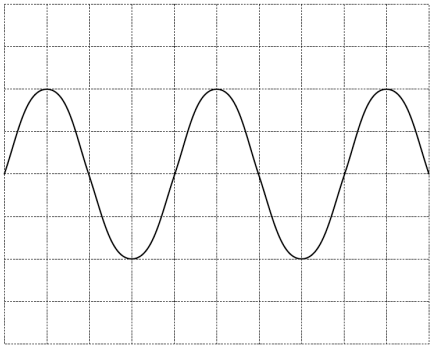
Questions compiled by Leong Yee Pak

Topic: Measurement techniques
2.1 Measurements
2.2 Errors and uncertainties

2.1 Measurement

***1 June 02 P1 Q26**

26 The diagram shows a cathode-ray oscilloscope trace of a sound wave. The time-base is calibrated at 2.0 ms cm^{-1}.

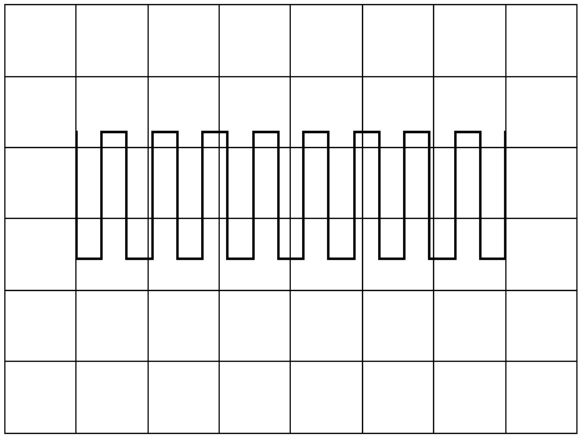


What is the frequency of the sound wave?

A 62.5 Hz **B** 125 Hz **C** 250 Hz **D** 500 Hz

****2 Nov 02 P1 Q7**

7 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

***3 June 03 P1 Q6**

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

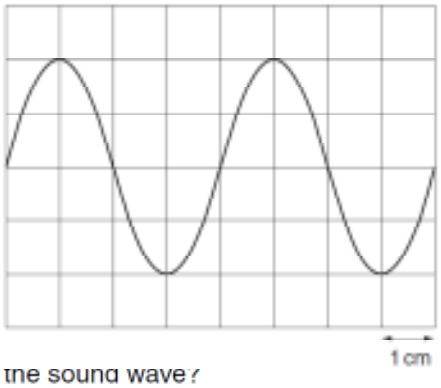
length / mm	892, 891, 892, 891, 891, 892

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

****4 June 03 P1 Q26**

26 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.

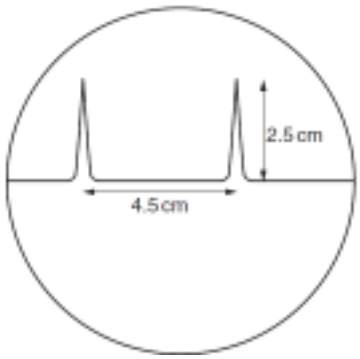


What is the frequency of the sound wave?

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

****5 Nov 03 P1 Q5**

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 Nov 03 P1 Q6**

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.

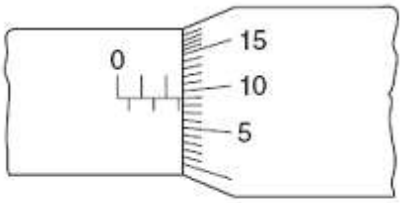


diagram 1

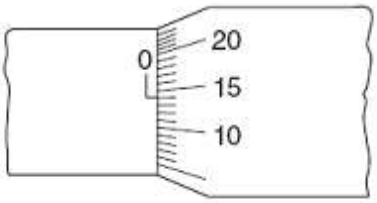


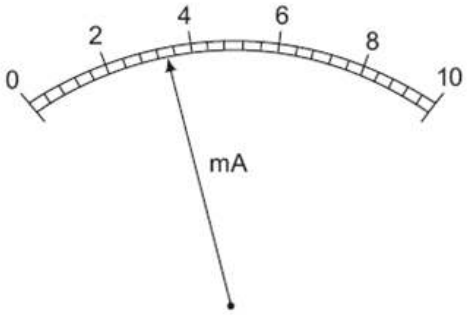
diagram 2

What is the diameter of the wire?

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

***7 June 04 P1 Q4**

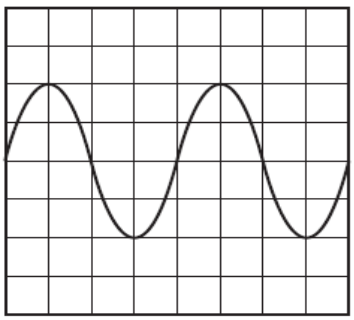
What is the reading shown on this milliammeter?



