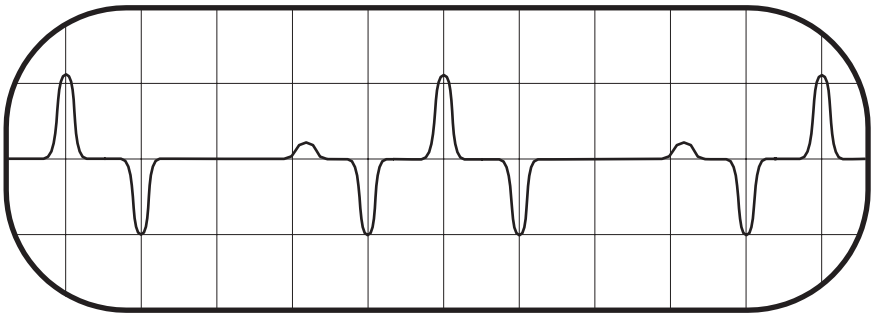
Measurement Techniques

TOPIC QUESTIONS (2)

Level	AS Level
Subject	Physics
Exam Board	CIE
Paper Type	Multiple Choice

Time Allowed : 1Hour 10Min

1. 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

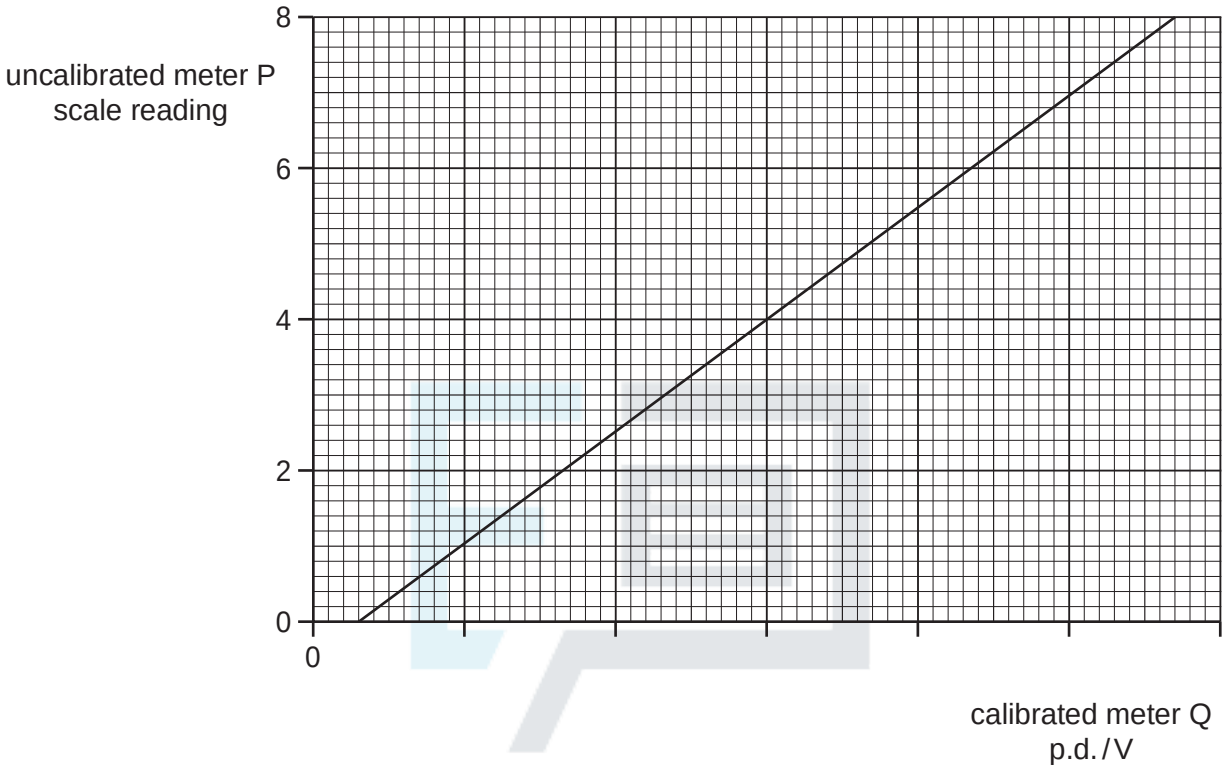
2 A micrometer screw gauge is used to measure the diameter of a small uniform steel sphere. The micrometer reading is 5.00 mm ± 0.01 mm.

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%

3 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

4.

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%

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

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

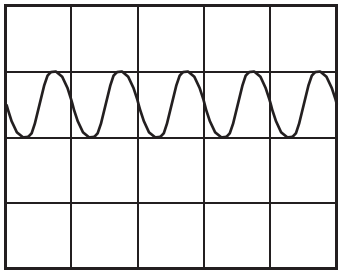
What is the uncertainty in the calculated value for g?

