# Physical quantities and units
(Past Year Topical Questions 2010-2015)

<u>May/June 2010 (11)</u>

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

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

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

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

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

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

    A   energy.

    B   force.

    C $\dfrac{force}{area}$.

    D $\dfrac{force}{length}$.

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

    D   the change in velocity of the ion

1

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 $10\,ms\,cm^{-1}$.
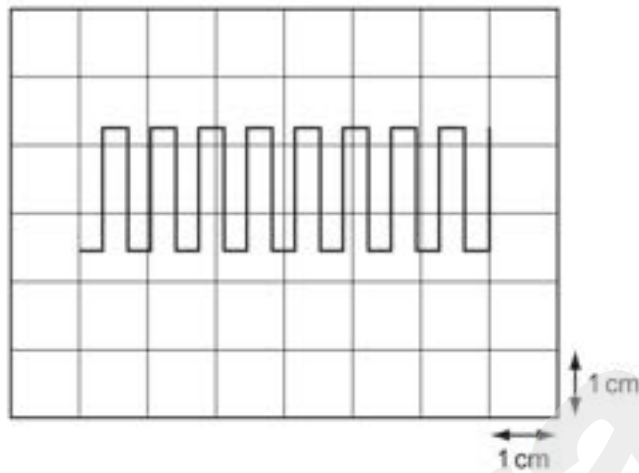
What is the approximate frequency of the square wave?

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

5   A vector quantity V is resolved into two perpendicular components X and Y. The angle between V and component X is θ.
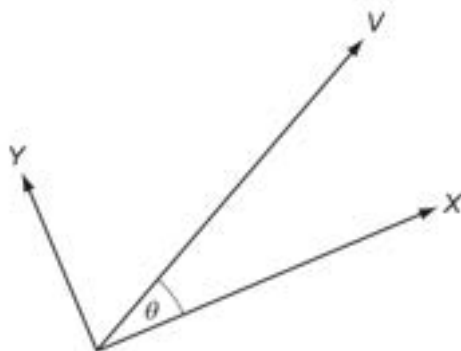
The angle between component X and the vector V is increased from $0°$ to $90°$.

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

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

$$\text{mass of empty beaker} = (20 \pm 1)\,g$$

$$\text{mass of beaker + liquid} = (70 \pm 1)\,g$$

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

He correctly calculates the density of the liquid as $5.0\,g\,cm^{-3}$.

What is the uncertainty in this value?

A $0.3\,g\,cm^{-3}$ B $0.5\,g\,cm^{-3}$ C $0.6\,g\,cm^{-3}$ D $2.6\,g\,cm^{-3}$

7 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

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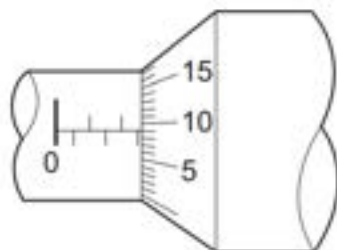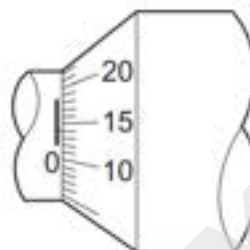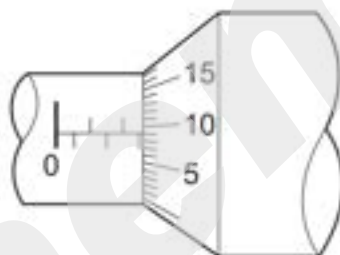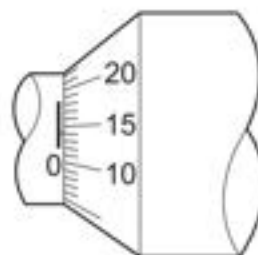

