SCIE1000 Tutorial sheet 4

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 periodic functions and seasonal change. As usual, 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 the concept of *loops* and how they relate to the idea of flow of execution, and to get some experience with using *while* loops in Python. This material is closely related to the content from last week, when we covered conditional statements. Ask your tutor if you are confused about anything.

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)

Many phenomena in nature show cyclic behaviour. For example, temperatures follow a broadly cyclic pattern during a year. Develop a simple, **very rough**, cyclic model of the maximum daily temperature in Brisbane, at any time t in months where t is between 0 (the start of January) and 12 (the start of January, one year later). 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 (2)

The University of Queensland has installed a large solar electricity generation capacity at each of its campuses. For example, there are numerous solar panels on the roof of the UQ Centre. This website (https://solar.uq.edu.au/user/reportPower.php) presents a range of real time and historical data about the amount and rate of electricity generation.

Use that website to create a graph for:

- *All sites combined*
- *All arrays combined*
- *Energy - cumulative*
- *No weather overlay*
- The year 2016.

Answer each of the following:

1. Develop a model of the data in the graph, using $\sin$, and briefly explain your model. Assume January is month number 0 in the year.

2. Give some physical reasons for the general shape of the given graph. For example, why was generation lower in June than in December? Also, why might generation have been lower in December than in October and November?

Question (3)

Read and understand Section A.5 in the Python Appendix of the lecture notes, covering "Loops". (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 loops in programs.

Question (4)

By hand, find the output from each of the three following partial Python programs. Write the answers on your sheet of paper for handing in. Also, write down your answers on another sheet of paper; you will need a copy to work with in class.

Program 1:

```
k = 0
while k <= 1:
    print(k)
    k = k + 0.5
print("done")
```

Program 2:

```
a = 2
b = 50
while b > a:
    a = a * 3
    b = b + 1
    print(a,b)
```

Program 3:

```
a = 2
b = 50
while b > a:
    a = a * 3
    b = b + 1
print(a,b)
```

Question (5)

In 1954, the band *Bill Haley and his Comets* (https://en.wikipedia.org/wiki/Bill_Haley_%26_His_Comets) released the song *Rock around the clock* (https://www.youtube.com/watch?v=zju6KbP_1xY), which commences:

> 1, 2, 3 o'clock, 4 o'clock, rock,
> 5, 6, 7 o'clock, 8 o'clock, rock,
> 9, 10, 11 o'clock, 12 o'clock, rock,
> We're gonna rock around the clock tonight.

Answer each of the following questions "by hand". You can type your code into Python later if you want to check the output. (In each case, don't worry about getting line breaks or commas correct in your output.)

1. What output is produced by the following piece of Python code.

```
i=1
while i <= 12:
    print(i," o'clock")
    i=i+1
print("We're gonna rock around the clock tonight.")
```

2. Use one or more `if`-statements to only print the word *o'clock* in the correct places for the song.

3. Show how to modify the code from Part 2 using one or more `if`-statements to print the word *rock* in the correct places for the song lyrics.

   It's not compulsory, but if you did not want to print so many line breaks in your song lyrics, then the following example shows how to stop a print statement from outputting a line break after the printed text: `print("hello",end="")`

Also, write down a copy of your program on another sheet of paper or take a photograph on your phone; you will need a copy to work with in class.

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)

1. Briefly discuss with a partner the role, use and importance of loops. Ensure that you both agree on the key points.

2. Briefly discuss your *Rock around the clock* program from Question (5) with your partner. Do your programs differ at all? If so, which components of each program are "better" than those in the other program?

3. Discuss your answers to Question (2) with your partner, and make sure you both agree with (or at least understand) the answers each of you found.

Question (7)

In this question you will investigate seasonal temperature models.

1. Compare your temperature model from Question (1) 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.

2. (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.

3. It is widely accepted that Earth is undergoing a period of rapid, human-induced climate change. There are fears that over the next century, average temperatures could rise by $4\ ^{\circ}$C. How would your model from Part 1 change if average Brisbane daily temperatures were to rise by this amount and the annual variation were to reduce by $2\ ^{\circ}$C?

Question (8)

(This question was on the midsemester examination in 2012, and worth 6 marks. Expected working time for this question was about 6 minutes.)

The *Three Gorges Dam* (https://en.wikipedia.org/wiki/Three_Gorges_Dam) is located on the Yangtze river in China, and the hydroelectric power station on the dam is the world's largest electricity power station (of any form).