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



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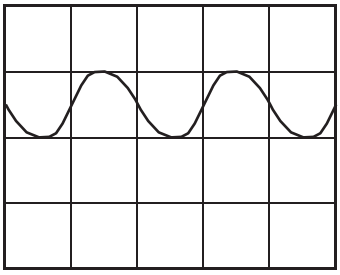

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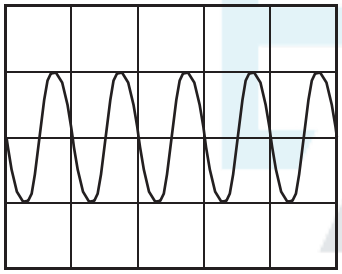

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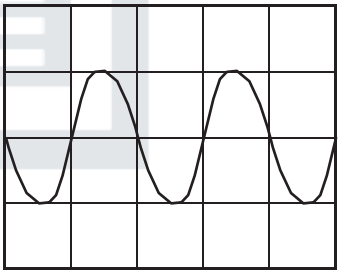


7. A student carried out an experiment in which an electric current was known to decrease with time. The readings he found, from first to last, were 3.62 mA, 2.81 mA, 1.13 mA, 1.76 mA and 0.90 mA.

Which statement could not explain the anomalous 1.13 mA reading?

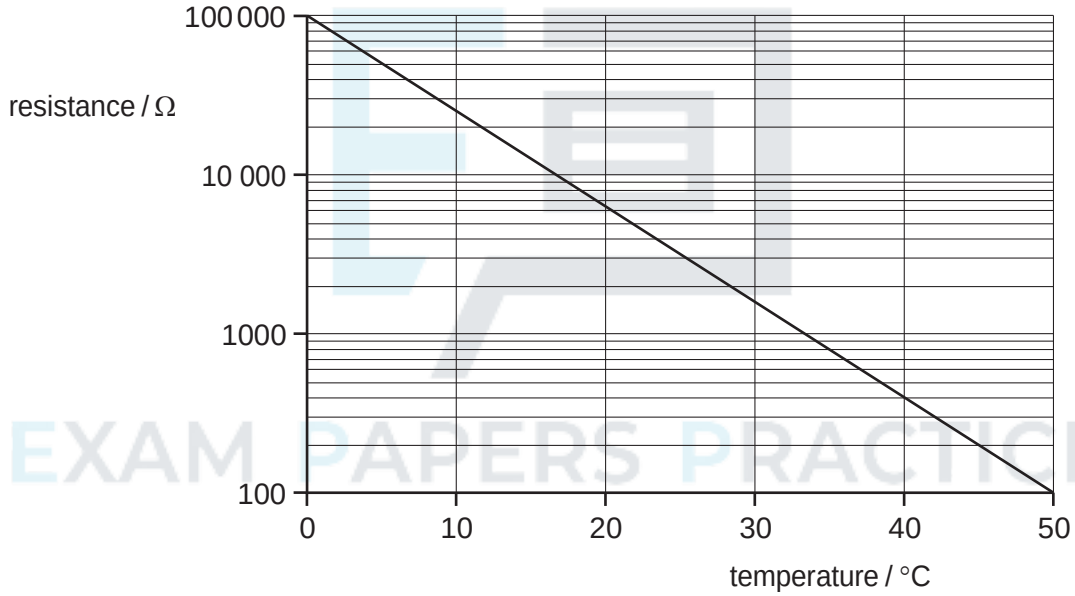
A He has reversed the third and fourth readings in the results table.

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.

8. 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

9. 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.

10. A steel rule can be read to the nearest millimetre. It is used to measure the length of a bar whosetrue length is 895 mm. Repeated measurements give the following readings.

length / mm	892, 891, 892, 891, 891, 892

Are the readings accurate and precise to within 1 mm?

	results are accurate to within 1 mm	results are precise to within 1 mm
A	no	no
B	no	yes
C	yes	no
D	yes	yes

11. A student carries out a series of determinations of the acceleration of free fall *g*. The table shows the results.

g/m s^{-2}
4.91
4.89
4.88
4.90
4.93
4.92

What can be said about this experiment?

A It is accurate and precise.

B It is accurate but not precise.

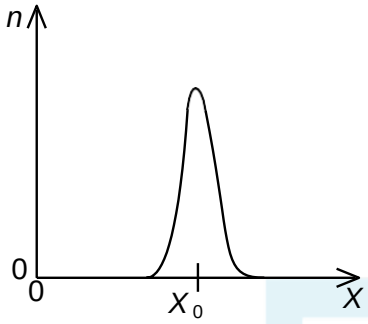
C It is not accurate and not precise.

D It is not accurate but is precise.

12. A quantity X is measured many times. A graph is plotted showing the number n of times a particular value of X is obtained. X has a true value X_0.

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

A



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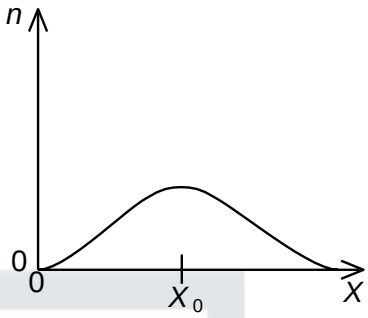

