

01 Measurement review questions

Part A: Magnitude knowledge:

State to the nearest order of magnitude:

- 1) (a) size of a neutron (b) extent of the visible universe.
- 2) (a) mass of an electron (b) mass of the universe
- 3) (a) time for passage of light across a nucleus (b) age of the universe.
- 4) What is the ratio of the size of an atom (10^{-10} m) to the size of the Milky way (10^{21} m)?

Part B: Magnitude estimations - radius of Earth 6380 km – mass of Earth 6×10^{24} kg

1. How long does light take to travel across (a) a proton? (b) the Milky Way?
2. How many hydrogen atoms does it take to make up the mass of the Earth?
3. The plank length is, according to theory, the smallest possible measureable length and is equal to 1.6×10^{-35} m. What is the radius of the Earth expressed in units of the Planck length?
4. How many heartbeats are there in the lifetime of a person?
5. Using the molar mass of water of 18 g mol^{-1} , how many molecules of water are there in you?
6. Give an order of magnitude estimate of the density of a proton.
7. Write these lengths in metres: a) 5.356 nm, b) c) 3.4 mm.
8. Write these energies in Joules: a) 4.834 MJ, b) 364 GeV.
9. Write these times in seconds: a) 4.76 ns, b) 24.0 ms.
10. What is the velocity of an electron that covers a distance of 15.68 mm in 87.50 ns?

Part C: Units

- 1) State the six fundamental units and the quantities they measure
- 2) Give the equivalent in fundamental units of:
 - a. Newtons
 - b. Coulombs
 - c. Joules
 - d. Volts
- 3) What quantity is measured by kWh (Kilowatt.hour), eV, kg m s^{-1}
- 4) In an experiment speed was measured several times and was judged to be between 6.82 and 8.02 m/s. Express this as a value with: a) an absolute uncertainty b) a fractional uncertainty, c) a percentage uncertainty.
- 5) To measure the resistance of an ohmic component you use a voltmeter accurate to 3% and an ammeter accurate to 2%. a) What is the accuracy of your resistance calculation? b) How could you improve the accuracy of your result without changing the meters?
- 6) a) Explain the difference between speed and velocity with reference to horizontal circular motion at a radius of 0.5m and a rate of 3.14 rad s^{-1} .

b) Calculate the magnitude of the velocity of the circular motion in part b.

Part D Uncertainty, error, precision, accuracy.

- 1) A student is performing an experiment measuring the resistance of a thermistor (temperature dependent resistor). The thermistor is in oil whose temperature is controlled and measured.

The student has not realized that the voltmeter he is using reads a value 5% smaller than the real value.

There is variation in EMF of the power supply used.

There is a small amount of heat generated inside the thermistor.

The milli-ammeters, contacts and wires that he is using have resistance.

The ammeter records current to the nearest milliamp.

The voltmeter records voltage to the nearest one hundredth of a volt.

- a) List the systematic errors
- b) Identify the random error and state how it could be reduced without changing an apparatus.
- c) Based on the precision of the instruments state the uncertainty that should be recorded.
- d) What is the percentage uncertainty in a voltmeter reading of 0.8V?
- e) What is the percentage uncertainty in a ammeter reading of 50mA?
- f) What is the percentage uncertainty in the measured value of the resistance?
- g) If the measured resistance values are 4% different to those stated by the manufacturer of the thermistor what should the conclusion of the student be?

Part E Vectors and Scalars

- 1) Give four examples of scalar quantities and four examples of vector quantities.
- 2) A rocket is flying 500m/s at an elevation of 50° what are the vertical and horizontal components of its velocity?
- 3) An object is being pushed by two forces A and B as shown. What is the size of the resultant force?

