Musselburgh Grammar School Physics Department

Higher Physics Study Guide Uncertainties

"Every measurement is subject to uncertainty"

1. Put a tick in the correct box in the table to match the descriptions with the three main types of uncertainty.

Description	Reading	Random	Systematic
This arises from using measuring apparatus which is not working properly			✓
This should be quoted as ±1 in the least significant digit when using a digital measuring device	✓		
This arises from having to judge where the pointer is on an analogue scale	✓		
This will normally produce results which are all too big or all too small			✓
This should be quoted as ± half of the smallest scale division when using an analogue measuring device	✓		
This arises from factors which cannot be controlled by the experimenter		✓	
This is equally likely to give results which are too big as results which are too small		✓	
This arises from faulty experimental technique			✓

2. When you are carrying out an experiment in Physics, it is important to repeat your measurements a number of times.

   Score out the statements below that **do not** describe good reasons for repeating your measurements.

   a) Repeated measurements can show up where mistakes have been made.

   b) ~~Repeated measurements can eliminate a systematic uncertainty.~~

   c) Repeated measurements can be averaged to reduce random uncertainties.

   d) The more often you repeat measurements, the smaller your approximate random uncertainty will be.

   e) The mean of a set of repeated measurements is the best estimate of the true value of the measured quantity.

3. A Sixth Year pupil is trying to measure the speed of sound. She gets the following results.

326 m/s 351 m/s 339 m/s 347 m/s 333 m/s 334 m/s 342 m/s

a) Calculate the mean of her values.

$$\text{MEAN} = \frac{326+351+339+347+333+334+342}{7} = 338.857$$

$$= 339$$

b) Calculate the approximate random uncertainty in her mean value.

$$\text{A.R.U.} = \frac{\text{RANGE}}{\text{NUMBER}} = \frac{351-326}{7} = 3.57$$

$$= 4$$

c) State the final result of her experiment and comment on how it compares with the accepted value of 340 m/s.

FINAL RESULT IS 339 ± 4 m/s

THIS IS A GOOD RESULT AS THE ACCEPTED VALUE LIES WITHIN THE UNCERTAINTY RANGE.

4. Score out the false statements about absolute and percentage uncertainties.

a) An absolute uncertainty is just a number that tells you about the accuracy of a measurement.

b) An absolute uncertainty should always be rounded to the same number of decimal places as the measurement it describes.

c) ~~To calculate a percentage uncertainty, you divide the measurement by its absolute uncertainty and multiply by 100.~~

d) Percentage uncertainties are useful for comparing the accuracy of different measurements.

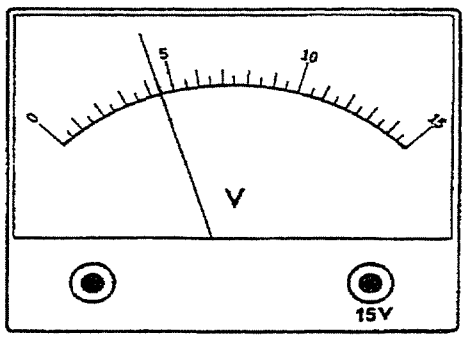
e) The percentage uncertainty in the result of a calculation should be taken as the greatest percentage uncertainty uncertainty in the measurements used in the calculation.

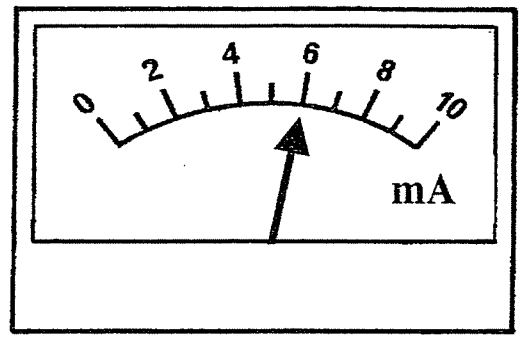
5. After doing any calculation required, state the absolute and percentage uncertainties in the experimental results described in question 3.

$$\%u = \frac{4}{339} \times 100 = 1.1799 = 1.2\%$$

absolute uncertainty = ± 4 m/s percentage uncertainty = $\pm 1.2\%$

6. The meters below show the voltage and current in a circuit to measure the power of an LED.





a) State the value of the voltage and its absolute uncertainty.

V = 4.50 ± 0.25 VOLTS (HALF SMALLEST SCALE DIVISION)

b) Calculate the percentage uncertainty in the voltage.

$\%u = \frac{0.25}{4.50} \times \frac{100}{1} = 5.6\%$

c) State the value of the current and its absolute uncertainty.

I = 6.0 ± 0.5 mA (HALF SMALLEST SCALE DIVISION)

d) Calculate the percentage uncertainty in the current.

$\%u = \frac{0.5}{6.0} \times 100 = 8.3\%$

e) Calculate the power of the LED and state the percentage uncertainty in it.

$P = IV = 6.0 \times 10^{-3} \times 4.50 = 2.7 \times 10^{-2} W = 27 mW$ $\quad \%u = \pm 8.3\%$

f) Calculate the absolute uncertainty in the power of the LED.

$u = \pm 8.3\% \times 27 mW = 2.241 = 2 mW$

7. In an experiment to measure the electrical energy used by a heater, a pupil measures the following quantities.

voltage supplied to heater = 12.0 ± 0.2 V $\quad \%u = \frac{0.2}{12.0} \times 100 = 1.7\%$

current drawn by heater = 3.0 ± 0.1 A $\quad \%u = \frac{0.1}{3.0} \times 100 = 3.3\%$ $\quad$ (E = Pt = ItV)

time heater switched on for = 100.00 ± 0.01 s $\quad \%u = \frac{0.01}{100.00} \times 100 = 0.01\%$

The formula to be used in the calculation is shown above on the right of the data.

Calculate the energy used and the absolute uncertainty in it.

$E = ItV = 3.0 \times 100.00 \times 12.0 = 3.6 \times 10^{3} J = 3.6 kJ$

$\%u$ IN $E = 3.3\%$ $\quad u = 3.3\%$ OF $3.6 kJ = 0.1188 kJ = 0.1 kJ$

$E = 3.6 \pm 0.1 kJ$