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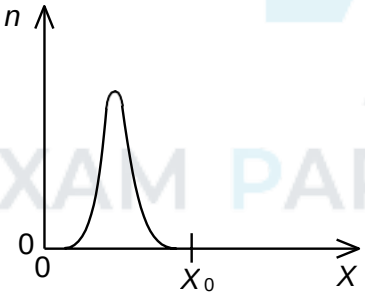
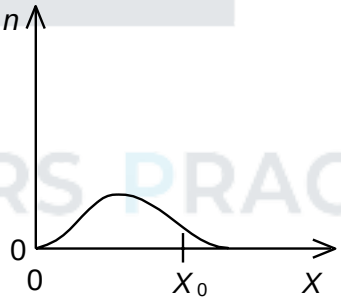
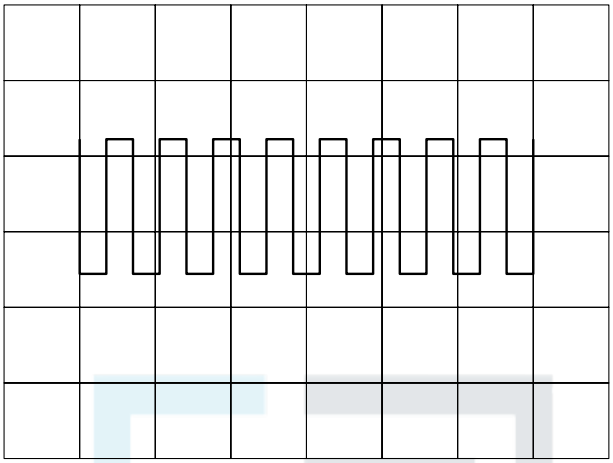


D



13. 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

14. A steel wire is stretched in an experiment to determine the Young modulus for steel.

The uncertainties in the measurements are given below.

measurement	uncertainty
load on wire	±2%
length of wire	±0.2%
diameter of wire	±1.5%
extension	±1%

What is the percentage uncertainty in the Young modulus?

A 1.3% B 1.8% C 4.7% D 6.2%

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

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

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

16. 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	$2.043 \pm 0.002\,\text{m}$
B	diameter of wire	d	$0.54 \pm 0.02\,\text{mm}$
C	force applied	F	$19.62 \pm 0.01\,\text{N}$
D	extension of wire with force applied	x	$5.2 \pm 0.2\,\text{mm}$

17. The speed v of waves in deep water is given by the equation

$$v^2 = \frac{g\lambda}{2\pi}$$

where λ is the wavelength of the waves and g is the acceleration of free fall.

A student measures the wavelength λ and the frequency f of a number of these waves.

Which graph should he plot to give a straight line through the origin?

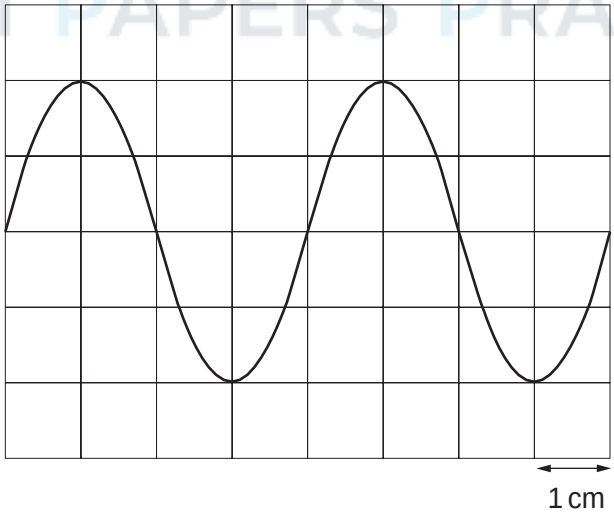
A f^2 against λ

B f against λ^2

C f against $\frac{1}{\lambda}$

D f^2 against $\frac{1}{\lambda}$

18. A sound wave is displayed on the screen of a cathode-ray oscilloscope. The time base of the c.r.o. is set at 2.5 ms / cm.



What is the frequency of the sound wave?

A 50 Hz **B** 100 Hz **C** 200 Hz **D** 400 Hz

19. The measurement of a physical quantity may be subject to random errors and to systematic errors.

Which statement is correct?

A Random errors can be reduced by taking the average of several measurements.
B Random errors are always caused by the person taking the measurement.
C A systematic error cannot be reduced.
D A systematic error results in a different reading each time the measurement is taken.

20. An experiment is done to measure the resistance of a wire. The current in the wire is 1.0 ± 0.2 A and the potential difference across the wire is 8.0 ± 0.4 V.

What is the resistance of the wire and its uncertainty? A (8.0 ± 0.2) Ω B (8.0 ± 0.6) Ω
C (8 ± 1) Ω D (8 ± 2) Ω

21. Which is a pair of SI base units?

A ampere joule B coulomb second
C kilogram Kelvin D metre newton

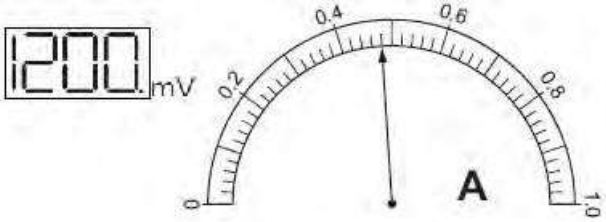
22. What is the ratio ? $\frac{1\mu m}{1Gm}$

A 10^{-3} B 10^{-9} C 10^{-12} D 10^{-15}

23. Which formula could be correct for the speed v of ocean waves in terms of the density ρ of seawater, the acceleration of free fall g, the depth h of the ocean and the wavelength λ?