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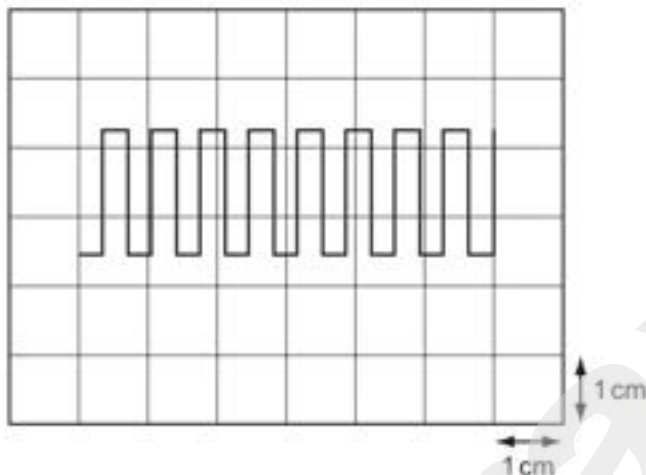
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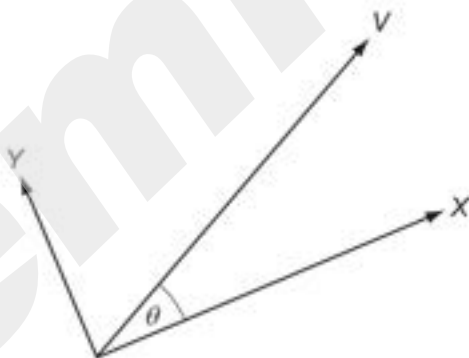
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October/November 2010 (11)

1 A signal has a frequency of 2.0 MHz.

What is the period of the signal?

A $2\,\mu s$ B $5\,\mu s$ C $200\,ns$ D $500\,ns$

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

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?

C

D
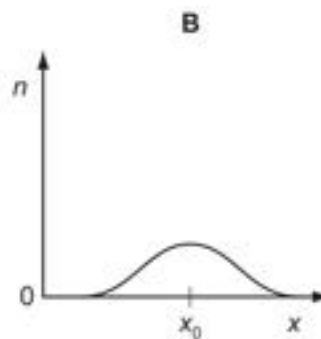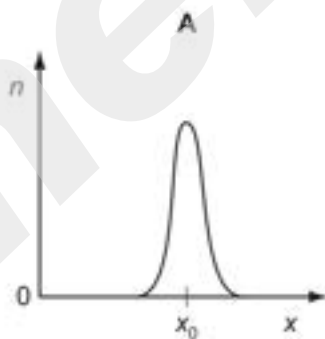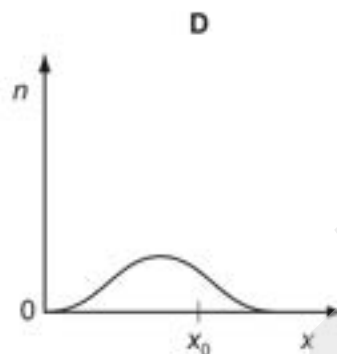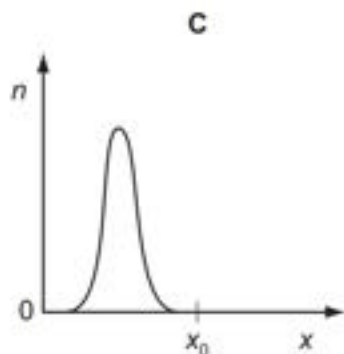
October/November 2010 (12)

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

	quantity	unit
A	current	A
B	mass	g
C	temperature	°C
D	weight	N

2   The frictional force F on a sphere falling through a fluid is given by the formula

$$F = 6\pi a \eta v$$

where a is the radius of the sphere, η is a constant relating to the fluid and v is the velocity of the sphere.

What are the units of η?

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

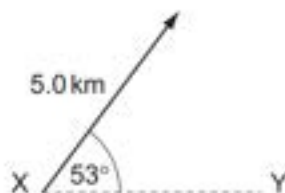**3**   What is the component of this displacement vector in the direction XY?

A   3.0 km   B   4.0 km   C   5.0 km   D   6.6 km

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4   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

5   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 %

October/November 2010 (13)

1   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

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4   A signal has a frequency of 2.0 MHz.

What is the period of the signal?

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May/June 2011 (11)

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 5.0N pushes a ball due north and another force of 3.0N pushes it due east.
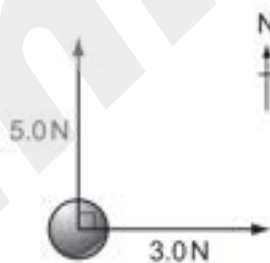
What is the magnitude of the net force acting on the ball?

