SCIE1000 Tutorial sheet 2

This tutorial contributes toward your final grade; see the Course Profile (https://www.uq.edu.au/study/course.html?course_code=SCIE1000). The tutorial will be marked out of 6, with 3 marks for the "Before class" work, and 3 marks for the "In class" assessment and working on the remaining "In class" questions until you finish them or the tutorial ends.

Goals. This week you will continue to improve your skills at formulating models, mostly relating to body mass, volume and surface area. You will need to decide what level of approximation is appropriate in your models, and justify your choices. There are also questions that require you to practice manipulating units and doing numerical calculations.

You will gradually build up your Python programming knowledge, this week learning how to use *variables*, *functions* and the `input` command. Important new programming concepts will be introduced over the next few weeks, but will rely on you having a good understanding of the material covered in previous weeks. Always ask a tutor for help if anything is unclear.

Many of the questions on this sheet are taken directly from previous exam papers. In each case, the question shows how many marks it was worth, and hence the approximate amount of time it should take to complete under exam conditions. There are more questions on the tutorial sheet than you can finish in class; do some of the remaining ones outside class, as they provide excellent exam preparation. Make sure you understand how these questions relate to your overall development as a scientist. Whatever discipline you are studying and science profession you choose, will need to formulate models, read and understand difficult problems, use numerical calculations to solve the problems, and interpret the answers.

To be completed before class

Complete the following questions before class, write (or type if you wish) your answers on a sheet of paper, put your name and student number on the top of the paper, and hand it to your tutor as you enter the room. **If you do not hand in the answers at the start of the class, as you enter the room, then you will lose the marks for this component.** Note that in some cases there are no "right" or "wrong" answers.

Question (1)

Develop simple models that allow you **very roughly** to estimate the body volume (BV) and body surface area (BSA) of a human, **requiring only a tape measure to find lengths and distances**, **measured in metres, m**. You must use at least two measurements in your model, but not more than four. Your models do not need to be very accurate; we are only after rough estimates. Do not look up other sources such as books or the internet; the aim of this exercise is to develop the models yourself. On your sheet of paper for handing in, write down the equation(s) of your models, and a brief explanation of what values you need to know in order to apply the models. (Also, write down your models on another sheet of paper or take a photograph with your phone; you will need a copy to work with in class.)

Question (2)

For this question, you will need to read the following research article: ***Body Surface Area and Body Weight Predict Total Liver Volume in Western Adults*** (http://onlinelibrary.wiley.com/doi/10.1053/jlts.2002.31654/abstract;jsessionid=71239F7CA30FCE04BDE28CB30A
The research article was based on a study of 292 individuals. The article derives two new models for estimating the total liver volume (TLV), one based on BSA and the other on weight. (Technically, the article should refer to "mass" rather than "weight".)

1. Read the article and find the two new models of TLV. Write these models on your sheet of paper for handing in.

2. Using the model based on BSA, find the largest difference between the modelled and actual TLV for any of the 292 study participants. In your answer, write the BSA, the modelled TLV, the actual TLV, and the approximate percentage error in modelled TLV versus actual TLV. (Hint: see Figure 1 in the article.)

3. Discuss briefly (on your sheet of paper) the fact that there is such a large difference between the modelled and actual TLV for this individual. (You could consider such things as: why might the difference be so large; does the large difference mean that the model is no good; and so on.)

Question (3)

In this question you will combine parts of your answerts to Questions (1) and (2).

1. Rewrite the models from Question (2) to enable TLV to be estimated using **your** models of BV and BSA that you derived in Question (1). (You may assume that the density of a human is the same as water, 1000 kg/m^3.)

2. Hypothesise briefly (on your sheet of paper) why it is plausible that a person's total liver volume could be correlated with their BV and with their BSA.

Question (4)

Read and understand Section A.3 in the Python Appendix of the lecture notes, covering "Variables, functions and errors". (This material is in the book of lecture notes, near the end.) On your sheet of paper, write a short paragraph explaining the importance, role and use of variables in programs.

Question (5)

The research article you read in Question (2) mentions *Body Mass Index* (BMI), which is defined to be mass (in kg) divided by height squared (with height measured in m). On your sheet of paper, show how to modify the following Python program so that, in addition to the current output, it also prints the height in m, and then calculates and prints the BMI. Do this by first including two new variables, `heightM` and `BMI`. (There is no need to reproduce the existing lines of code in your answer.)

```
# A mass/height program.
from pylab import *

massKG = 38.5
heightCM = 155
print("Mass = ",massKG)
```

To be completed in class

Complete the following questions in class. They involve a mix of individual work, and discussions with others. Make sure that you read the questions before class and think about how you might approach answering them. Don't rely on someone else doing all of the work. You need to work by yourself on the final exam, so it is important that you work hard now.

Feedback: Be proactive!