A $v = \sqrt{g\lambda}$ B $v = \sqrt{\frac{g}{h}}$ C $v = \sqrt{\rho g h}$ D $v = \sqrt{\frac{g}{\rho}}$

24. The resistance of an electrical component is measured. The following meter readings are obtained.



What is the resistance?
A 2.5 Ω B 2.7 Ω C 2500 Ω D 2700 Ω

25. The equation relating pressure and density is p = ρgh
How can both sides of this equation be written in terms of base units?

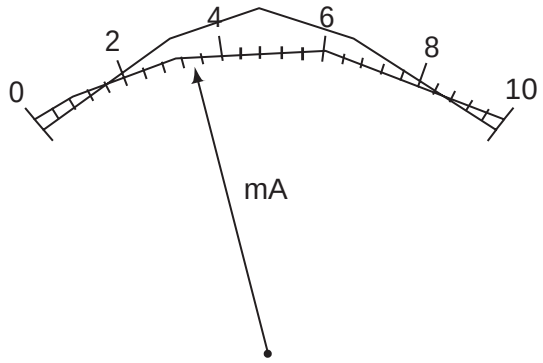
A $[N m^{-1}] = [kg m^{-3}] [m s^{-1}] [m]$
B $[N m^{-2}] = [kg m^{-3}] [m s^{-2}] [m]$
C $[kg m^{-1} s^{-2}] = [kg m^{-3}] [m s^{-2}] [m]$
D $[kg m^{-1} s^{-1}] = [kg m^{-1}] [m s^{-2}] [m]$

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

Which student obtained a set of results that could be described as precise but not accurate?

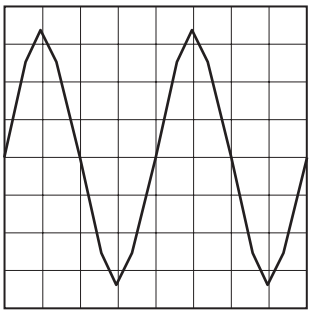
student	results, g / m s^{-2}			
A	9.81	9.79	9.84	9.83
B	9.81	10.12	9.89	8.94
C	9.45	9.21	8.99	8.76
D	8.45	8.46	8.50	8.41

27. What is the reading shown on this milliammeter?



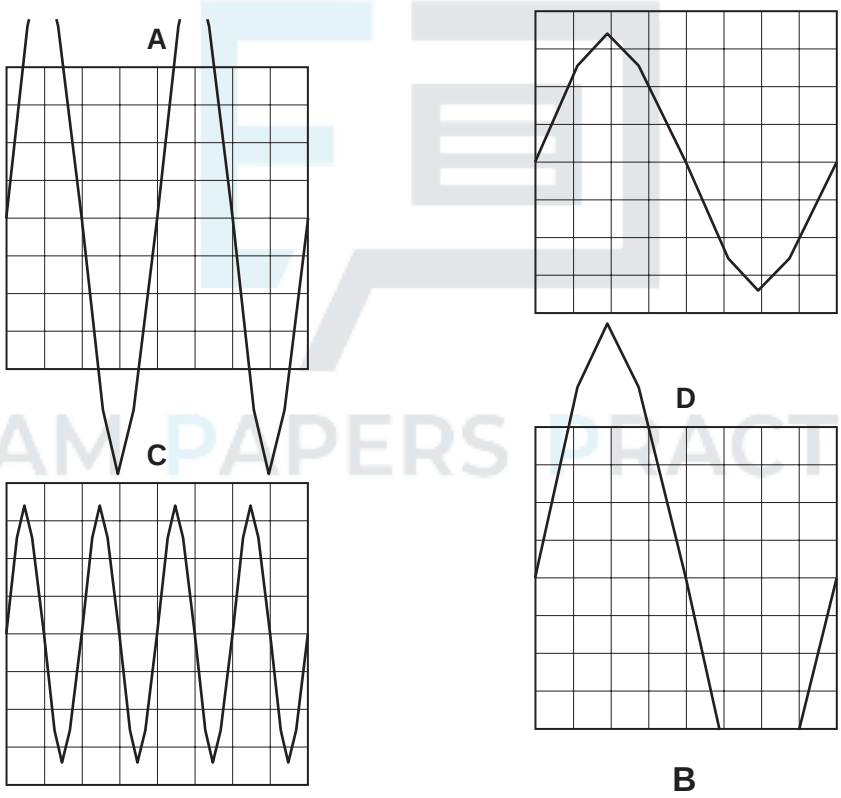
A 2.35 mA B 2.7 mA C 3.4 mA D 3.7 mA

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



The setting of the time base is then changed from 10 ms cm^{-1} to 20 ms cm^{-1} and the Y-sensitivity is unaltered.

Which trace is now seen on the screen?



29. 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%

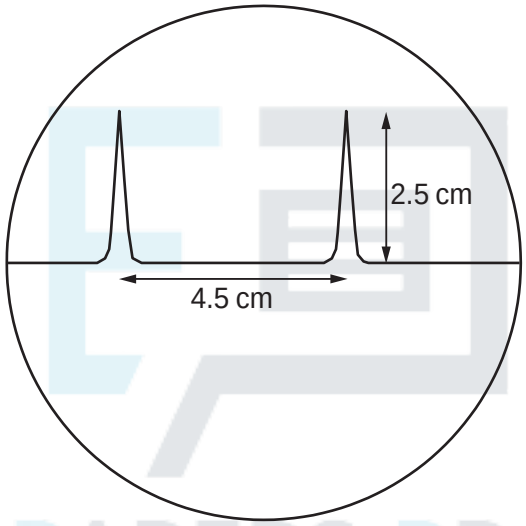
30. A thermometer can be read to an accuracy of ±0.5 °C. This thermometer is used to measure a temperature rise from 40 °C to 100 °C.