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

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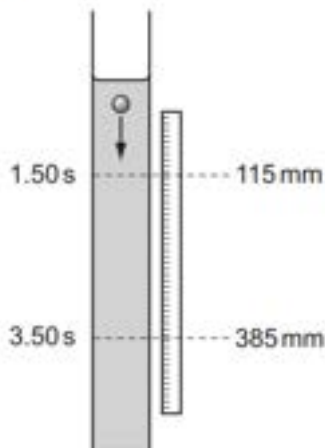
There are two marks on the tube. The top mark is positioned at 115 ± 1 mm on the adjacent rule and the lower mark at 385 ± 1 mm. The ball passes the top mark at 1.50 ± 0.02 s and passes the lower mark at 3.50 ± 0.02 s.

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

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

A $\quad \dfrac{2}{270} + \dfrac{0.04}{2.00}$

B $\quad \dfrac{2}{270} - \dfrac{0.04}{2.00}$

C $\quad \dfrac{1}{270} \times \dfrac{0.02}{2.00}$

D $\quad \dfrac{1}{270} + \dfrac{0.02}{2.00}$

1 Stress has the same SI base units as

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

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

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

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

<u>May/June 2011 (13)</u>

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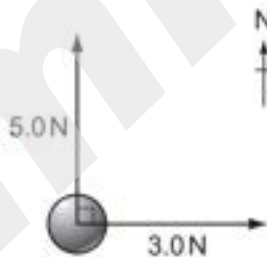
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October/November 2011 (11)

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

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

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

C $1\,Mm = 10^6\,m$

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

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 $4 \times 10^2\,J$ B $4 \times 10^3\,J$ C $4 \times 10^4\,J$ D $4 \times 10^5\,J$

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

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

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

    A electric charge

    B electric potential

    C energy

    D power

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

    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.

What can be deduced from the graph about the motion of the body?

A It accelerates continuously.

B It starts from rest.

C The distance is proportional to time.

D The speed changes.

18 What is the unit of power in SI base units?

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

May/June 2012 (11)

1 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

2   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 (Ns^{-1})

    B   newton second (Ns)

    C   newton metre (Nm)

    D   newton metre per second (Nms^{-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

5   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 $16 \pm 1\,ms^{-1}$

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

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

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

6   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

May/June 2012 (12)

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

   A Js^{-1} **B** $m^2 kg s^{-1}$ **C** $m^2 kg s^{-3}$ **D** Nms^{-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.
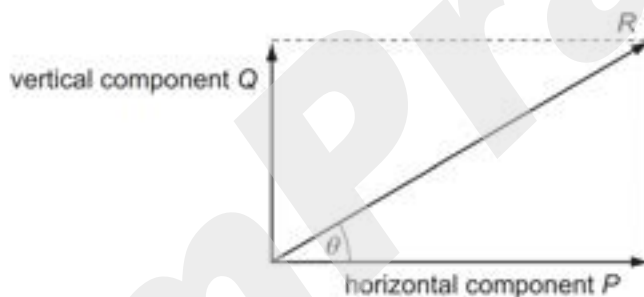
   Which row correctly describes the perpendicular components?

	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.
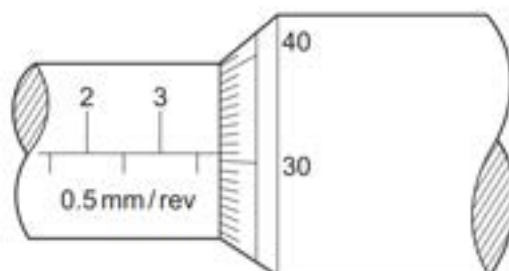
What is the cross-sectional area of the rod?

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 $9.8\,ms^{-2}$.

	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.

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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   C   D

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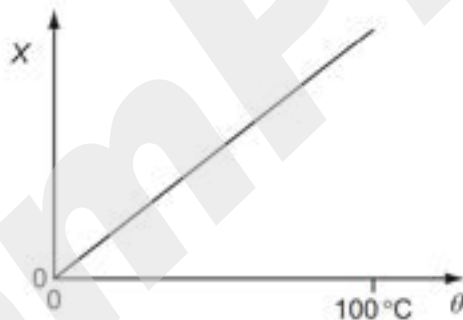
θ is determined from the corresponding values of X by using this graph.
X is measured with a percentage uncertainty of $\pm 1\%$ of its value at all temperatures.

    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 $100\,°C$.

7   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 by adjusting the apparatus.