Run the Python program in the following cell, which plots a graph showing the rate of generating hydroelectric power at the Three Gorges dam in 2008. (The program contains a number of Python commands we haven't yet studied; you are welcome to look at the program content if you wish.)

1. By hand, derive a function $P(t)$ that models the graph. Your function should be of the form

$$P(t) = A \sin\left(\frac{2\pi}{12}(t - S)\right) + E,$$

   where you need to find values for A, S and E.

2. The second Python cell contains a program that allows you to investigate your model. Enter your values for A, S and E near the top of the program, and when you run the program it will plot the corresponding graph of $P(t)$ as a solid, red curve. Try several different values for each of A, S and E and understand how the graph changes each time.

3. Explain briefly how your function $P(t)$ would change in the following (independent) scenarios:
   A. China undergoes a drought, with much less rain and snow than usual over the year.
   B. Winter lasted much longer than usual, with snow melting several months later.

In [ ]:

```
# Power generation, Three Gorges Dam, 2008
from pylab import *

t=arange(0,13)
actual=array([5.8,4,3.9,3.9,5,9.3,10.4,14,14.1,15.8,9.7,7,5.8])
title("Three Gorges Dam hydroelectric power generation output, 2008")
ylabel("Power output (gigawatts)")
xlabel("Month of the year")
plot(t,actual,'bx',mew=3,markersize=9,label="Average power output")
grid()
show()
```

In [ ]:
```
# Experiment with your own model of power generation, Three Gorges Dam, 2008
from pylab import *

# Enter your values for A, S and E in the next three lines.
A = 0
S = 0
E = 0

t=arange(0,13)
actual=array([5.8,4,3.9,3.9,5,9.3,10.4,14,14.1,15.8,9.7,7,5.8])
title("Three Gorges Dam hydroelectric power generation output, 2008")
ylabel("Power output (gigawatts)")
xlabel("Month of the year")
plot(t,actual,'bx',mew=3,markersize=9,label="Average power output")
#
# Plot the user's model.
#
t = arange(0,12.05,0.1)
elec = A*sin(2*pi/12 * (t-S)) + E
plot(t,elec,'r-',linewidth=3)
grid()
show()
```

Question (9)

Let B_i denote the total biomass (in kg) of a population of an organism at the start of any month i, so B_0 is the initial biomass at the start of Month 0, B_1 is the biomass at the start of Month 1, and so on. The biomass changes over time, as individuals are born, some die, and others increase or decrease in mass. Assuming that the biomass has a constant growth rate of r in a given month i, then the biomass at the start of the next month is given by $B_{i+1} = (1 + r) \times B_i$. (This is, of course, identical to the formula for interest compounding on a bank account over a single time period.)

1. On a certain coral reef, the initial biomass of a fish species is $B_0 = 100$ kg. Ecologists have shown that the monthly growth rate of the biomass is 8 % (so $r = 0.08$). Find the fish biomass at the start of each of Months 1 and 2 (that is, find B_1 and B_2). **Do not** round your answers to whole numbers.

2. In the following Python cell, write a program that uses a loop to calculate and print the values of B_i for $i = 1, 2, \ldots, 12$. Check your output for the first two months against your answers to Part 1.

3. Modify your program from Part 2 so that it uses `input` statements to obtain the initial fish biomass and the number of months to use in the loop (don't forget to prompt the user with helpful messages). Check your program by entering an initial biomass of 100 kg and choosing 12 months.

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

Question (10)

Many organisms have different population growth rates in different seasons, due to factors such as the temperature and the number of daylight hours.

Consider a population of fish in which the change in biomass per month, r_i, in Month i is given by

$$r_i = 0.04 + 0.06 \sin\left(\frac{2\pi(i-9)}{12}\right)$$

where i is the month number between 0 and 11.

1. Find the largest and smallest monthly change in biomass during the year, and the month numbers in which they occur. Interpret your answer.

2. By hand, calculate the values of r_0 and r_1.

3. In the following Python cell, write a program that uses a loop to calculate and print the values of r_i for $i = 0, 1, \ldots, 11$. Check your answers for the first two months against your answers to Part 2.