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

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

31. 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

32. 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.

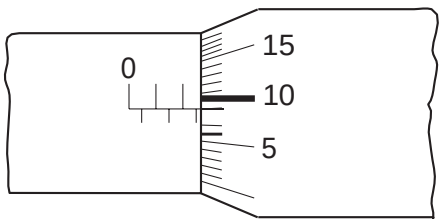


diagram 1

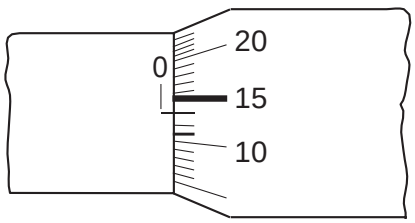


diagram 2

What is the diameter of the wire?

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

33. Which experimental technique reduces the systematic error of the quantity being investigated?

A adjusting an ammeter to remove its zero error before measuring a current

B measuring several internodal distances on a standing wave to find the mean internodaldistance

C measuring the diameter of a wire repeatedly and calculating the average

D timing a large number of oscillations to find a period

34. A student makes measurements from which she calculates the speed of sound as 327.66 $m\,s^{-1}$.She estimates that her result is accurate to ±3 %.

Which of the following gives her result expressed to the appropriate number of significant figures?

A 327.7 $m\,s^{-1}$ **B** 328 $m\,s^{-1}$ **C** 330 $m\,s^{-1}$ **D** 300 $m\,s^{-1}$

35. 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 differenceacross 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 amplitudeof oscillation of a pendulum

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

36. In an experiment to determine the acceleration of free fall g, the time t taken for a ball to fall through distance s was measured. The uncertainty in the measurement of s is estimated to be 2 %. The uncertainty in the measurement of t is estimated to be 3 %.

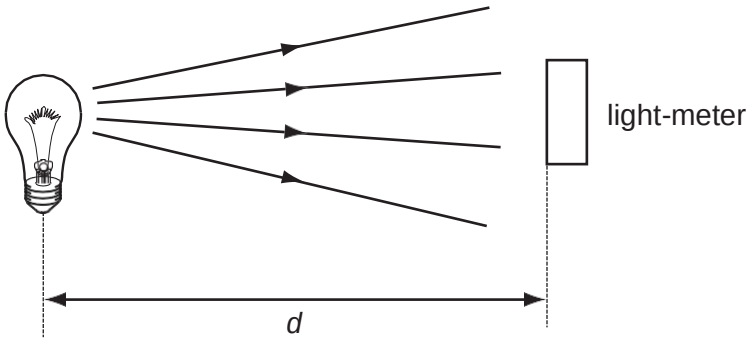
The value of g is determined using the equation

$$g = \frac{2s}{t^2}.$$

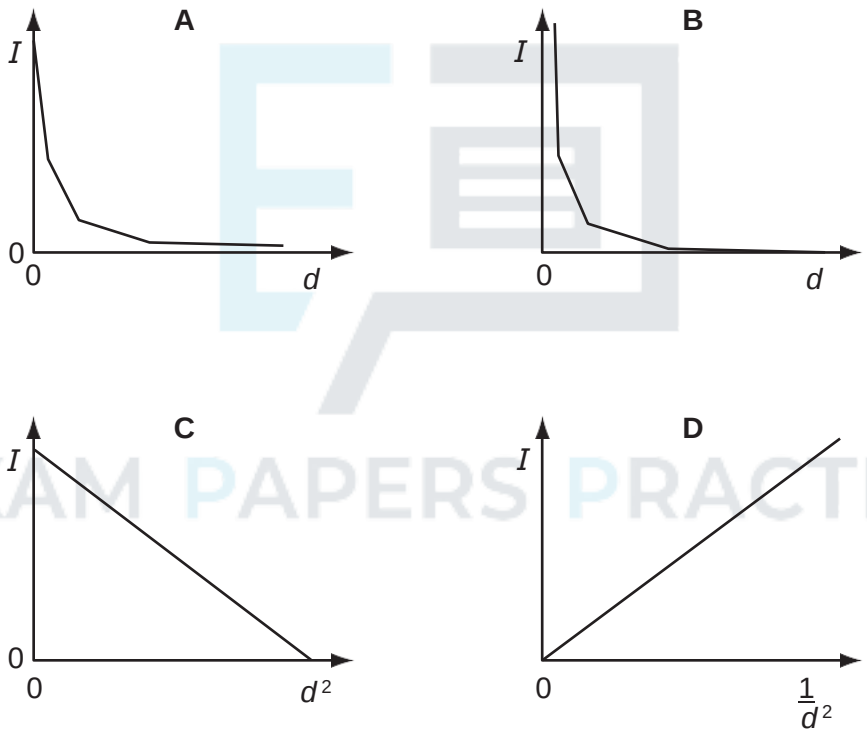
What is the uncertainty in the calculated value of g?

A 1 % B 5 % C 8 % D 11 %

37. 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?