D   A systematic error results in a different reading each time the measurement is taken.
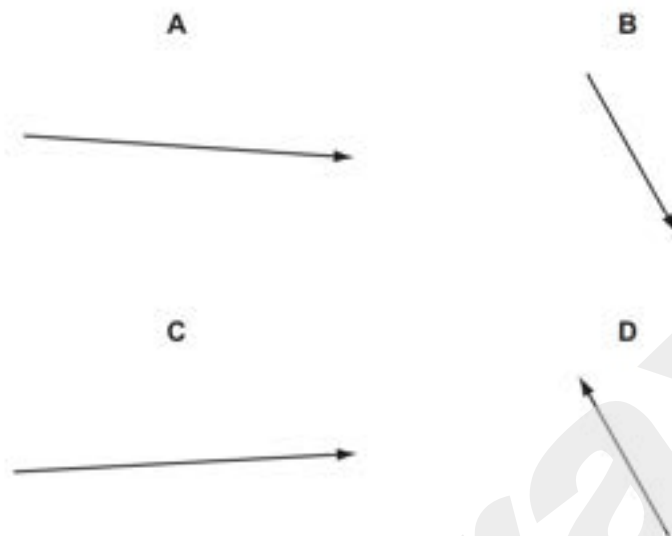
October/November 2012 (12)

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

6 Variables x and y are related by the equation $y = p - qx$ where p and q are constants.

Values of x and y are measured experimentally. The results contain a systematic error.

Which graph best represents these results?
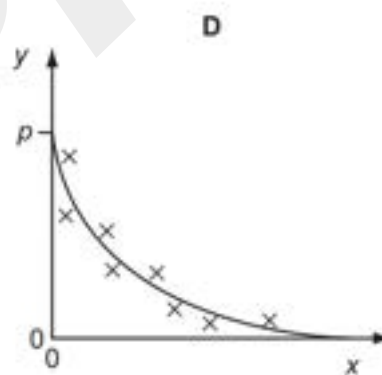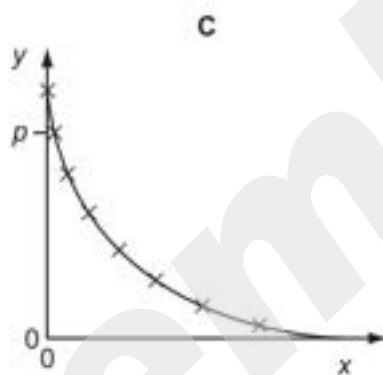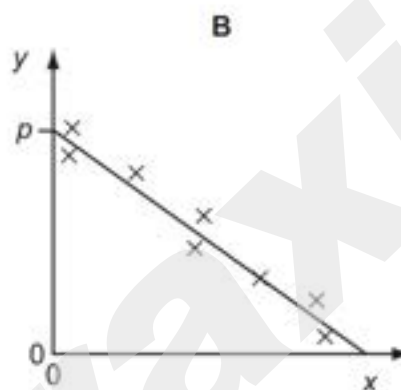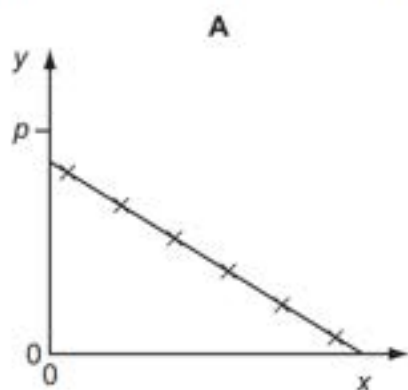
7 The speed of a car is calculated from measurements of the distance travelled and the time taken.

The distance is measured as 200 m, with an uncertainty of ±2 m.

The time is measured as 10.0 s, with an uncertainty of ±0.2 s.

What is the percentage uncertainty in the calculated speed?

A ±0.5%   B ±1%   C ±2%   D ±3%

<u>October/November 2012 (13)</u>

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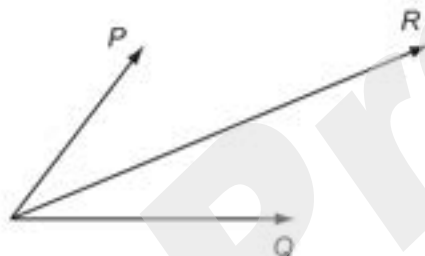
Which quantity could be represented by P and by Q?

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 $\dfrac{\text{energy}}{\text{distance}}$

B force

C power $\times$ time

D rate of change of momentum

6   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

7   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 %

May/June 2013 (11)

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

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%

<u>May/June 2013 (12)</u>

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

   A   displacement; acceleration

   B   force; kinetic energy
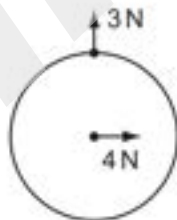
   C   power; speed

   D   work; potential energy

2   The unit of resistivity, expressed in terms of base units, is given by
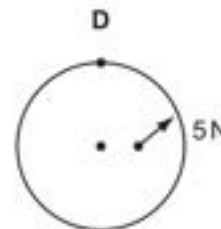
$$kg\,x^3\,y^{-2}\,z^{-3}.$$

   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

3   Two forces act on a circular disc as shown.

   Which diagram shows the line of action of the resultant force?
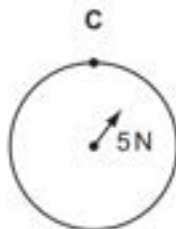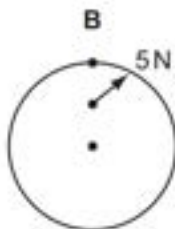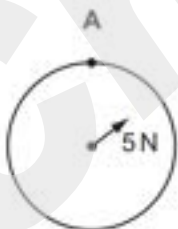
4 A student carried out an experiment in which an electric current was known to decrease with time. The readings he found, from first to last, were 3.62 mA, 2.81 mA, 1.13 mA, 1.76 mA and 0.90 mA.

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.

<u>May/June 2013 (13)</u>

1 The diagram shows a displacement vector.

What is the vertical component of this displacement vector?

A 3.0 km   **B** 4.0 km   **C** 5.0 km   **D** 6.6 km

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 $1 \times 10^5\,Pa$.

B Light takes $5 \times 10^2\,s$ to reach us from the Sun.

C The frequency of ultra-violet light is $3 \times 10^{12}\,Hz$.

D The life-span of a man is about $2 \times 10^9\,s$.

4   A cyclist is travelling due south with velocity *u*. The wind is blowing from the north-east with velocity *w*.
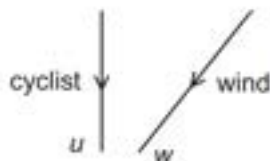
The wind has a velocity *v* relative to the cyclist, where *v = w − u*.

Which vector diagram shows the magnitude and direction of velocity *v*?
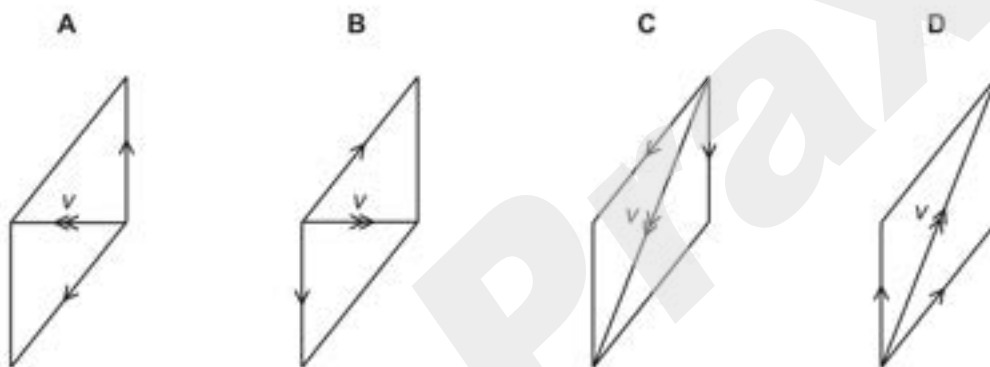
5   A student takes measurements of the current in a resistor of constant resistance and the potential difference (p.d.) across it. The readings are then used to plot a graph of current against p.d.

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.

October/November 2013 (11)

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

	SI base quantity	unit
A	charge	coulomb
B	current	ampere
C	potential difference	volt
D	temperature	degree 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

5   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%

October/November 2013 (12)

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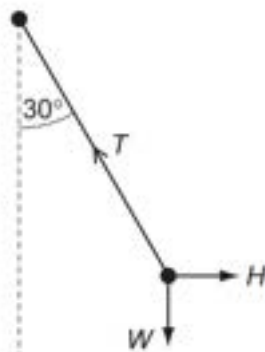
A 1   B 2   C 3   D 4

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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%

October/November 2013 (13)

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 Nm^{-2} B Nm^{-1} C Nm D Nm^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.
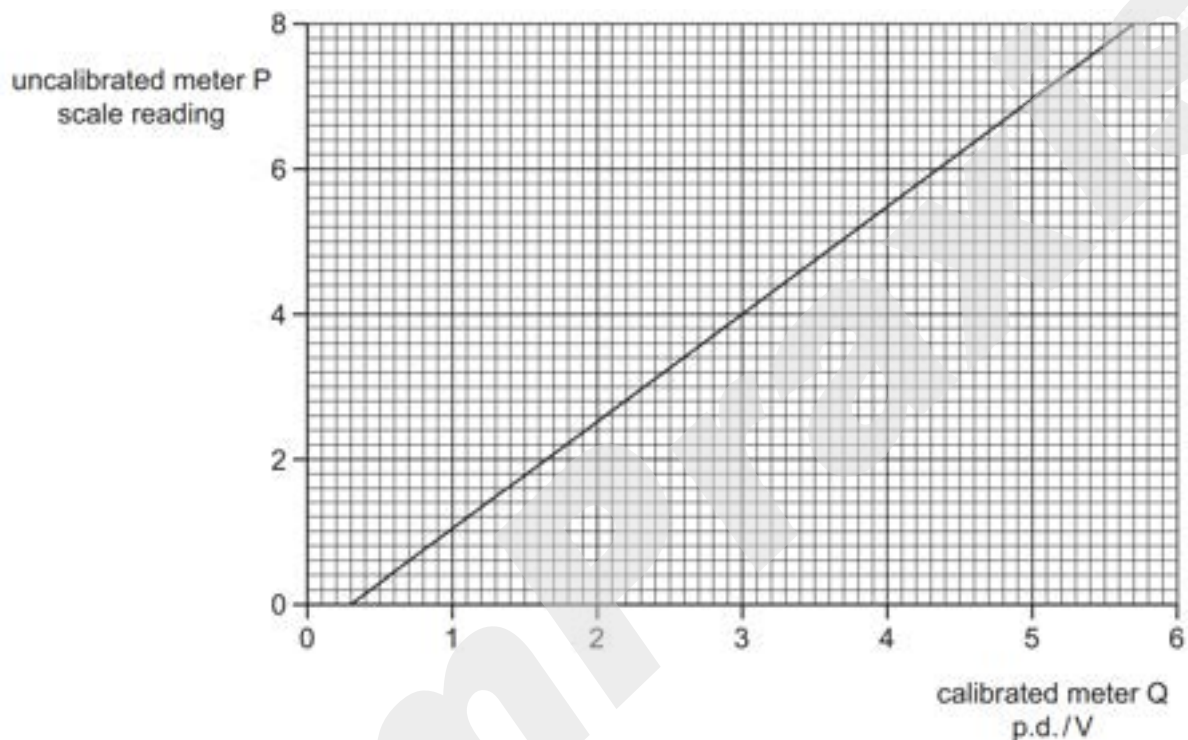
The graph shows that meter P has a zero error. This meter is now adjusted to remove this zero error. When the meter is recalibrated, the gradient of the calibration graph is found to be unchanged.

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:

$$mass = (0.506 \pm 0.005)\,g$$

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

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%

May/June 2014 (11)

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

May/June 2014 (12)

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

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

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

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

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 %

May/June 2014 (13)

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 ± 0.01 m

B 0.0285 ± 0.001 m

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

D $(2.850 \pm 0.001) \times 10^{-3}$ m

October/November 2014 (11)

1   A 0.10 kg mass is taken to Mars and then weighed on a spring balance and on a lever balance. The acceleration due to gravity on Mars is 38% of its value on Earth.

What are the readings on the two balances on Mars? (Assume that on Earth $g = 10 \, \text{m s}^{-2}$.)

	spring balance / N	lever balance / kg
A	0.38	0.038
B	0.38	0.10
C	1.0	0.038
D	1.0	0.10

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

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

4 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%

October/November 2014 (12)

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measurement	uncertainty
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length of wire	±0.2%
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extension	±1%

What is the percentage uncertainty in the Young modulus?

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

October/November 2014 (13)

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

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

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

The value of R is calculated to be 7.5 Ω.

What is the uncertainty in this value for R?