Australian government research shows that students often feel they don't receive adequate feedback on their work. In a class of 800 students, it is not possible for the course coordinator to give direct feedback to each student. Instead, tutorial classes are designed to be the place in which you can get feedback on your work from classmates and the tutors. You can ask for help, show them your answers, and discuss your understanding of any of the course material. As an adult learner, the onus is on **you** to seek feedback; tutors and classmates are happy to give it, if you want it.

Question (6)

Briefly discuss with a partner the role, use and importance of variables in computer programs. Ensure that you both agree on the key points.

Question (7)

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.

1. Compare your models from Question (1) with the models your partner developed. Jointly agree on which model of BSA is "better", and which model of BV is "better". What factors did you consider when deciding which models are better? Finally, verify that the units in your final models "make sense".

2. With your partner, choose good models for BSA and BV (these may be the same as one of the models you developed, or can be variations or even completely different). Use these models to estimate the BSA and BV of your tutor. How realistic are your results?

3. Using your models from Part 2, find an expression for the ratio of volume-to-BSA for a human, and explain the units in your answer.

4. Use your model to estimate the volumes, BSAs and volume-to-BSA ratios for a 1 month-old baby, an athletic 17-year old, and an overweight 50 year-old. Write your answers on a whiteboard, in a table, along with the values from other pairs of classmates.

5. (You may need to delay answering this question until most of your classmates have written their answers on the whiteboard. While you wait, keep on answering subsequent questions.) As a group, come up with estimates of the answers to Part 4, and justify why they are reasonable values.

6. Briefly describe (in a single sentence for each) two situations in which the comparison between volumes and surface areas is important in science.

Question (8)

Two commonly used formulae for estimating the BSA (https://en.wikipedia.org/wiki/Body_surface_area) B in m^2 of a person of mass M in kg and height H in cm are:

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

The American actress Nicole Richie (https://en.wikipedia.org/wiki/Nicole_Richie) was arrested for DUI (Driving Under the Influence, or Drink Driving) in 2006. Her mass was 38.5 kg, and her height was 155 cm.

1. Use the BSA model that you and your partner developed in Question (7) Part 2 to estimate Nicole Richie's BSA (estimate any measurements you require).

2. Use the Mosteller formula and the Dubois & Dubois formula to estimate Nicole Richie's BSA.

3. Comment on the differences between the three estimates in Parts (A) and (B).

4. Find the radius of a sphere with the same volume as Nicole Richie, and find the surface area of that sphere. (Hint: first estimate her volume; note that her mass was 38.5 kg. The volume of a sphere with radius r is $4\pi r^3/3$ and the surface area of that sphere is $4\pi r^2$.)

Question (9)

In the next few questions you will develop a Python program in several stages. First, write a Python program to print the values of each of the following.

- $0.0167\sqrt{38.5 \times 155}$ (recall that Python uses `sqrt(a)` to find $\sqrt{a}$).
- $0.007184 \times 38.5^{0.425} \times 155^{0.725}$ (recall that Python uses `a**b` to find a^b).

These values are estimates of Nicole Richie's BSA, calculated using the Mosteller formula and the Dubois & Dubois formula; compare the output of your program with the values you calculated in Question (8). If the answers differ significantly, then you have made an error.

(Hint: Because this is one of the first programs you have written, here are some useful reminders. Type your program into the cell immediately below this one. We have already included the important line `from pylab import *`. When you are ready to run your program, press the Shift and Enter keys at the same time; the output will appear below your program. If you make any errors or need to make other changes, you can simply repeat the same process.)

In [ ]:
```
# Put a useful comment here.

from pylab import *

# Write your code below this line
```

Question (10)

Modify your program from Question (9) so that it now stores the estimated BSAs in variables called `BSAMos` and `BSADub` respectively, and prints both estimated values with some text (for example, `Estimated BSA using Mosteller formula is ...`). Finally, also print the **difference** between the estimated BSAs. Check that the output is correct.

(Hint: Write your new program in the cell below this one, not in the previous cell. You can copy and paste your previous program into this cell, if you wish.)

In [ ]:
```
# Write your program here... make sure you include the line: from pylab import *
```

Question (11)

Modify your program from Question (10) so that rather than "fixing" the values of the mass and height, the program instead asks the user to enter the mass (in kg) and height (in cm) from the keyboard, and then prints the two estimated BSAs and the difference between them. Test your program by inputting a mass of 38.5 kg and a height of 155 cm. (Hint: use two variables, called `mass` and `heightCM`, to store the mass and height of the person. You will need to modify the formulae in the program to use these new variables.)

In [ ]:
```
# Write your program here... make sure you include the line: from pylab import *
```

Question (12)

This question is a required, in-class assessment piece. To receive the marks for this component, you and your partner must show your answers to a tutor during your tutorial.

Modify your program from Question (11) so that it does all of the following:

- prints a suitable introductory message
- prompts the user to enter a mass in kg and a height in cm
- calculates and prints the estimated BSA using each formula, with an appropriate message
- prints the difference in estimated BSAs, with an appropriate message.