38. 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 $16 \pm 1\,m\,s^{-1}$

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

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

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

39. In an experiment to determine the acceleration of free fall using a falling body, what would lead to a value that is too large?

A air resistance

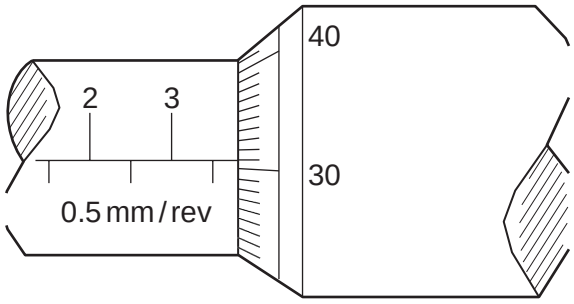
B dimensions of the body are too large

C measured distance longer than true distance

D measured time longer than true time

40. 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 $45.6\,mm^2$

41. 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.	0.73	0.59	0.64

Which statement best relates to the experiment?

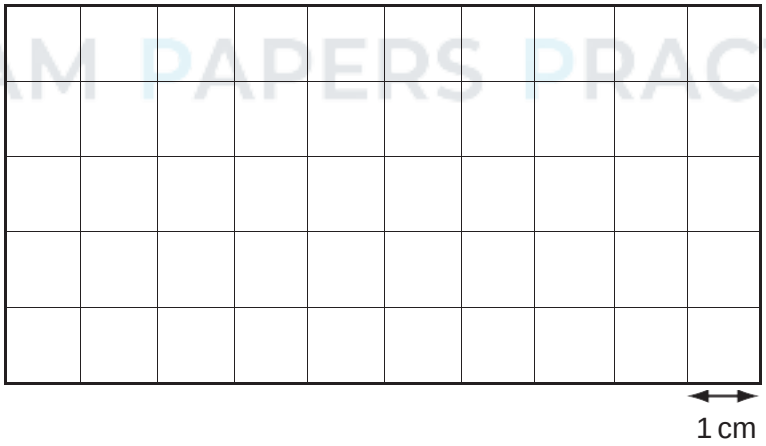
A The measurements are precise and accurate with no evidence of random errors.

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.

42. 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 $1\,\mu s\,cm^{-1}$.



How long does each pulse last?

A 2 µs B 3 µs C 4 µs D 6 µs

43. 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	$m^2\ s^{-2}$
B	m^2	$m\ s^{-2}$
C	m^2	$m^3\ s^{-2}$
D	m^3	ms^{-2}

44. 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

45. 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

46. 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.

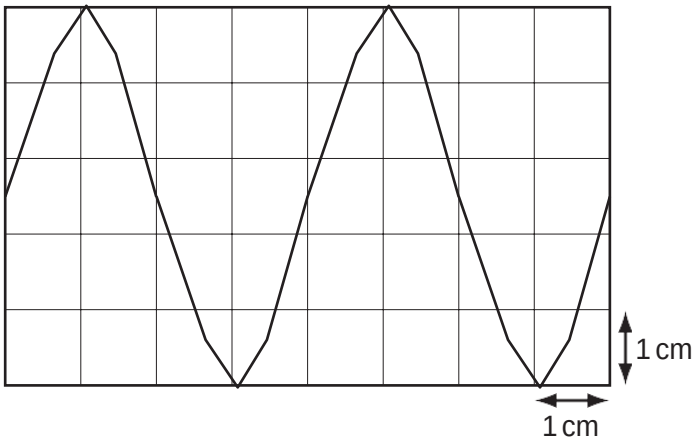
b. The driver's eye is not always in the same position in relation to the pointer.

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.

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

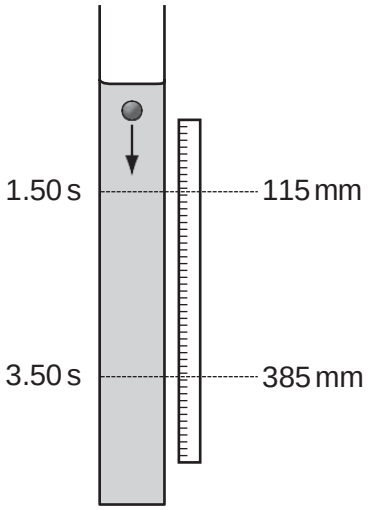
The vertical and horizontal gridlines have a spacing of 1.0 cm. The voltage scaling is 4 V cm^{-1} and the time scaling is 5 ms cm^{-1}.



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

48. 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 $\frac{1}{270} \div \frac{0.02}{2.00}$

49. 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

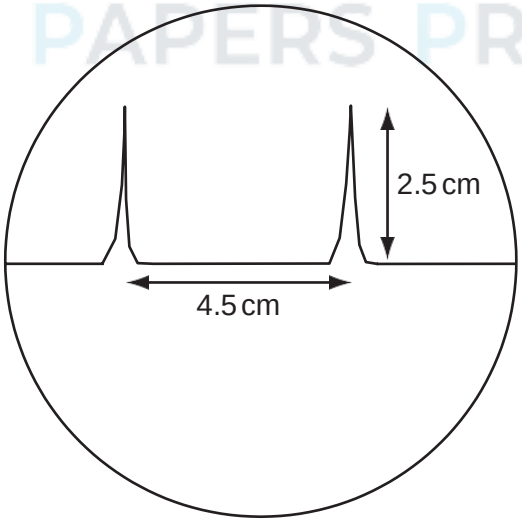
6 mass of trolley using a balance measuring to the nearest 10 g = 6×10^{-2} kg