4. Explain what will happen to the values of r_i for a month with number larger than 11.

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

Question (11)

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, write a program that does all of the following (you can modify your previous programs to help):

- Prints a suitable introductory message.
- Prompts the user to enter the initial biomass in kg and the number of months.
- Uses the monthly population change formula given in Question 10 to calculate the growth rate for each month.
- Applies the appropriate monthly change to the population size for each month.
- Prints the final population size, with a suitable message.
- Includes appropriate comments.

Use your program to find the biomass of a population of fish after 24 months, for which the initial biomass is 500 kg.

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

Question (12)

1. If the wind velocity is 76.1 km/h, show that the apparent wind chill temperature W in $^\circ$C is approximately given by $W = -9.62 + 1.41t$ where t is the ambient air temperature in $^\circ$C. (Hint: $W = 13.112 + 0.6215t - 11.37v^{0.16} + 0.3965tv^{0.16}$.)

2. Using the result from Part 1, if the wind velocity is 76.1 km/h, find the ambient air temperature T for which a 5 $^\circ$C rise in ambient temperature would result in the value of W doubling.

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 midsemester examination in 2012, and worth 9 marks. Expected working time for this question was about 9 minutes.)

A recent research paper (http://www.nature.com/nclimate/journal/v2/n6/full/nclimate1453.html?message-global=remove) (from researchers in ecology at UQ) predicts the extinction rates of endemic vertebrate species in Mexican cloud forests. Here is an edited extract from that paper:

> The species-area relationship had the form of $S = cA^z$, where S is the number of species, A is habitat area and c (the y-intercept) and z (the slope) are constants. We used $z = 0.25$ given that cloud forest is a fragmented habitat with high species richness. Values of A corresponding to present cloud forest, its predicted future extent under climate change and the remaining cloud forest that overlaps protected areas are, respectively, $A_0 = 17274$ km^2, $A_1 = 5557$ km^2 and $A_2 = 151$ km^2. Values of A, together with species richness and extinction estimates for these regions (S_0, S_1 and S_2 respectively), are shown in the table.

S_0 **(number)**	A_0 **(km^2)**	S_1 **(predicted)**	A_1 **(km^2)**	S_2 **(predicted)**	A_2 **(km^2)**
37	17274	?	5557	11	151

1. Show how the authors calculated $S_2 = 11$.

2. Find the area of cloud forest that would be required to support $S = 5$ vertebrate species. Is this likely to be realistic? Why or why not?

3. Draw a rough sketch of the graph of S, marking all values that you know from earlier parts of this question.

Question (14)

Indicate which of the following segments of Python code are infinite loops and explain why. First work this out "by hand", then investigate using in the following Python cell. Note that the command `control-C` interrupts an infinite loop.

Program 1:

```
a = 1
while a <= 10:
    a = a+1
print("Done, a=",a)
```

Program 2:

```
a = 1
while a != 20:
    a = a * 2
print("Done, a=",a)
```

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

Question (15)

In the following Python cell, write a program code that uses a loop to print to the screen each of the (whole) numbers counted down from 10 to 0, printing *Ignition* when the count reaches 3, and printing *We have lift off!* when the count reaches 0.

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

Question (16)

(This question was on the final examination in 2008, and worth 8 marks. Expected working time for this question was about 8 minutes.)

A young child suffered an asthma attack and was hospitalised. The doctor used a spirometer to monitor her respiration. Her tidal volume was 0.4 L, her residual capacity 1.6 L, and a complete inhalation-exhalation cycle took 4 s.

1. Draw a rough sketch modelling her lung capacity, $V(t)$, as a function of time. (Put labels and scales on your axes, and show two full inhalation-exhalation cycles.)
2. Write an equation for $V(t)$.
3. After ventolin treatment, her respiration rate slowed to 10 breaths per minute and her tidal volume increased to 0.6 L. Write a new equation for $V(t)$.
4. Briefly describe the meaning of the changes in the values of the constants in the equations in Parts 2 and 3.

Question (17)

The planet Neptune has a similar tilt to that of Earth, so has a similar seasonal pattern (but with seasons of different durations, of course). It takes about 16 earth hours for Neptune to rotate around its axis, and about 165 earth years to revolve around the sun. Derive an equation for the number of earth hours of "daytime" on Neptune on each day of a Neptune year. You may assume that the Neptune year starts on any Neptune day that you choose.

Question (18)

Scissors-Paper-Rock (https://en.wikipedia.org/wiki/Rock%E2%80%93paper%E2%80%93scissors), or *Rock, