SCIE1000 Tutorial sheet 3

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 completing the "Before class" work, and 3 marks for completing 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 work through some general calculation and discussion questions, mostly relating to Body Water Proportion and Blood Alcohol Concentration. As usual, you should recognise that the broad concepts and techniques are more important than the specific examples. Do not try to commit lots of facts to memory; instead, know **how** to do things, and **when** certain models and approaches are appropriate.

The aim of the computing component of this tutorial is to understand statements in Python that are `True` or `False`, and how to use *conditional statements* in your programs. 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.

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)

It is often useful to be able to estimate the *Body Water Proportion* (https://en.wikipedia.org/wiki/Body_water) (BWP) of an individual, which is the proportion of their mass that is water. At school you might have learned that the human body is approximately 70 % water. This is a generalisation, and in fact there is significant variation between individuals.

Three factors that influence the BWP are height, mass and gender. In each of the following cases, **assuming that both other factors remain constant**, will the stated condition **typically** increase or decrease BWP? Write each answer on your sheet of paper for handing in, with a short explanation. Also, write down your answers on another sheet of paper or take a photograph on your phone; you will need a copy to work with in class.

1. A larger mass versus a smaller mass (with height and gender unchanged).
2. A larger height versus a smaller height (with mass and gender unchanged).
3. Being female versus male (with mass and height unchanged).

Question (2)

Use your answer to Question (1) to develop a simple model that allows you **very roughly** to estimate the BWP of a human. Your model should include mass M, height H and gender G, where $G = 1$ if the person is female and $G = 0$ if the person is male. Your model will (probably) need to include constant(s) for which you will not know the value(s); use lower case letters a, b and so on as constants with unknown values in your model. (Hint: for example, if you thought that BWP is proportional to the product of mass and height, your model could be: $BWP = aMH$, where a is a constant of proportionality whose value you do not know.) Do not look up other sources such as books or the internet; the whole point is to develop the model yourself. On your sheet of paper for handing in, write down the equation(s) of your model. Also, write down your model on another sheet of paper or take a photograph on your phone; you will need a copy to work with in class.

Question (3)

Read and understand Section A.4 in the Python Appendix of the lecture notes, covering "Conditionals". (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 conditionals (`if`-statements) in programs.

Question (4)

By hand, find the output from the following partial Python program, for a person of mass of 45 kg and BWP of 0.64, after consuming 20 g of pure alcohol. Write the answer on your sheet of paper.

```
# A program to investigate Blood Alcohol Concentration (BAC)
from pylab import *

mass = eval(input("Enter mass in kg: "))
BWP = eval(input("Enter BWP: "))
alcoholG = eval(input("How much pure alcohol consumed in g: "))
waterG = BWP * mass * 1000
BACpercent = 100 * alcoholG / waterG
print("Peak Blood Alcohol content = ", BACpercent)
```

Question (5)

Write the answer to each of the following on your sheet of paper.

1. Modify the program from Question 4 so that it also does the following:
   - If BAC is 0, the words `Zero alcohol` are printed
   - If BAC is more than 0 and less than 0.05, the words `Legal to drive on an open licence` are printed
   - If BAC is 0.05 or more, the words `Not legal to drive` are printed

   (Hint: use the commands `if`, `else` and `elif`. There is no need to include the existing lines of the program in your answer.)

2. Calculate the amount of pure alcohol consumed at which this person (with mass 45 kg and BWP of 0.64) first becomes not legal to drive on an open licence.

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 conditionals. Ensure that you both agree on the key points.

Question (7)

In this question you will investigate models that allow you to estimate the Body Water Proportion (BWP) of an individual.

1. Compare your answers to Question (1) with your partner's answers. If you disagree, then decide which answers are correct. Then check your answers with another pair of classmates.

2. Compare your BWP model from Question (2) with the one your partner obtained, then agree on which model is "better", or jointly develop another model. Write your answer on a whiteboard, along with other models developed by your classmates.

3. (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, decide which models are reasonable, and justify why.

Question (8)

Body Water Proportion is a useful quantity to measure, for a range of reasons. When modelling Blood Alcohol Concentration (https://en.wikipedia.org/wiki/Blood_alcohol_content) (BAC), the BWP of an individual is commonly called the *Widmark factor* (we will see why it is called this later). The Widmark factor is commonly denoted r; here are models for estimating the values of r for females and males, where M is the mass of the person in kg and H is the height of the person in metres, m.

- For females, $r = 0.31223 - 0.006446M + 0.4466H$.
- For males, $r = 0.3161 - 0.004831M + 0.4632H$.

Answer each of the following:

1. Last week, we saw that when arrested in 2006, American actress Nicole Richie was 1.55 m tall with mass 38.5 kg. Estimate the percentage of her body mass that was water.

2. We also encountered Arnold Schwarzenegger. Estimate the percentage of his body mass that was water when he was 1.88 m tall with mass 107 kg.

3. Consider a group of males and females of varying heights, but all of whom have mass 70 kg. Find expressions for the values of r for both genders, and plot (by hand) graphs of the values of r for H between 1.4 m and 1.9 m.

4. Both expressions for r in Part 3 should be linear functions. Give some physical reasons why the y-intercepts and gradients of the (straight line) graphs of r differ between males and females.

5. Write a new Python program (in the Python cell below) to calculate modelled values of the Widmark factor r. The program must:

   - Ask the user to input the mass in kg and height in m
   - Print the message `Enter 0 for male, anything else for female:` and use an `input` statement to allow the user to input their choice
   - Calculate the value of r for a person of that gender and print the result.

6. Test your program on a female with mass 38.5 kg and height 1.55 m (Nicole Richie) and a male with mass 107 kg and height 1.88 m (Arnold Schwarzenegger), and compare your answers with the answers to Parts 1 and 2. (Don't forget to use the *Shift* and *Enter* keys at the same time to run your program.)

In [ ]:
```
# Write your program here
from pylab import *
```

Question (9)

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.

In the Python cell below, modify your program from Question (8) so that it does all of the following:

- Prints a suitable introductory message.
- Prompts the user to enter a mass in kg, a height in m, and a gender.
- Calculates and prints the estimated value of r for a person with the given mass, height and gender.
- Calculates the **total mass of water** in the person's body, and prints this value with a useful text message.
- Includes appropriate comments.

In the 1920s, "average" Australian women aged in her late 20s had a mass of 59 kg and a height of 1.61 m, and "average" men had a mass of 72 kg and a height of 1.74 m. Now, comparable women have mass 71 kg and height 1.63 m, and men have mass 85 kg and height 1.77 m. Using your program, estimate how much of the 12 kg increase in mass for women and 13 kg increase for men is water, and how much is non-water. Interpret your answers.

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

Question (10)

The rate of removal of alcohol from an individual's body is roughly constant (we will see why later in semester).

1. At 9 pm a person's Blood Alcohol Concentration (BAC) is measured to be 0.12 %, and at 11 pm it is 0.09 %. Find the rate of change of BAC $B(t)$ for this person. (Include units in your answer.)

2. Estimate the **total change** in the person's BAC between 9 pm and 12.30 pm. (Include units in your answer.)

3. Assume that it is legal for this person to drive when their BAC is less than 0.05 %. Estimate the time at which this happens, if no more alcohol is consumed.

4. Assuming that the person consumed all of the alcohol rapidly at 8 pm, draw a graph of their BAC from 8 pm until 6 am.

Question (11)

This question asks you to compare two models relating to BAC.

In lectures very early in semester we modelled the time taken for BAC for males to return to zero, using the model $t = 240n/M$, where n is the number of standard drinks consumed and M is the total mass of the male, in pounds.

In practice (particularly in legal cases), the most frequently used model of BAC is the _Widmark formula_, developed in 1932. The formula is:

$$B = \frac{A}{rM} \times 100\% - 0.015t$$

where the BAC B is measured in %, A is the amount of alcohol consumed in g, the _Widmark factor_ r is the Body Water Proportion, and M is the total mass of the person in g.

1. Rewrite the equation $t = 240n/M$ to instead include the mass of the person in g, and the mass of alcohol consumed in g. (Hint: use 2.2 pounds per kilogram, and 10 g of alcohol per standard drink.)

2. Rewrite the Widmark formula to estimate the time for BAC to return to 0.

3. Use your answers to Parts 1 and 2 to find two estimates for the time taken for BAC to return to 0 for a male with mass 107 kg, consuming 4 standard drinks. (Use $r = 0.67$ for this man.)

4. Compare the equations you used in Part 3, describing and explaining similarities and variations. Which formula appears to be more conservative when estimating time for BAC to return to 0?

Question (12)

(This question was on the final examination in 2011, and worth 10 marks. Expected working time for this question was about 10 minutes.)

1. Assume that the biomass of all of the people living on Earth were "compacted" into a cube of side s. Estimate the value of s **in km**. Show all working, list any values that you have assumed, and include units in your answer. (Hints: assume that there are no air gaps or spaces within the cube. The average density of a human is about 1000 kg per m^3. The volume of a cube of side s is s^3. There are 1000 L per m^3.)

2. Use your approach from Part 1 to write a mathematical expression for the length s of the side of the cube into which you could pack the biomass of N people.

3. Sketch a rough graph of s, showing the shape of the graph as N increases.

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 (13)

(This question was on the final examination in 2011, and worth 7 marks. Expected working time for this question was about 7 minutes.)

Recall from the tutorial sheet last week that the mass M of a pig in kg can be modelled using the equation

$$M \approx 79.6G^2L,$$

where G is the girth of the pig in m and L is the length of the pig in m.

1. On a single set of axes, roughly sketch (and label) two graphs showing M versus L for: pigs with a **fixed girth**, say G_1; and pigs with a **fixed girth**, equal to $2G_1$.

2. On another single set of axes, roughly sketch (and label) two graphs showing M versus G for: pigs with a **fixed length**, say L_1; and pigs with a **fixed length**, equal to $2L_1$.

3. Consider two pigs, P_1 and P_2, with identical estimated masses. If the radius of P_1 is 20 % larger than the radius of P_2, find the ratio of the length of P_1 to that of P_2.

Question (14)

(This question was on the final examination in 2009, and worth 5 marks. Expected working time for this question was about 5 minutes.)

In a particular region, the number of species $S_1(a)$ that occur in an area of size a in km^2 is $S_1(a) = 10a^{0.5}$.

1. A national park in this region covers 25 km^2. Find the predicted **average rate of change** in the number of species per km^2 if the size of the park is increased to 100 km^2.

2. The species diversity in a different region is given by $S_2(a) = 15a^{0.8}$. List two possible features of the second region that could explain the differences in the equations for S_1 and S_2. Briefly justify your answer.

Question (15)

Consider the following partial Python program:

```
# Program with lots of conditionals

from pylab import *

v1 = eval(input("What is v1?"))
v2 = eval(input("What is v2?"))
if (v1 == 0) and (v2 == 0):
    print("London")
elif (v1 == 0) or (v2 == 0):
    print("Athens")
elif v1 > 4:
    if v1 != v2:
        print("Paris")
    elif v1 <= 6:
        print("Amsterdam")
    else:
        print("Barcelona")
elif (v1+v2 >= 4) and (v2 <= v1):
    print("Rome")
elif v2 < 0:
    if v1+v2 > 0:
        print("Helsinki")
    else:
        print("Moscow")
else:
    print("Munich")
```

1. What will be the output if the user enters each of the pairs of values for `v1` and `v2`. (Work out your answers "by hand".)
   A. `v1` $= 0$ and `v2` $= 4$.
   B. `v1` $= 4$ and `v2` $= 3$.
   C. `v1` $= 3$ and `v2` $= 4$.
   D. `v1` $= 5$ and `v2` $= 1$.
   E. `v1` $= 0$ and `v2` $= 0$.
   F. `v1` $= 1$ and `v2` $= -1$.
   G. `v1` $= -1$ and `v2` $= 1$.

2. Find values for `v1` and `v2` that will result in the program printing:
   A. `Helsinki`
   B. `Amsterdam`
   C. `Barcelona`

3. Paste the program into the following Python cell and check your answers. If your answers disagree with the output, make sure you understand why.

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