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

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

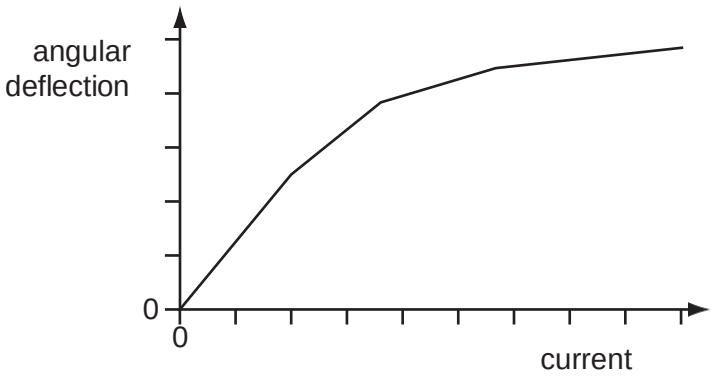
A trace consisting of two pulses is recorded as shown in the diagram.



What is the time interval between the two pulses?

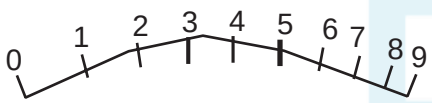
A 0.42 ms B 0.75 ms C 1.33 ms D 27 ms

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

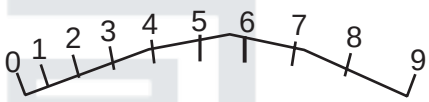


Which diagram could represent the appearance of the scale on this meter?

A

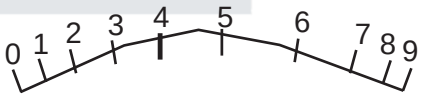


B

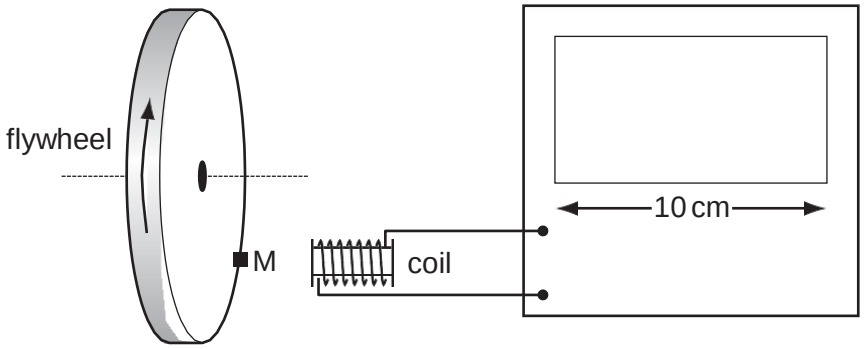


C

D



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



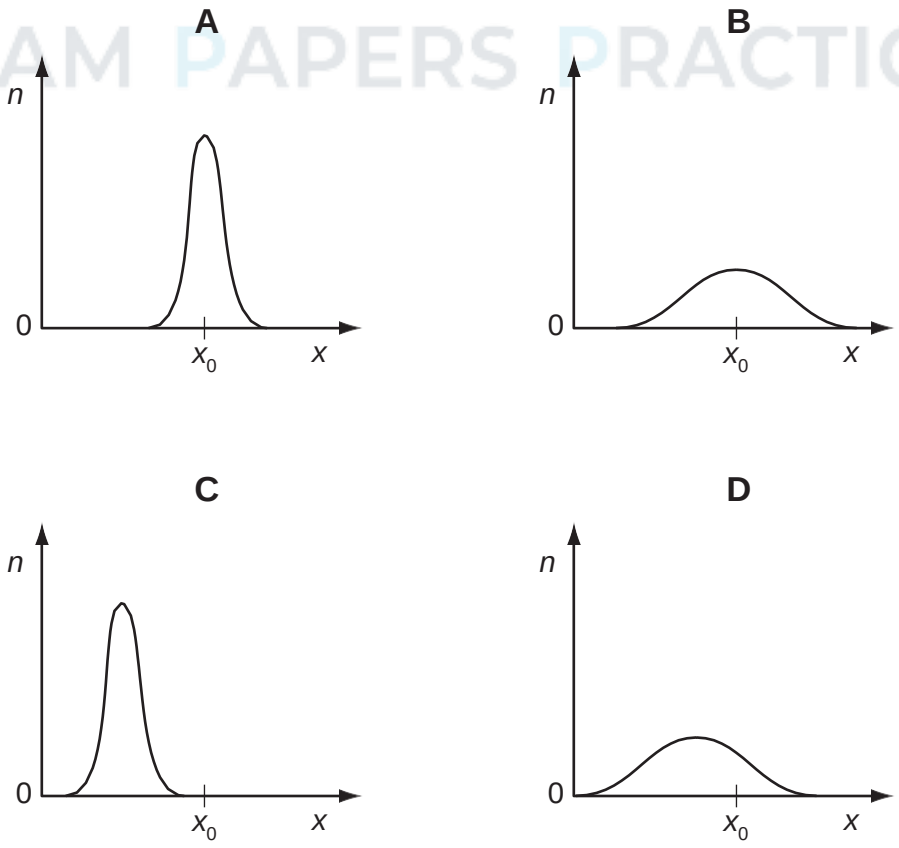
The flywheel has a small magnet M mounted on it. Each time the magnet passes the coil, a voltage pulse is generated, which is passed to the c.r.o. The display of the c.r.o. is 10 cm wide. The flywheel is rotating at a rate of about 3000 revolutions per minute.

