MEASUREMENT

Challenging **MCQ** questions by The Physics Cafe

Compiled and selected by The Physics Cafe

1 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 $\pm 1\%$.

Which value of the 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

2 An 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 4×10^2 J **B** 4×10^3 J **C** 4×10^4 J **D** 4×10^5 J

3 Which of the following pairs of physical quantities are both vector quantities?

A work done, electric current
B work done, electric field strength
C force, electric current
D force, electric field strength

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4 The diameter *D* of a sphere is measured to be 5.0 cm with a fractional uncertainty of 0.02. What is the absolute uncertainty and fractional uncertainty of the radius *R* of the sphere?

	absolute uncertainty of *R*	fractional uncertainty of *R*
A	0.05 cm	0.01
B	0.1 cm	0.01
C	0.05 cm	0.02
D	0.1 cm	0.02

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5 The precision and accuracy of a measurement is affected by:

	precision	accuracy
A	Systematic error	Random error
B	Random error	Random error
C	Systematic error	Systematic error
D	Random error	Systematic error

6 The Helmholtz Energy of a system, *H*, is given by the equation,

$$H = U - TS$$

where *U* is the internal energy of the system, *T* is the thermodynamic temperature and *S* is the entropy of the system.

What are the SI base units of entropy, *S?*

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

7 An electrician needs to know the effective resistance of a circuit consisting of two resistors connected in parallel. Using an ohmmeter, he finds that the resistances of the two resistors are $(3.00 \pm 0.05)\ \Omega$ and $(0.60 \pm 0.05)\ \Omega$.

What is the effective resistance of the circuit, expressed with its appropriate uncertainty?

A $(0.50 \pm 0.02)\ \Omega$ **B** $(0.50 \pm 0.04)\ \Omega$

C $(0.50 \pm 0.10)\ \Omega$ **D** $(3.60 \pm 0.10)\ \Omega$

8 Which quantity has different units from the other three?

A rate of change of momentum
B gradient of electric potential energy
C impulse per unit time
D power over displacement

9 The Lyman series is the series of transitions resulting in ultraviolet emission lines of hydrogen atom as an electron goes from higher energy levels to ground state. It is given by the formula

$$\frac{1}{\lambda} = R_H\left(1-\frac{1}{n^2}\right)$$

where n is a natural number greater than or equal to 2.

A student conducted an experiment to determine the constant R_H. The results are summarized below:

n	wavelength λ (nm)
2	122 ± 2

What is the average value for R_H and its corresponding uncertainty?

A $(1.093 \pm 0.009) \times 10^7\ \text{m}^{-1}$ **B** $(1.09 \pm 0.02) \times 10^7\ \text{m}^{-1}$
C $(1.09 \pm 0.04) \times 10^7\ \text{m}^{-1}$ **D** $(1.1 \pm 0.1) \times 10^7\ \text{m}^{-1}$

10 What is the best estimate for the value of the mass of a raindrop?

A 4 μg
B 4 mg
C 4 g
D 4 kg

11 A student measures two lengths as follows:

$X = 15.0 \pm 0.2$ cm
$Y = 30.0 \pm 0.2$ cm.

The student calculates:

F_X the fractional uncertainty in X

F_Y the fractional uncertainty in Y

F_{Y-X} the fractional uncertainty in $(Y - X)$

F_{X+Y} the fractional uncertainty in $(X + Y)$

Which of these uncertainties has the **largest** magnitude?

A F_X

B F_Y

C F_{Y-X}

D F_{X+Y}

12 The ideal gas law can be expressed in the equation

$$P V = n R T$$

where P is the absolute pressure of the gas, V is the volume of the gas, n is the amount of substance of gas (measured in moles), R is the molar gas constant, and T is the absolute temperature of the gas.

Which one of the following is the SI base unit for R?

A $J\ K^{-1}\ mol^{-1}$

B $Pa\ m^3\ K^{-1}\ mol^{-1}$

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

D $kg^2\ m^3\ K\ mol^{-1}\ s^{-2}$

13 In a simple electrical circuit, the current in a resistor is measured as (3.50 ± 0.05) mA. The resistor is marked as having a value of $4.3\ \Omega \pm 2\%$.

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

A 3% **B** 4% **C** 5% **D** 6%

14 Which estimate is realistic?

A The temperature in the domestic refrigerator is 200 K.

B The surface area of a standard soccer ball is 0.15 m^2.

C The current drawn by a laptop is 15 A.

D The volume of a pen is 4.0×10^{-3} m^3.

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15 *P* and *Q* represent two forces.

Fig. 2.1, 2.2 and 2.3 represent three possible vector diagrams for *P* and *Q*.

