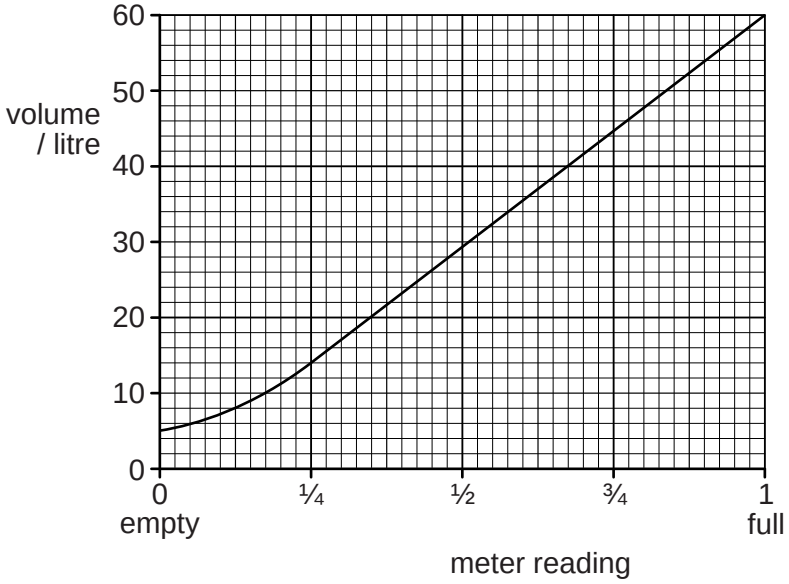


Fig. 1.2

The meter is calibrated in terms of the fraction of the tank that remains filled with fuel.

5

For Examiner's Use

(a) The car uses 1.0 litre of fuel when travelling 14 km. The car starts a journey with a full tank of fuel.

(i) Calculate the volume of fuel remaining in the tank after a journey of 210 km.

volume = ... litres [2]

(ii) Use your answer to **(i)** and Fig. 1.2 to determine the change in the meter reading during the 210 km journey.

from *full* to ..... [1]

(b) There is a systematic error in the meter.

(i) State the feature of Fig. 1.2 that indicates that there is a systematic error.

.....

..... [1]

(ii) Suggest why, for this meter, it is an advantage to have this systematic error.

.....

..... [1]

[Turn over

Answer **all** the questions in the spaces provided.

For Examiner's Use

1 A simple pendulum may be used to determine a value for the acceleration of free fall g. Measurements are made of the length L of the pendulum and the period T of oscillation.

The values obtained, with their uncertainties, are as shown.

$T = (1.93 \pm 0.03)$ s
$L = (92 \pm 1)$ cm

(a) Calculate the percentage uncertainty in the measurement of

(i) the period T,

uncertainty = ... % [1]

(ii) the length L.

uncertainty = ... % [1]

5

(b) The relationship between T, L and g is given by

$$g = \frac{4\pi^2 L}{T^2} .$$

Using your answers in **(a)**, calculate the percentage uncertainty in the value of g.

For Examiner's Use

uncertainty = ... % [1]

(c) The values of L and T are used to calculate a value of g as 9.751 m s^{-2}.

(i) By reference to the measurements of L and T, suggest why it would not be correct to quote the value of g as 9.751 m s^{-2}.

.....

..... [1]

(ii) Use your answer in **(b)** to determine the absolute uncertainty in g.

Hence state the value of g, with its uncertainty, to an appropriate number of significant figures.

g = ... ± ..... m s^{-2} [2]

[Turn over

4

Answer **all** the questions in the spaces provided.

For Examiner's Use

1 **(a)** Two of the SI base quantities are mass and time. State three other SI base quantities.

1. .....

2. .....

3. .....

[3]

(b) A sphere of radius r is moving at speed v through air of density ρ. The resistive force F acting on the sphere is given by the expression

$$F = Br^2\rho v^k$$

where B and k are constants without units.

(i) State the SI base units of F, ρ and v.

F .....

ρ .....

v .....

[3]

(ii) Use base units to determine the value of k.

$k =$ ..... [2]

4

Answer **all** the questions in the spaces provided.

For Examiner's Use

1 **(a)** State two SI base units other than the kilogram, metre and second.

1. .....

2. .....

[2]

(b) A metal wire has original length l_0. It is then suspended and hangs vertically as shown in Fig. 1.1.

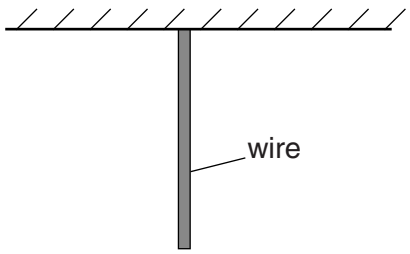


Fig. 1.1

The weight of the wire causes it to stretch. The elastic potential energy stored in the wire is E.

