# SCIE1000, Tutorial Week 2, Semester 1, 2011.

## Aims

- You will continue to improve your skills at formulating models. You will need to decide what level of approximation is appropriate, and justify your choices.
- There are also questions that require you to practise manipulating units and doing numerical calculations.
- Make sure you understand how these tutorial questions relate to your overall development as a scientist. Whatever discipline you are studying, the problem-solving skills you will improve by doing these questions are very important. Everyone, no matter what their chosen profession, will need to be able to formulate models, read and understand problems that are sometimes not immediately obvious, use numerical calculations to solve them, and interpret the answers.

## Questions

1. (Final special exam, 2010. Worth 5 marks, so about 5 minutes to work.) Estimate the total amount of power used by electric lights in Australian residential homes each year. **Use units in your calculations and clearly state any values you assume.**

2. The Ideal Gas Equation gives the relationships between gas pressure, volume, amount and temperature as:
$$PV = nRT$$
where $P$ is pressure, $V$ is volume, $n$ is amount, $T$ is temperature, and $R$ is a constant.

   In a closed system, where the amount of gas does not change, the Combined Gas Law resolves to:
$$\frac{P_1 V_1}{P_2 V_2} = \frac{T_1}{T_2}.$$
   When the temperature is constant we have $P_1V_1 = P_2V_2$, which is Boyle's Law.

   When the pressure is constant we have $V_1/V_2 = T_1/T_2$, which is Charles' Law.

   When the volume is constant, we have $P_1/P_2 = T_1/T_2$, which is Gay-Lussac's Law.

   **(a)** If $P$ is measured in atmospheres (atm), $V$ in litres (L), $n$ in moles (mol) and $T$ in kelvin (K), then the value of $R$ is 0.0821 in appropriate units. Find these units.

   **(b)** A quantity of 0.25 mol of a gas occupies a volume of 545 cm$^3$ at a temperature of 25 °C. Calculate the pressure of the gas.

   **(c)** A gas has a volume of 2.5 L at a temperature of 40 °C. What will be the volume of the gas if its temperature is raised to 75 °C while its pressure is kept constant?

3. (Final exam, 2009. Worth 2 marks, so about 2 minutes to work.) The Hagen-Poiseuille equation for fluid flow through a tube is $Q = \dfrac{\Delta P \pi r^4}{8\mu L}$, where $Q$ is the flow rate in m$^3$ s$^{-1}$, $\Delta P$ is the pressure drop in Pa, $L$ is the pipe length in m, $\mu$ is the viscosity, and $r$ is the radius of the tube in m. Find the SI units for viscosity. Show all work.

4. In lectures we answered the question, "By what percentage does Peter need to increase his HDL [blood cholesterol] so that his ratio of total cholesterol to HDL equals 4". It is very unlikely that Peter can increase his HDL by the amount calculated in lectures. Assume instead that his HDL rises by 20%. By what percentage does he need to reduce his LDL so that his ratio of total cholesterol to HDL equals 4? (Assume his VLDL remains unchanged. Recall that Peter's total cholesterol was 4.7 mmol/L, with his HDL 0.9 mmol/L and his LDL 3.5 mmol/L.)

5. The ratio of volume to surface area is very important in nature. In this question you will investigate models that allow you to estimate the ratio of volume to surface area for a person.

   **(a)** **Roughly** estimate the body surface area (BSA) of one of your tutors. (Do not put a lot of time into this − the estimate should be rough.) Do this individually, then compare answers across the class.

   **(b)** Develop a simple **rough** model that will allow you to calculate the approximate volume and BSA of a human body given appropriate measurements, and hence find the ratio of volume to surface area. Justify your choice of model, explain what measurements you would require and show how to mathematically derive the volume and surface area. (Your model does not need to be too accurate, however modelling a body as a sphere or cube is **not** sufficiently accurate.)

   **(c)** Use your model to compare the volume to BSA ratios for a 1 month-old baby, an athletic 17-year old, and an overweight 50 year-old. Briefly interpret your answers. (Use units in your calculations.)

6. Two commonly used formulae for estimating the BSA $B$ in $\mathrm{m}^2$ of a person of weight $W$ in kg and height $H$ in cm are:

   - The **Mosteller formula**: $B = 0.0167\sqrt{WH}$; and
   - The **Dubois & Dubois formula**: $B = 0.007184W^{0.425}H^{0.725}$.

   **(a)** Later in semester we will see that American actress Nicole Richie was arrested for DUI (driving under the influence) in 2006. Her weight was 38.5 kg, and her height was 1.55 m. Use your model, and the two formulae given above, to estimate her BSA. Comment on any variations in your answers.

   **(b)** In the computer tutorials over the next few weeks, you will gradually develop a collection of programs that model a number of aspects of the human body. This week, you will write a program that implements the two BSA models given above. If you have time, discuss with classmates how you would approach writing such a program.

**The end**