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

*****8 June 04 P1 Q5**

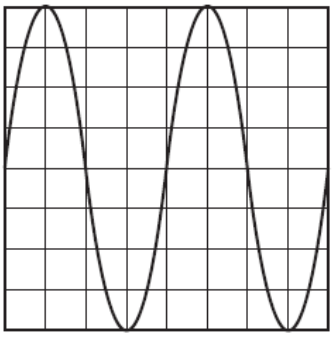
The following tracae is seen on the screen of a cathode-ray oscilloscope.



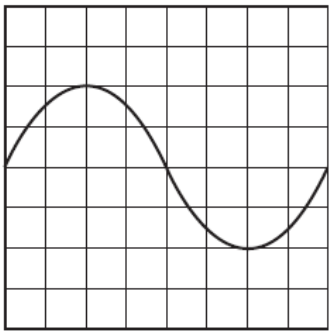
The setting of the time base is then changed from 10 ms cm^{-1} to 20 ms cm^{-1} and the Y-sensitivity is unaltered.

Which trace is now seen on the screen?

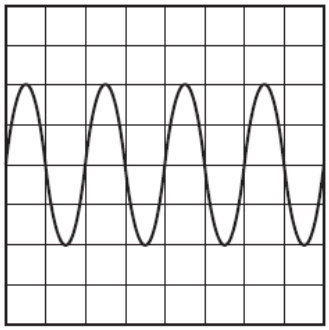
A



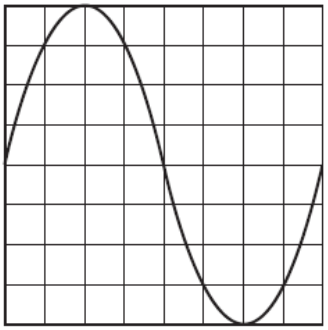
B



C

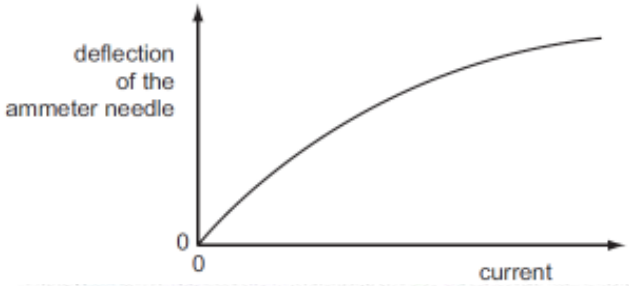


D



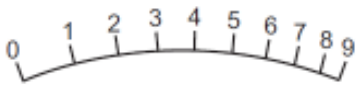
***9 Nov 04 P1 Q4**

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



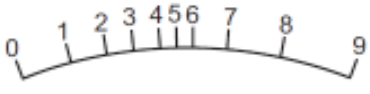
Which diagram could represent the appearance of the scale of this meter?

A

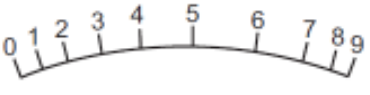


B

C

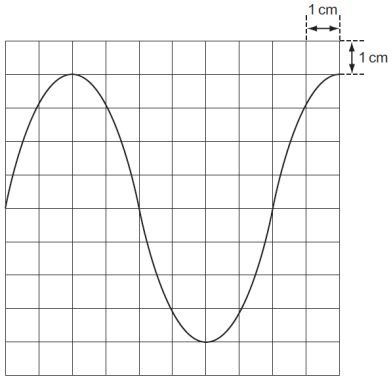


D



**10 Nov 04 P1 Q5

5 When a 12 V 50 Hz supply is connected to the Y-terminals of an oscilloscope, the trace in the diagram is obtained.

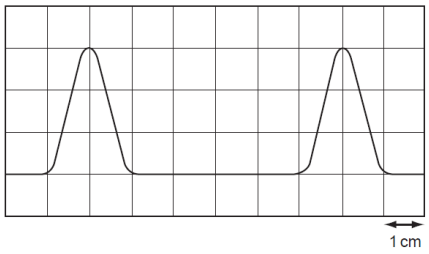


What is the setting of the time-base control?

A 2.0 ms cm^{-1} **B** 2.5 ms cm^{-1} **C** 5 ms cm^{-1} **D** 20 ms cm^{-1}

*11 June 05 P1 Q5

5 The diagram shows two 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}.

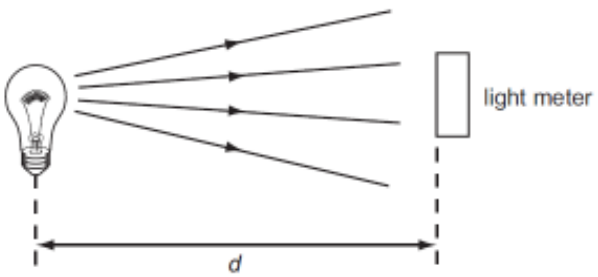


How long does each pulse last?