(i) Show that the SI base units of E are $\text{kg m}^2\text{ s}^{-2}$.

[2]

5

(ii) The elastic potential energy E is given by

$$E = C\rho^2 g^2 A l_0^3$$

where ρ is the density of the metal,
g is the acceleration of free fall,
A is the cross-sectional area of the wire
and C is a constant.

Determine the SI base units of C.

For Examiner's Use

SI base units of C .....[3]

Answer **all** the questions in the spaces provided.

For Examiner's Use

1 A cylindrical disc is shown in Fig. 1.1.

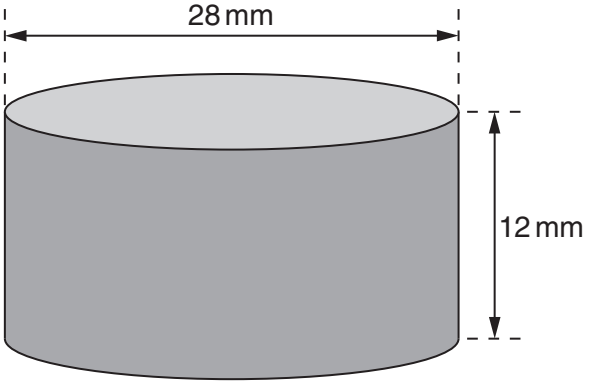


Fig. 1.1

The disc has diameter 28 mm and thickness 12 mm.
The material of the disc has density 6.8×10^3 kg m^{-3}.

Calculate, to two significant figures, the weight of the disc.

weight = ... N [4]

2 The time T for a satellite to orbit the Earth is given by

$$T = \sqrt{\left(\frac{KR^3}{M}\right)}$$

where R is the distance of the satellite from the centre of the Earth,
M is the mass of the Earth,
and K is a constant.

For Examiner's Use

(a) Determine the SI base units of K.

SI base units of K ..... [2]

(b) Data for a particular satellite are given in Fig. 2.1.

quantity	measurement	uncertainty
T	8.64×10^4 s	± 0.5%
R	4.23×10^7 m	± 1%
M	6.0×10^{24} kg	± 2%

Fig. 2.1

Calculate K and its actual uncertainty in SI units.

K = ... ± ..... SI units [4]

4

Answer **all** the questions in the spaces provided.

1 **(a)** Mass, length and time are SI base quantities.
State two other base quantities.

1. .....

2. .....
[2]

(b) A mass *m* is placed on the end of a spring that is hanging vertically, as shown in Fig. 1.1.

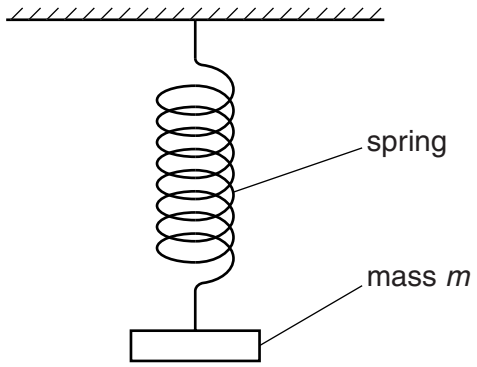


Fig. 1.1

The mass is made to oscillate vertically. The time period of the oscillations of the mass is *T*.

The period *T* is given by

$$T = C\sqrt{\frac{m}{k}}$$

where *C* is a constant and *k* is the spring constant.

Show that *C* has no units.

[3]

2 **(a)** Define *pressure*.

..... [1]

(b) A cylinder is placed on a horizontal surface, as shown in Fig. 2.1.

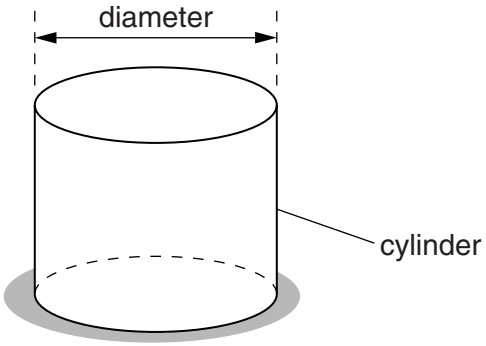


Fig. 2.1

The following measurements were made on the cylinder:

mass = 5.09 ± 0.01 kg
diameter = 9.4 ± 0.1 cm.

(i) Calculate the pressure produced by the cylinder on the surface.

pressure = ... Pa [3]

(ii) Calculate the actual uncertainty in the pressure.

actual uncertainty = ... Pa [3]

(iii) State the pressure, with its actual uncertainty.

pressure = ... ± ..... Pa [1]

Answer **all** the questions in the spaces provided.