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

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

53. 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?



54. A metre rule is used to measure the length of a piece of wire. It is found to be 70 cm long to the nearest millimetre.

How should this result be recorded in a table of results?

A 0.7 m B 0.70 m C 0.700 m D 0.7000 m

55. A quantity x is to be determined from the equation

$$x = P - Q.$$

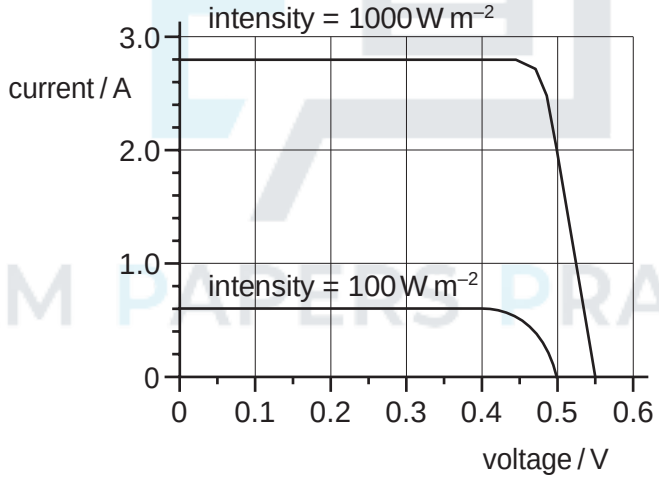
P is measured as 1.27 ± 0.02 m.

Q is measured as 0.83 ± 0.01 m.

What is the percentage uncertainty in x to one significant figure?

A 0.4 % B 2 % C 3 % D 7 %

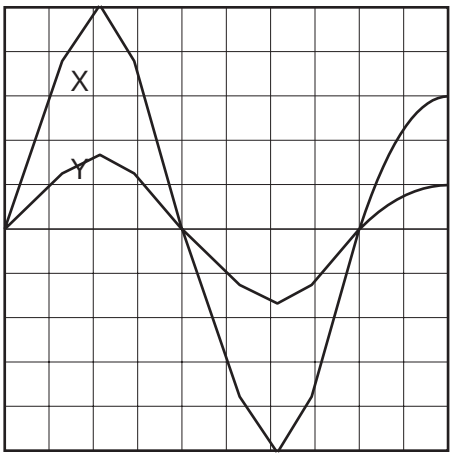
56. The graph shows two current-voltage calibration curves for a solar cell exposed to different light intensities.



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

A 1.1 B 4.7 C 8.0 D 10

57. The diagram shows an oscilloscope screen displaying two signals.



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

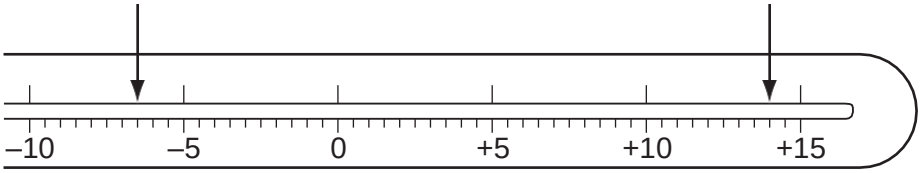
What is the period and peak voltage of signal Y?

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

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

initial temperature

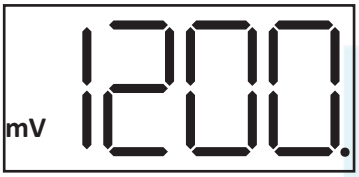
final temperature

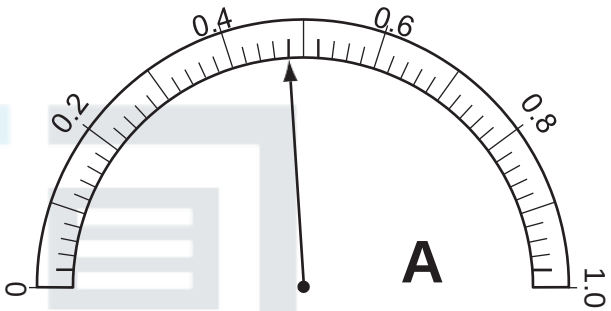


What is the temperature change expressed to an appropriate number of significant figures?

A 14 °C B 20.5 °C C 21 °C D 22.0 °C

59. The diagrams show digital voltmeter and analogue ammeter readings from a circuit in whichelectrical 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

60. A student uses a digital ammeter to measure a current. The reading of the ammeter is found tofluctuate between 1.98 A and 2.02 A.

The manufacturer of the ammeter states that any reading has a systematic uncertainty of ± 1 %.Which value of current should be quoted by the student?

A (2.00 ± 0.01) A

B (2.00 ± 0.02) A

C (2.00 ± 0.03) A

D (2.00 ± 0.04) A