A ±0.3 Ω   B ±0.5 Ω   C ±0.7 Ω   D ±1 Ω

May/June 2015 (11)

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** $13.0\,k_1$

May/June 2015 (12)

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 $kg^{-1}m^{-1}s^2K$

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

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

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

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.
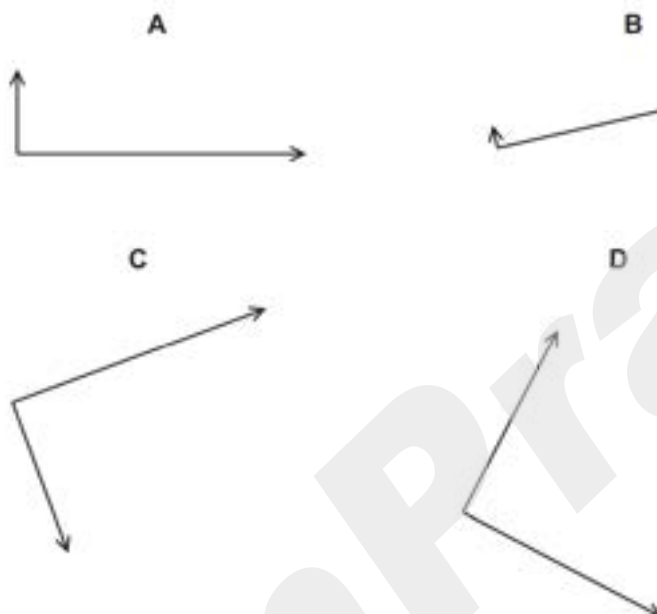
Which diagram best represents the calibration graph needed to obtain an accurate current reading?
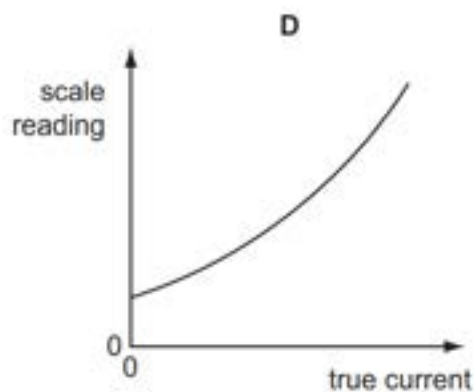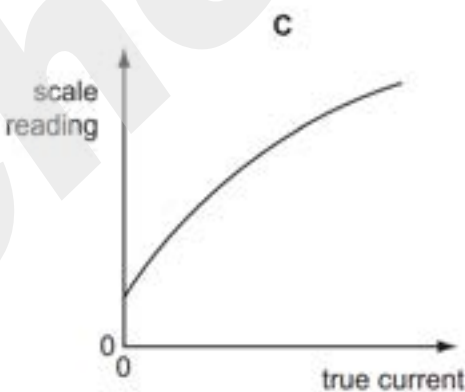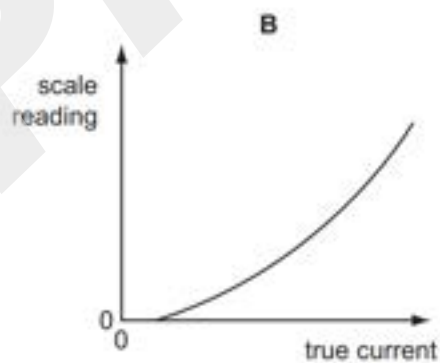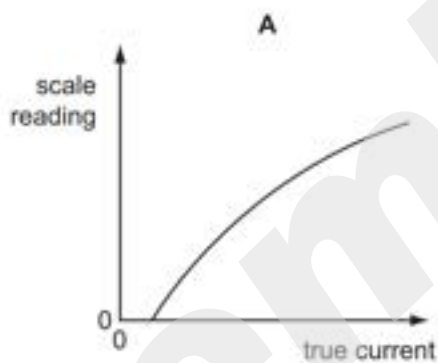
4 The arrow represents the vector R.
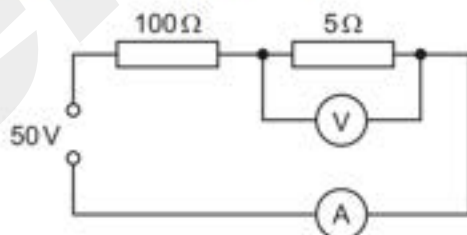

Which diagram does **not** represent R as two perpendicular components?

A

B

C

D

5 A power supply of electromotive force (e.m.f.) 50V and negligible internal resistance is connected in series with resistors of resistance 100Ω and 5Ω, as shown.

A voltmeter measures the potential difference (p.d.) across the 5Ω resistor and an ammeter measures the current in the circuit.