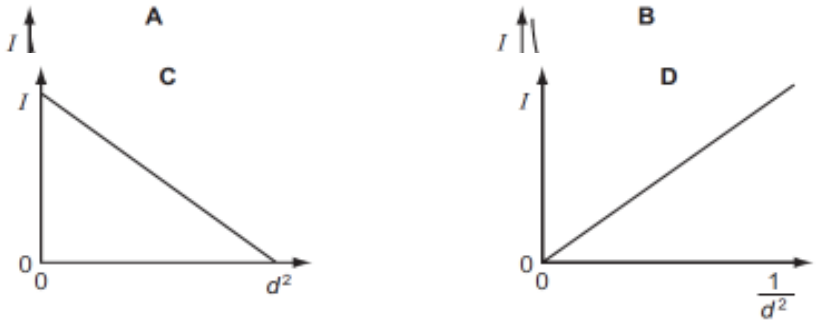
A 2 μs **B** 3 μs **C** 4 μs **D** 6 μs

**12 June 06 P1 Q4

4 A light meter measures the intensity *I* of the light falling on it. Theory suggests that this varies as the inverse square of the distance *d*.

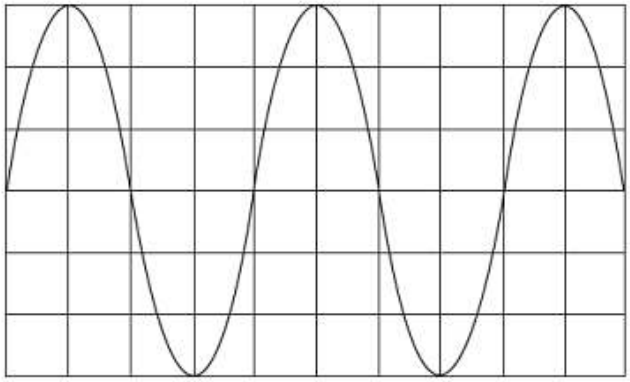


Which graph of the results supports this throry?



***13 June 06 P1 Q5**

The cathode-ray oscilloscope (c.r.o.) display shows the waveform produced by an electronic circuit. The c.r.o. time-base is set at 10 ms per division.



What is the period of the signal shown?

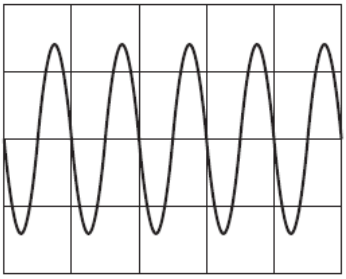
A 20 ms **B** 30 ms **C** 40 ms **D** 80 ms

*****14 Nov 06 P1 Q4**

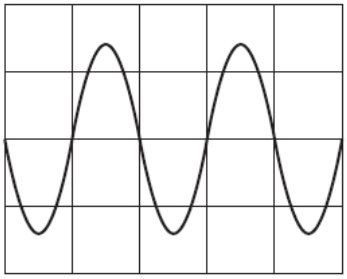
4 The Y-input terminals of a cathode-ray oscilloscope (c.r.o.) are connected to a supply of peak value 5.0 V and of frequency 50 Hz. The time-base is set at 10 ms per division and the Y-gain at 5.0 V per division.

Which trace is obtained?

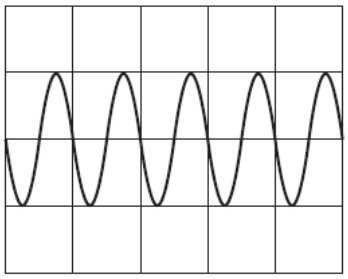
A



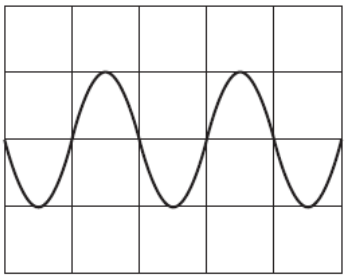
B



C

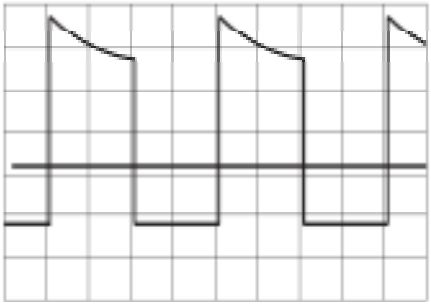


D



**15 June 07 P1 Q4

4 An oscilloscope display consists of two separate traces, a waveform and a long horizontal line. The horizontal line may be taken as the zero level.
The grid on the screen is calibrated in cm squares, the timebase setting is 2.5 ms cm^{-1}, and the Y-sensitivity is 5 mV cm^{-1}.

