01 Measurement review answers

Part A: Magnitude knowledge:

State to the nearest order of magnitude:

1) (a) size of a neutron 10^{-15}m (b)extent of the visible universe. 10^{23}m
2) (a)mass of an electron 10^{-30}kg (b) mass of the universe 10^{50}kg
3) (a light across a nucleus10^{-23} s (b) age of the universe. 10^{18}s
4) What is the ratio of the size of an atom (10^{-10}m to the size of the Milky way 10^{21}m) 10^{-31}?

Part B: Magnitude estimations - radius of Earth 6380 km – mass of Earth $6x10^{24}$ kg

1. Light traversal: proton? 10^{-15}m / $3x10^{8}$ms^{-1} = $3x10^{-24}$s Milky Way? = 10^{21}m / $3x10^{8}$ms^{-1} = $3x10^{12}$s
2. Hydrogen to make up the mass of the Earth? **$6x10^{24}$kg / $1.7x10^{-27}$kg/ = $4x10^{51}$**
3. The radius of the Earth expressed in units of the Planck length? **$6.4x10^{6}$ m /$1.6x10^{-35}$m = $4x10^{41}$**
4. How many heartbeats are there in the lifetime of a person? **$80x365x24x60x60 = 2.5x10^{9}$**
5. Using the molar mass of water of 18gmol^{-1}, how many molecules of water are there in you?
   Molecules = N_A x Mass ÷ Molar mass = $6x10^{23}$ x 80 ÷ 0.018 = 3 x 10^{27}
6. Give an order of magnitude estimate of the density of a proton. (approximating a proton as a cube) = mass / volume = **$1.7x10^{-27}$kg / (**$10^{-15)3}$ = $1.7x10^{18}$ kg/m^3.
7. Write these lengths in metres: a) 5.356 nm, b) 3.4 mm. **[n:10-9, f:10-15, m:10-3]**
8. Write these energies in Joules: a) 4.834 MJ, b) 364 GeV. **[M:106, p:10-12: G:109]**
9. Write these times in seconds: a) 4.76 ns, b) 24.0 ms, **[n:10^{-9}, m:10-3]**
10. What is the velocity of an electron that covers a distance of 15.68 mm in 87.50 ns?

= $15.68x10^{-3}$m / $87.5x10^{-9}$s=$1.8x10^{5}$ ms^{-1}

http://htwins.net/scale/

Part C: Units

1) the six fundamental units. **Kilogram (mass), metre (length), second (time), ampere (current), mole (amount of substance) and kelvin (temperature).**
2) Equivalent in fundamental units of:
   Newtons -(F=ma) kgms^{-2}, Coulombs- (Q=It) As,
   Joules – (Work = F.s) kgm^{2}s^{-2} Volts: (V = E/q) kgm^{2}A^{-1}s^{-3}
3) What quantity is measured by kWh (Kilowatt.hour) - **Energy**, eV - **Energy**, kgms^{-1} **Momentum**
4) In an experiment speed was measured several times and was judged to be between 6.82 and 8.02 m/s-1. Express this as a value with: a) an absolute uncertainty b) a fractional uncertainty, c) a percentage uncertainty. **7.42 +/- 0.60, or +/- 8%**
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? **5%** b) How could you improve the accuracy of your result without changing the meters? **Make several measurements at different currents and plot a I vs V graph, 1/gradient = resistance**
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 rads-1. **Speed will be constant, velocity will have a constant magnitude but direction that rotates once every 2 seconds (tangential to the circle)**
   b) Calculate the magnitude of the velocity of the circular motion in part a.
   Speed = 0.5x3.14 = 1.57

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.

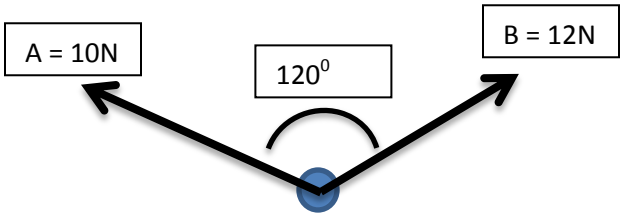
A The student has not realized the voltmeter he is using reads a value 5% smaller than the real value.
B There is variation in EMF of the power supply used.
C There is a small amount of heat generated inside the thermistor.
D The milli-ammeters, contacts and wires that he is using have resistance.
E The ammeter records current to the nearest milliamp.
F The voltmeter records voltage to the nearest one hundredth of a volt.

a) List the systematic errors: **A, C, D**
b) Identify the random error and state how it could be reduced without changing an apparatus. **B, repeat readings to reduce this error.**
c) Based on the precision of the instruments state the uncertainty that should be recorded. **+/- 1mA, +/- 0.01V**
d) What is the percentage uncertainty in a voltmeter reading of 0.8V? **100*0.01/8 = 0.1 %**
e) What is the percentage uncertainty in a ammeter reading of 50mA? **100*1/50 = 2%**
f) What is the percentage uncertainty in the measured value of the resistance? **2.1%**
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? **The systematic errors are significant.**

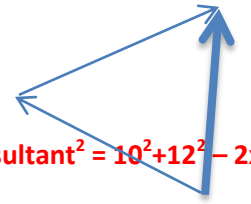
Part E Vectors and Scalars

1) Give four examples of scalar quantities and four examples of vector quantities.
Scalar : mass, density, length, speed…. Vector: displacement, force, velocity, momentum.
2) A rocket is flying 500m/s at an elevation of 50° what are the vertical and horizontal components of its velocity? **Vertical = 500sin(50 °) = 383m/s, Horizontal = 500cos(50 °) = 321m/s**
3) An object is being pushed by two forces A and B as shown. What is the size of the resultant force?

Parallel to A: Force = 10 – 12 cos(60) = 4N
Perpendicular to A: Force = 12 sin(60) = 10.4N
$\sqrt{(4^2 + 10.4^2)} = 11.1$ N



Or… $a^2 = b^2 + c^2 - 2bc \cos A$



Resultant^2 = 10^2+12^2 – 2x10x12xcos(60)

Resultant^2 = 100 + 144 – 120

Resultant = 11.0N