1 **(a)** The kilogram, metre and second are SI base units.

State two other base units.

1. .....

2. .....
[2]

(b) Determine the SI base units of

(i) stress,

SI base units .....[2]

(ii) the Young modulus.

SI base units .....[1]

4

Answer **all** the questions in the spaces provided.

1 **(a)** State two SI base quantities other than mass, length and time.

1. .....

2. .....

[2]

(b) A beam is clamped at one end and an object X is attached to the other end of the beam, as shown in Fig. 1.1.

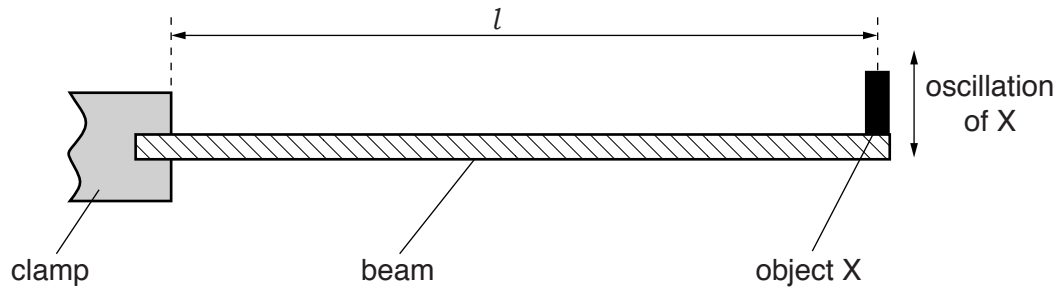


Fig. 1.1

The object X is made to oscillate vertically.

The time period T of the oscillations is given by

$$T = K\sqrt{\frac{Ml^3}{E}}$$

where M is the mass of X,
l is the length between the clamp and X,
E is the Young modulus of the material of the beam
and K is a constant.

(i) **1.** Show that the SI base units of the Young modulus are $kg\,m^{-1}\,s^{-2}$.

[1]

2. Determine the SI base units of K.

SI base units of K ..... [2]

(ii) Data in SI units for the oscillations of X are shown in Fig. 1.2.

quantity	value	uncertainty
T	0.45	± 2.0%
l	0.892	± 0.2%
M	0.2068	± 0.1%
K	1.48×10^5	± 1.5%

Fig. 1.2

Calculate E and its actual uncertainty.

E = ... ± ..... kg m^{-1} s^{-2} [4]

[Turn over

4

Answer **all** the questions in the spaces provided.

1 **(a)** The intensity of a progressive wave is defined as the average power transmitted through a surface per unit area.

Show that the SI base units of intensity are $kg\,s^{-3}$.

[2]

(b) **(i)** The intensity I of a sound wave is related to the amplitude x_0 of the wave by

$$I = K\rho c f^2 x_0^2$$

where ρ is the density of the medium through which the sound is passing,
c is the speed of the sound wave,
f is the frequency of the sound wave
and K is a constant.

Show that K has no units.

[2]

5

(ii) Calculate the intensity, in pW m^{-2}, of a sound wave where

$K = 20$,
$\rho = 1.2$ in SI base units,
$c = 330$ in SI base units,
$f = 260$ in SI base units
and $x_0 = 0.24\,\text{nm}$.

intensity = ...pW m^{-2} [3]

5

Answer **all** the questions in the spaces provided.

1 (a) (i) Define *pressure*.

.....

.....[1]

(ii) Show that the SI base units of pressure are $kg\,m^{-1}\,s^{-2}$.

[1]

(b) Gas flows through the narrow end (nozzle) of a pipe. Under certain conditions, the mass m of gas that flows through the nozzle in a short time t is given by

$$\frac{m}{t} = kC\sqrt{\rho P}$$

where k is a constant with no units,
C is a quantity that depends on the nozzle size,
ρ is the density of the gas arriving at the nozzle,
P is the pressure of the gas arriving at the nozzle.

Determine the base units of C.

base units .....[3]

[Total: 5]

5

Answer **all** the questions in the spaces provided.

1 **(a)** Define *density*.

.....

.....[1]

(b) The mass m of a metal sphere is given by the expression

$$m = \frac{\pi d^3 \rho}{6}$$

where ρ is the density of the metal and d is the diameter of the sphere.

Data for the density and the mass are given in Fig. 1.1.

quantity	value	uncertainty
ρ	$8100\,\text{kg}\,\text{m}^{-3}$	± 5%
m	7.5 kg	± 4%

Fig. 1.1

(i) Calculate the diameter d.

d = ... m [1]

(ii) Use your answer in **(i)** and the data in Fig. 1.1 to determine the value of d, with its absolute uncertainty, to an appropriate number of significant figures.

d = ... ± ..... m [3]

[Total: 5]