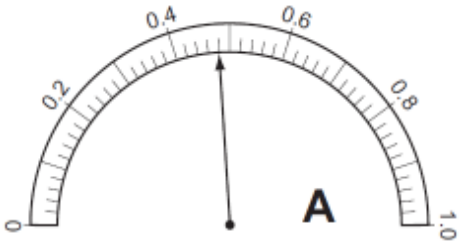


What are the period and the peak positive voltage of the waveform in the diagrama?

	period / ms	peak positive voltage / mV
A	5	17
B	5	25
C	10	17
D	10	25

**16 June 07 P1 Q5

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

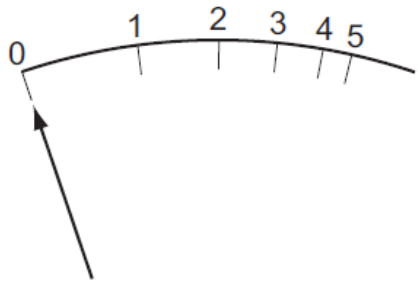


What is the resistance?

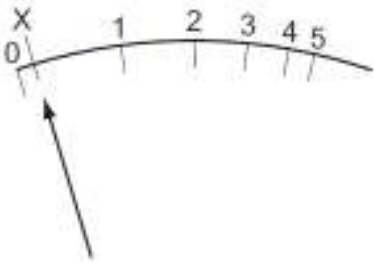
A 2.5Ω B 2.7Ω C 2500Ω D 2700Ω

**17 Nov 07 P1 Q6

6 The diagram shows the graduations of a correctly calibrated ammeter. When the current is zero, the pointer is at 0.

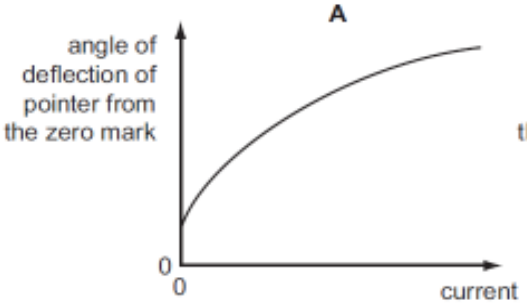


The ammeter is accidentally readjusted so that when the current is zero, the pointer is at X.

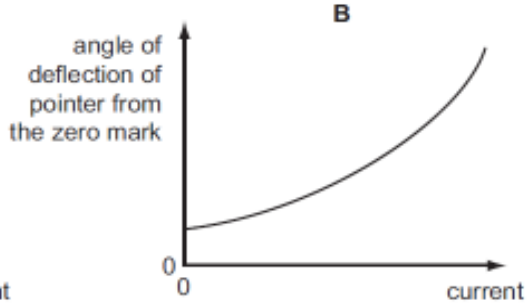


Which calibration graph best represents the response of the readjusted ammeter?

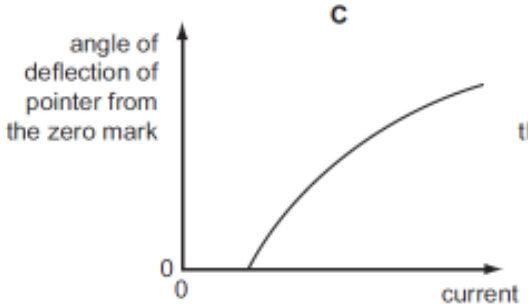
A



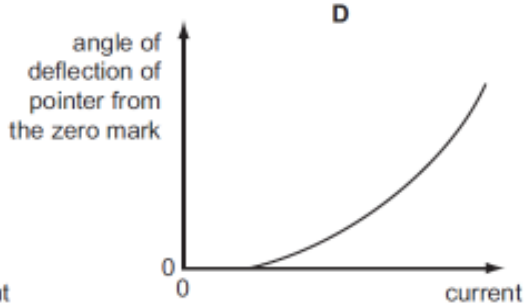
B



C

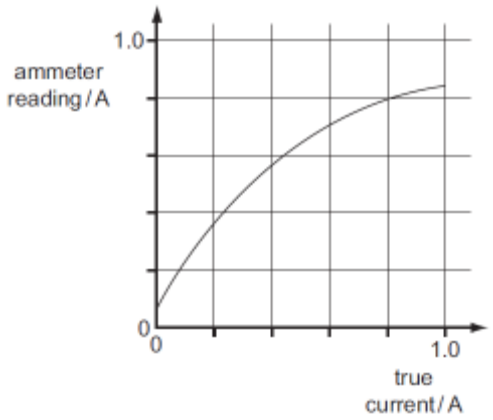


D



***18 Nov 08 P1 Q5**

A calibration graph is produced for a faulty ammeter.