What are suitable ranges for the ammeter and for the voltmeter?

	ammeter range/A	voltmeter range/V
A	0–0.1	0–1
B	0–0.1	0–3
C	0–1.0	0–1
D	0–1.0	0–3

6　A single sheet of aluminium foil is folded twice to produce a stack of four sheets. The total thickness of the stack of sheets is measured to be (0.80 ± 0.02) mm. This measurement is made using a digital caliper with a zero error of (-0.20 ± 0.02) mm.

What is the percentage uncertainty in the calculated thickness of a single sheet?

A　1.0%　　　　B　2.0%　　　　C　4.0%　　　　D　6.7%

May/June 2015 (13)

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　$kg\,m^2\,s^{-2}$

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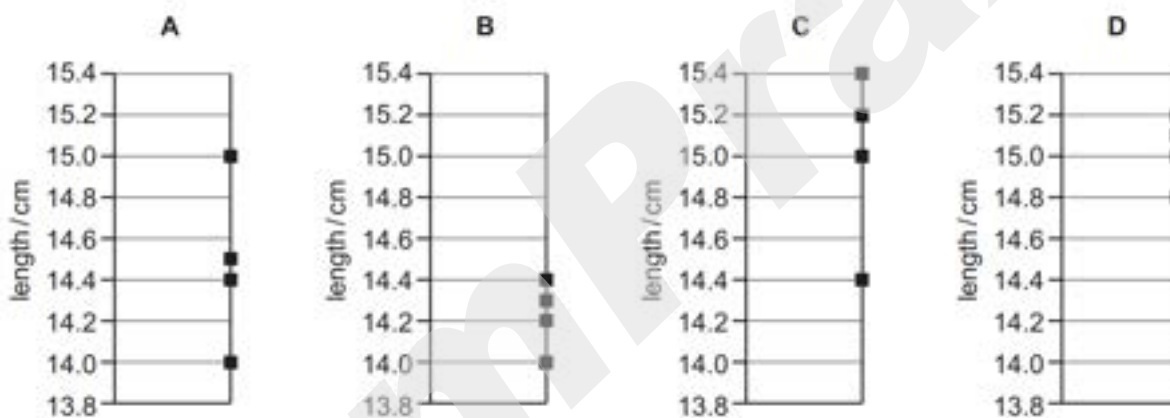
6   In a simple electrical circuit, the current in a resistor is measured as (2.50 ± 0.05) mA. The resistor is marked as having a value of 4.7 Ω ± 2%.

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%

October/November 2015 (11)

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   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 $J\,kg^{-1}\,K^{-1}$.

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

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

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

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

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

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.

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.

vernier calipers

four square
cross-section rods
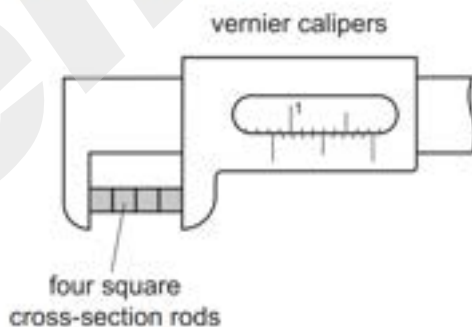
The measurement is (8.4 ± 0.1) mm and the zero reading on the calipers is (0.0 ± 0.1) mm.

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

October/November 2015 (12)

1 Which list shows increasing lengths from beginning to end?

A 1 cm   1 nm   1 mm   1 μm

B 1 μm   1 mm   1 nm   1 cm

C 1 nm   1 μm   1 mm   1 cm

D 1 mm   1 cm   1 μm   1 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 $kg^{-1}m^{-3}s^2$ B $kg^{-1}m^3s^2$ C $kg\,m^{-3}s^2$ D $kg\,m^3s^2$

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

	mass/kg	speed/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

5   A student measures the time T for one complete oscillation of a pendulum of length l.

Her results are shown in the table.

l/m	T/s
0.420 ± 0.001	1.3 ± 0.1

She uses the formula

$$T = 2\pi\sqrt{\frac{l}{g}}$$

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%

October/November 2015 (13)

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

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

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

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

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

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

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	$m s^{-2}$

7   Variables *x* and *y* are related by the equation $y = p - qx$ where *p* and *q* are constants.

Values of *x* and *y* are measured experimentally. The results contain a systematic error.

Which graph best represents these results?

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