Test your program by inputting a mass of 38.5 kg and a height of 155 cm. Then use your program to estimate the BSA of the actor, ex-Californian Governor and famous body builder, Arnold Schwarzenegger (https://en.wikipedia.org/wiki/Arnold_Schwarzenegger), when he was 188 cm tall with mass 107 kg.

In [ ]:
```
# Write your program here
```

Question (13)

A "traditional" method for estimating the mass of a pig proceeds as follows:

- measure the heart girth (or cicumference) of the pig, just behind its front legs; call this measurement x; and
- measure the length of the pig from the base of its ear to the base of its tail; call this measurement y.
- if x and y are measured in inches, then the mass p of the pig, in pounds, is estimated by

$$p = \frac{x^2 y}{400}.$$

Answer each of the following questions.

1. Demonstrate how to make the dimensions on either side of this formula for p equivalent.

2. Let M be the mass of the pig expressed in kg. Write an expression for the mass p (in pounds) in terms of M. Include units in your answers. (Hint: there are 2.2 pounds per kg. Your answer should begin with "$p = \ldots$".)

3. Let G and L be the girth and length of the pig (respectively) in metres. Write an expression for the girth x (in inches) in terms of G, and an expression for the length y (in inches) in terms of L. Include units in your answers. (Hint: there are 39.4 inches per metre.)

4. Use your answers to Parts 2 and 3 to show that when the girth G and length L are measured in metres, the mass M expressed in kg is as follows (include units in your answer): $M \approx 69.5 G^2 L.$

5. Assume instead that a pig is modelled as a cylinder of circumference G metres and length L metres. Show that its estimated mass M expressed in kg is as follows (include units): $M \approx 79.6 G^2 L.$ (Hint: assume that there is 1000 kg per m^3 of pig. The circumference of a circle of radius r is $2\pi r$. The volume of a cylinder of radius r and length l is $\pi r^2 l$.)

Extra questions

Here are some extra practise questions, for you to do in class (if you have time), or outside class. You do not need to do them all, but may like to choose some to help with your preparation for the final exam.

Question (14)

(This question was on the final examination in 2013, and worth 7 marks. Expected working time for this question was about 7 minutes.)

The following information is from the year 2010.

- Population of the country Niger: 15.6 million
- Total daily consumption of refined petroleum in Niger: 5600 barrels
- Total annual electricity consumption in Niger: 702 million kilowatt hours (kWh)

Answer each of the following questions:

1. When measuring the volume of petroleum products, a *barrel* contains 159 litres. Burning a litre of petrol produces about 2.2 kg of CO_2 emissions. Calculate Niger's **annual** CO_2 emissions from using refined petroleum in 2010. Show all working, and include units in your answer.

2. In 2010, Niger's **annual, per-capita** usage of electricity was about 45, in appropriate units. Show how this figure is calculated, and find the units.

Question (15)

Question (13) gives a "traditional" method of estimating the mass of a pig. The following Python program is intended to implement this method, and estimate the mass of the pig in kg. Note that there are 2.2 pounds per kg. However the program contains five errors.

```
# This program estimates the mass of a pig using a "traditional" method.
from pylab import *
print("---Welcome to PigCalc v1.0---")

First, input the mass of the pig.
x = eval(input("Please enter the girth of the pig (in inches): "))
y = eval(input("Please enter the length of the pig (in inches): "))
MassPd = x * y/400
MassKG = MassPd * 2.2
#Finally, print the results
print("The mass is ,MassPd," kg")
```

Complete each of the following questions.

1. Identify and correct the errors.

2. Type or paste the corrected the program in the following cell and verify that it works correctly.

3. Use the program to estimate the mass (in kg) of a pig with girth 54 inches and length 48 inches.

```
In [ ]: # Write your program here
```

Question (16)

(This question was on the final examination in 2009, and worth 2 marks. Expected working time for this question was about 2 minutes.)

The Hagen-Poiseuille equation for fluid flow through a tube is

$$Q = \frac{\Delta P \pi r^4}{8 \mu L},$$

where Q is the flow rate in m^3 s^{-1}, ΔP is the pressure drop in Pa, L is the pipe length in m, μ is the viscosity, and r is the radius of the tube in m. Find the SI units for viscosity. Show all work.

Question (17)

(This question was on the final examination in 2010, and worth 4 marks. Expected working time for this question was about 4 minutes.)

Convert a pressure of 0.1267 bar to an equivalent pressure with units mm Hg. Show all work, including a dimensional analysis. (Hint: 1 mm Hg equals 1 torr; 1 torr equals 0.0193 pounds per square inch; 7.5 torr equals 10^3 Pa; 10^5 Pa equals 1 bar.)

Question (18)

The gas law for an ideal gas at temperature T (in kelvin, K), pressure P (in atmospheres, atm), and volume V (in litres, L) is $PV = nRT$ where n is the number of moles of the gas and $R = 0.0821$ (with appropriate units) is the ideal gas constant. Find the units of R.