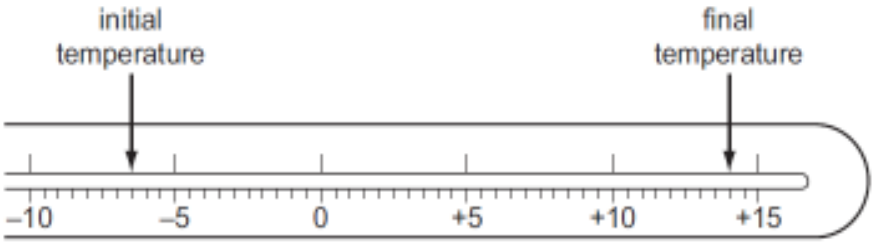


Which ammeter reading will be nearest to the correct value?

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

***19 June 09 P1 Q3**

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

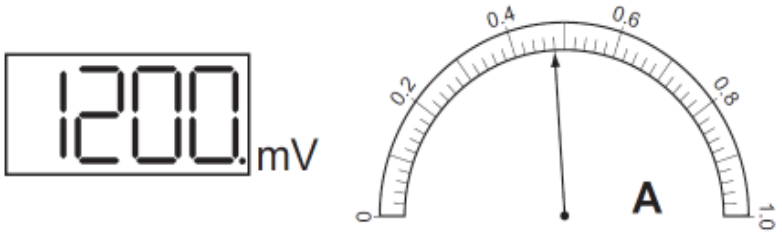


What is the temperature change expressed to an appropriate number of significant figures?

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

****20 June 09 P1 Q4**

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

Section B

1 June 07 P2 Q1

1 The uncalibrated scale and the pointer of a meter are shown in Fig. 1.1.

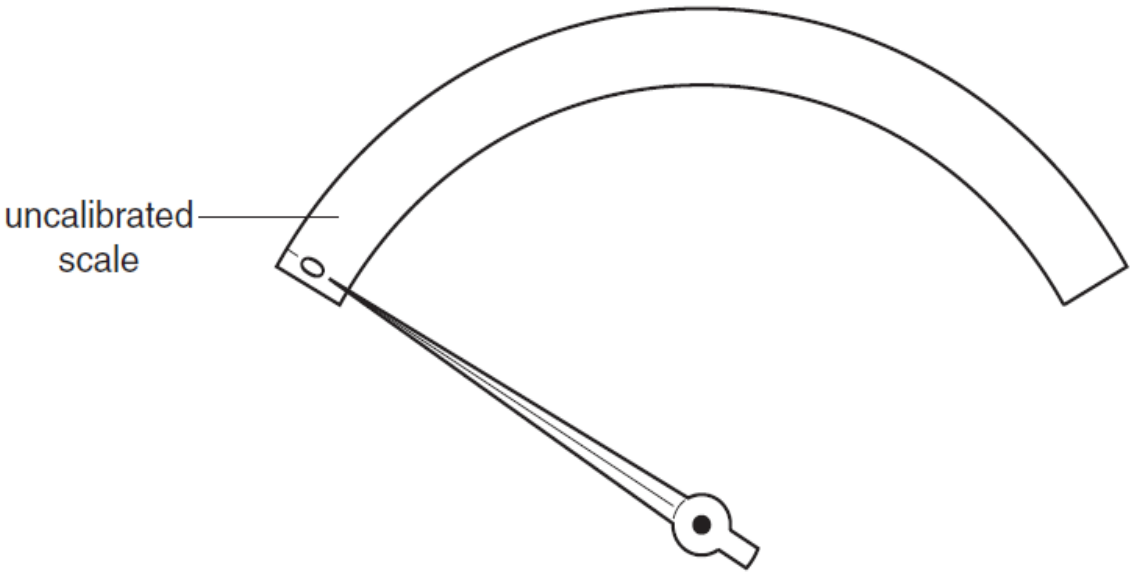
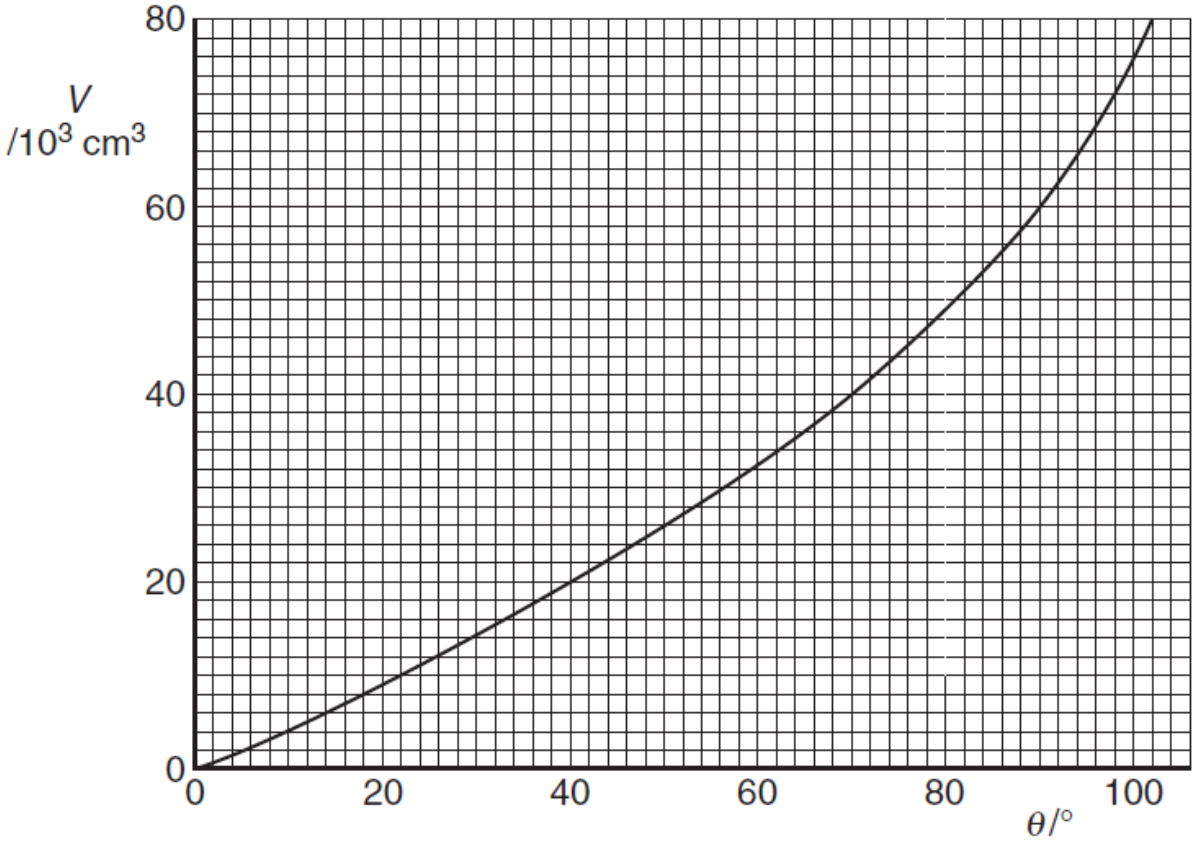


Fig. 1.1

The pointer is shown in the zero position.
The meter is to be used to indicate the volume of fuel in the tank of a car.
A known volume V of fuel is poured into the tank and the deflection θ of the pointer is noted.
Fig. 1.2 shows the variation with θ of V.



(a) On Fig. 1.1,

(i) calibrate the scale at 20×10^3 cm^3 intervals, [2]

(ii) mark a possible position for a volume of 1.0×10^5 cm^3. [1]

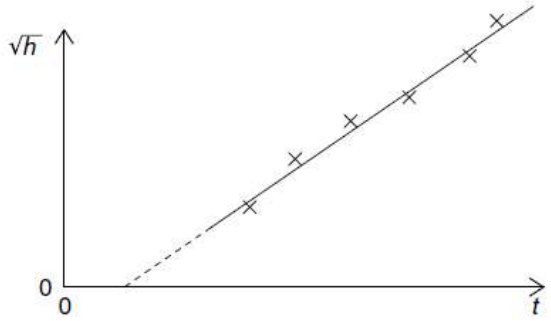
(b) Suggest one advantage of this scale, as compared with a uniform scale, for measuring fuel volumes in the tank of the car.

[1]

2.2 Errors and uncertainties
Section A

**1 June 02 P1 Q4

4 A student measures the time t for a ball to fall from rest through a vertical distance h. Knowing that the equation $h = \frac{1}{2} gt^2$ applies, the student plots the graph shown.



Which of the following is an explanation for the intercept on the t axis?

A Air resistance has not been taken into account for larger values of h.

B There is a constant delay between starting the timer and releasing the ball.

C There is an error in the timer that consistently makes it run fast.

D The student should have plotted h against t^2.

*2 June 02 P1 Q5

The power loss P in a resistor is calculated using the formula $P = V^2/R$.

The uncertainty in the potential difference V is 3% and the uncertainty in the resistance R is 2%.

What is the uncertainty in P?

A 4% B 7% C 8% D 11%

*3 Nov 02 P1 Q5

5 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.

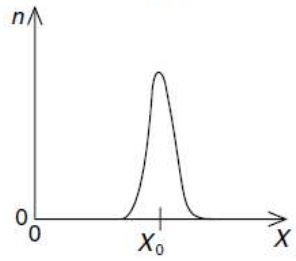
D It is not accurate but is precise.