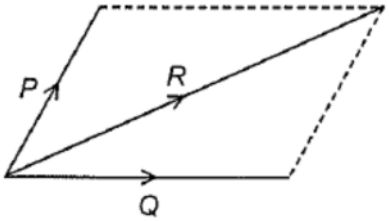

Fig. 2.1

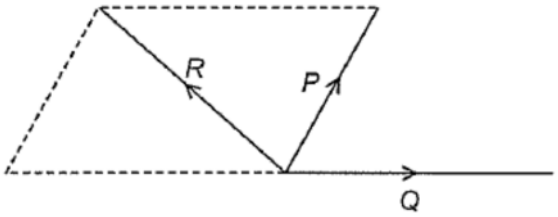

Fig. 2.2

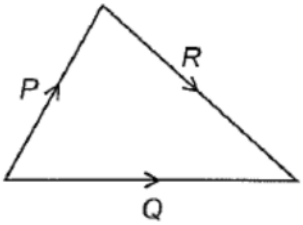

Fig. 2.3

Which of the following correctly represents the vectors *R*, *S* and *T*?

	Fig 2.1	***Fig 2.2***	***Fig 2.3***
A	$P + Q$	$Q - P$	$P - Q$
B	$P + Q$	$P - Q$	$Q - P$
C	$P - Q$	$P + Q$	$Q - P$
D	$Q - P$	$P - Q$	$P + Q$

MEASUREMENT WORKED SOLUTIONS

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1 Ans: **D**
random errors is ±0.02 + systematic error is ±0.02

2 Ans: **B**
estimate average speed. apply ½ mv^2.

3 Ans: **D**
Even though work done can be negative, it is a scalar since the negative does not represent its direction.
Electric current flows along the wire and therefore has no fixed direction in space.

4 Ans: **C**
The absolute uncertainty of the diameter is 0.02 x 5.0 = 0.1 cm.
The absolute uncertainty of the radius will be 0.1 cm / 2 = 0.05 cm
The fractional uncertainty of the radius will be 0.05 cm / 2.5 cm = 0.02.

5 Ans: **D**
Random error causes a scatter of points about an average which affects the precision.
Systematic error causes a shift in the value away from the true value which affects the accuracy.

6 Ans: **D**

$$[H] = [U] = [TS]$$
$$[U] = [T][S]$$
$$\mathrm{J} = \mathrm{K}[S]$$
$$[S] = \mathrm{J\,K^{-1}}$$
$$= \mathrm{kg\,m^2\ s^{-2}\ K^{-1}}$$

7 Ans: **B**

Effective resistance:

$$\frac{1}{R_{eff}} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{3.00} + \frac{1}{0.60}$$
$$R_{eff} = 0.50\,\Omega$$

Using the extreme value method:

maximum :

$$\frac{1}{R_{eff}} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{3.05} + \frac{1}{0.65}$$
$$R_{eff} = 0.54\,\Omega$$

minimum :

$$\frac{1}{R_{eff}} = \frac{1}{R_1} + \frac{1}{R_2} = \frac{1}{2.95} + \frac{1}{0.55}$$
$$R_{eff} = 0.46\,\Omega$$

Uncertainty of R_{eff}

$$\Delta R_{eff} = \frac{0.54 - 0.46}{2}$$
$$= 0.04\,\Omega$$

8 Ans: **D**

9 Ans: **B**

10 Ans: **B**

11 Ans: **C**

12 Ans: **C**

$$R = \frac{PV}{nT}$$

$$[R] = \frac{[P][V]}{[n][T]} = \frac{[F/A][V]}{[n][T]} = \frac{(kg\ m^{-1}\ s^{-2})}{(mol)}\frac{m^3}{(K)} = kg\ m^2\ K^{-1} mol^{-1} s^{-2}$$

13 Ans: **C**

$$P = I^2 R$$

$$\frac{\Delta P}{P} \times 100 = 2\frac{\Delta I}{I} \times 100 + \frac{\Delta R}{R} \times 100$$

$$\frac{\Delta P}{P} \times 100 = 2\frac{0.05}{3.50} \times 100 + \frac{2}{100} \times 100$$
$$= 2.86 + 2$$
$$= 5\%$$

14 Ans: **B**

A - 300 K = 26.85 °C (room temperature)
B - Diameter of soccer ball = 22 cm

Surface Area = $4\pi\left(\frac{0.22}{2}\right)^2 = 0.15\ \text{m}^2$

C - Typical laptop p.d. = 19 V and current = 4.22 A
D - Diameter of a pen = 1.0 cm; length of pen = 0.100 m

Volume = $\pi\left(\frac{0.01}{2}\right)^2 (0.100) = 7.85 \times 10^{-6}\ \text{m}^3$

15 Ans: **B**
Using the parallelogram addition of vectors,
R = P + Q
S = P + (–Q)
T = (–P) + Q