01 Measurement and uncertainties review answers

Part A: Measurements

1) State the six fundamental units and the quantities they measure.
Kilogram (mass), metre (length), second (time), ampere (current), mole (amount of substance) and kelvin (temperature).

2) Why have definitions of the fundamental units changed from those originally set up.
Improvements in instrumentation have allowed more accurate standards to be defined.

3) Give the equivalent in fundamental units of:
   a. Newtons **The relationship F=ma gives N = $kgms^{-2}$**
   b. Coulombs **The relationship Q=It gives C = As**
   c. Joules **The relationship Work = F.s gives J = Nm = kgm^2s^{-2}**
   d. Volts **Potential difference = E/q gives V = J/C = $kgm^2A^{-1}s^{-3}$**

4) What quantity is measured by:
   a. the electron-volt, eV **Energy**
   b. $kgms^{-1}$ **Momentum**
   c. Watt **Power**

5) A body is moving with constant speed in a horizontal circular motion at a radius of 0.5m and a rate of 3.14 $rads^{-1}$.
   a. Calculate the magnitude of the velocity of the motion: **$v = r\omega = 0.5x3.14 = 1.57ms^{-1}$**
   b. Explain why speed is constant but velocity is not. **Direction of velocity is changing**

Part B Uncertainty, error, precision, accuracy.

1) In an experiment speed was measured several times and was judged to be between 6.82 and 8.02 ms^{-1}. Express this as a value with:
   a. an absolute uncertainty range **$7.42ms^{-1}$ +/- 0.60 ms^{-1}**
   b. a fractional uncertainty **7.42 ms^{-1} +/- 0.08**
   c. a percentage uncertainty. **7.42 ms^{-1} +/- 8%**

2) To measure the resistance of an Ohmic component you use a voltmeter accurate to 0.1V and an ammeter accurate to 0.02A. The voltage reading is 4.3V and the current reading is 0.21A.
   a. State the most likely value for the resistance of the component.

      R=V/I = 4.3/0.21=20(.5) Ω [20.47]

   b. What is the absolute uncertainty of your resistance calculation?

      Maximum R = 4.4/0.19 = 23.16 Ω Minumum R = 4.2/0.23 = 18.26 Ω

      23.16-20.47 = 2.69, 20.5-18.3 = 2.21 so uncertainty is biggest of these: 2.7 Ω

   c. What is the percentage uncertainty of your resistance calculation?

(2.69/20.47) * 100 = 13%

Better: (0.1/4.3 + 0.02/0.21) * 100 = 12%

d. How could you improve the percentage accuracy of your result without changing the meters?

Take readings at higher voltage and current values and/or Make several measurements at different currents and plot a I vs V graph, 1/gradient = resistance

3) 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 that 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**

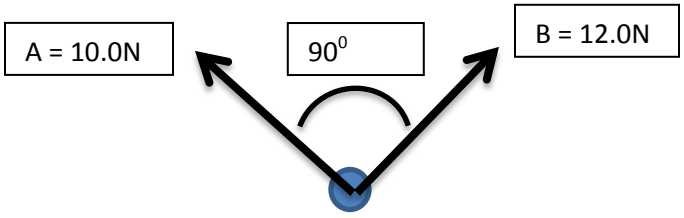
Part C Vectors and Scalars

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^{o} to the horizontal what are the vertical and horizontal components of its velocity? **Vertical = 500sin(50 ^{o}) = 383m/s, Horizontal = 500cos(50 ^{o}) = 321m/s**

3) An object is being pushed by two forces A and B as shown. What is the size of the resultant force?
By pythagorous = √(102+122) = 15.6N



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

1) What is the ratio of the size of an atom (radius=10^{-10}m) to the size of the Earth? **(2 S.F.)**
10^{-10} : $6400x10^{3}$
1 : $6.4x10^{16}$
2) The plank length is, according to theory, the smallest possible measureable length and is equal to $1.6x10^{-35}$m. What is the radius of the Earth expressed in units of the Planck length? **$6.4x10^{6}$ m /$1.6x10^{-35}$m = $4x10^{41}$**
3) How many heartbeats are there in the lifetime of a person? **80x365x24x60x60 = $2.5x10^{9}$** (number of seconds in 80 years)
4) Using the molar mass of water of 18gmol^{-1}, how many molecules of water are there in you?
5) Write these lengths in metres: a) 5.356 nm, b) c) 3.4 mm. . **[n:10-9, f:10-15, m:10-3]**
6) Write these energies in Joules: a) 4.834 MJ, b) 364 GeV. **[M:106, p:10-12: G:109]**
7) Write these times in seconds: a) 47.6 ns, b) 24.0 ms. **[a:$4.76x10^{-8}$s, b:$2.4x10^{-2}$s or 0.024s]**

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/