***4 Nov 02 P1 Q6**

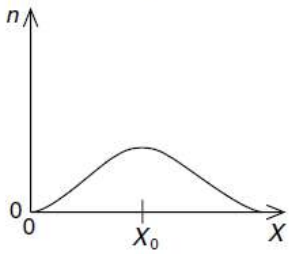
6 A quantity X is measured many times. A graph is plotted showing the number n of times a particular value of X is obtained. X has a true value X_0.

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

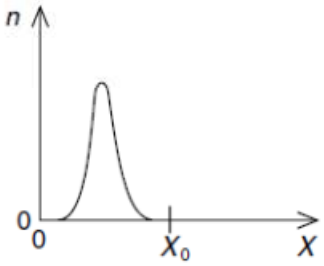
A



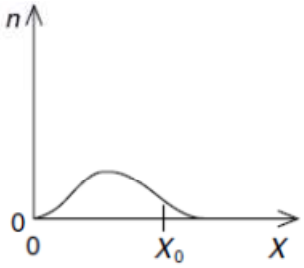
B



C



D



***5 June 03 P1Q4**

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 internodal distance

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

D timing a large number of oscillations to find a period

**6 June 03 P1 Q5

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}

**7 Nov 03 P1 Q4

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 %

**8 June 04 P1 Q6

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%

*9 Nov 04 P1 Q6

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

**10 June 05 P1 Q4

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 ± 1 m s^{-1}

B 16.0 ± 0.2 m s^{-1}

C 16.0 ± 0.4 m s^{-1}

D 16.00 ± 0.36 m s^{-1}

***11 Nov 05 P1Q4**

4 A steel rule can be read to the nearest millimetre. It is used to measure the length of a bar whose true 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

****12 Nov 05 P1 Q5**

5 The density of the material of a rectangular block is determined by measuring the mass and linear dimensions of the block. The table shows the results obtained, together with their uncertainties.

mass = (25.0 ± 0.1) g

length = (5.00 ± 0.01) cm

breadth = (2.00 ± 0.01) cm

height = (1.00 ± 0.01) cm

The density is calculated to be 2.50 g cm^{-3}.

What is the uncertainty in this result?

A ± 0.01 g cm^{-3} **B** ± 0.02 g cm^{-3} **C** ± 0.05 g cm^{-3} **D** ± 0.13 g cm^{-3}

****13 June 06 P1 Q6**

The resistance R of an unknown resistor is found by measuring the potential difference V across the resistor and the current I through it and using the equation $R = \frac{V}{I}$. The voltmeter reading has a 3 % uncertainty and the ammeter reading has a 2 % uncertainty.

What is the uncertainty in the calculated resistance?

A 1.5 % **B** 3 % **C** 5 % **D** 6 %

***14 Nov 06 P1 Q5**

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.

****15 Nov 06 P1 Q6**

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 $(8.0 \pm 0.2)\Omega$

B $(8.0 \pm 0.6)\Omega$

C $(8 \pm 1)\Omega$

D $(8 \pm 2)\Omega$

***16 Nov 07 P1 Q4**

4 A series of measurements of the acceleration of free fall g is shown in the table.

Which set of results is precise but notg accurate?

	g/m s^{-2}				
A	9.81	9.79	9.84	9.83	9.79
B	9.81	10.12	9.89	8.94	9.42
C	9.45	9.21	8.99	8.76	8.51
D	8.45	8.46	8.50	8.41	8.47

****17 Nov 07 P1 Q5**

5 A mass m has acceleration a. It moves through a distance s in time t. The power used in accelerating the mass is equal to the product of force and velocity. The percentage uncertainties are

0.1 % in m,

1 % in a,

1.5 % in s,

0.5 % in t.

What is the percentage uncertainty in the average power?

A 2.1% **B** 2.6% **C** 3.1% **D** 4.1%

***18 June 08 P1 Q4**

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%

***19 June 08 P1 Q5**

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

*****20 Nov 08 P1 Q4**

4 A student uses a digital ammeter to measure a current. The reading of the ammeter is found to fluctuate 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

Section B

1 June 02 P2 Q2

A student uses a micrometer screw gauge to measure the diameter of a wire. He fails to notice that, with the gauge fully closed, the reading is not zero.

(a) State and explain whether the omission introduces a random error or a systematic error into the readings of the diameter.

.....

.....[2]

(b) Explain why the readings are precise but not accurate.

.....

.....

.....[2]

2 Nov 02 P2 Q2

2 A student uses a metre rule to measure the length of an elastic band before and after stretching it.
The lengths are recorded as

length of band before stretching, $L_0 = 50.0 \pm 0.1$ cm

length of band after stretching, $L_S = 51.6 \pm 0.1$ cm.

Determine

(a) The change in length $(L_S - L_0)$, quoting your answer with its uncertainty.

$(L_S - L_0)$ = ... cm [1]

(b) the fractional change in length, $\frac{(L_S - L_0)}{L_0}$,

fractional change = ... [1]

(c) the uncertainty in your answer in **(b)**.

uncertainty = ... [3]

3 Nov 04 P2 Q1

A student takes readings to measure the mean diameter of a wire using a micrometer screw gauge.

(a) Make suggestions, one in each case, that the student may adopt in order to

(i) reduce a systematic error in the readings,

.....

.....

(ii) allow for a wire of varying diameter along its length,

.....

.....

(iii) allow for a non-circular cross-section of the wire.

.....

.....

[3]

(b) The mean diameter of the wire is found to be 0.50 ± 0.02 mm. Calculate the percentage uncertainty in

(i) the diameter,

uncertainty = ... %

(ii) the area of cross-section of the wire.

uncertainty = ... %

[2]

4 Nov 06 P2 Q1

A student investigates the speed of a trolley as it rolls down a slope, as illustrated in Fig. 2.1.

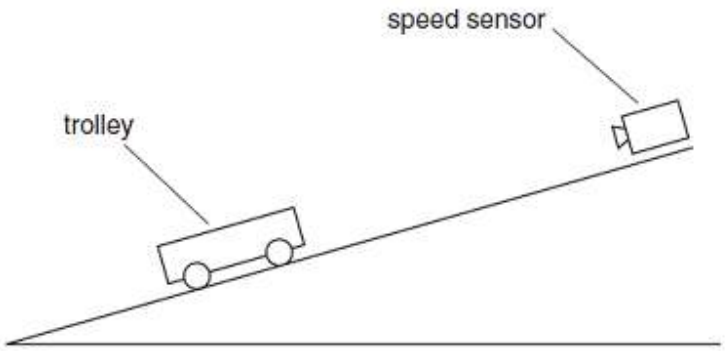
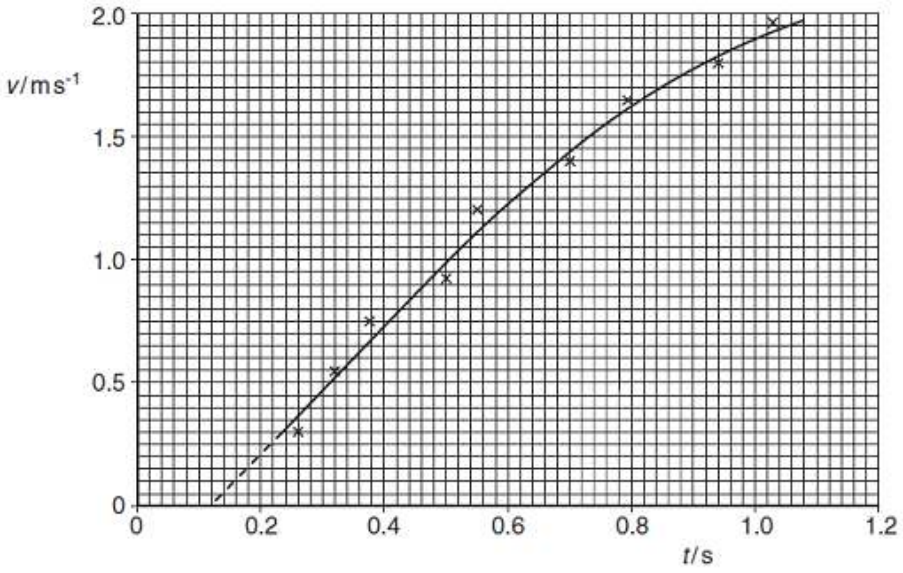


Fig. 2.1

The speed v of the trolley is measured using a speed sensor for different values of the time t that the trolley has moved from rest down the slope.

Fig. 2.2 shows the variation with t of v.



(c) Name the feature of Fig. 2.2 that indicates the presence of

(i) random error,

.....

..... [1]

(ii) systematic error.

.....

..... [1]

5 Nov 07 P2 Q1

1 (a) Distinguish between systematic errors and random errors.

[2]

(b) A cylinder of length L has a circular cross-section of radius R, as shown in Fig. 1.1.

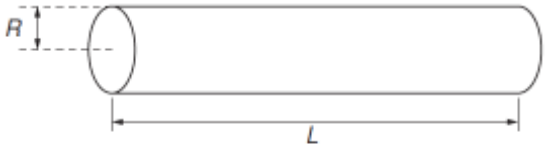


Fig. 1.1

The volume V of the cylinder is given by the expression

$$V = \pi R^2 L.$$

The volume and length of the cylinder are measured as

$V = 15.0 \pm 0.5\,\text{cm}^3$
$L = 20.0 \pm 0.1\,\text{cm}.$

Calculate the radius of the cylinder, with its uncertainty.

radius = ... ± ..... cm [5]

6 June 09 P2 Q1

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 ilament 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.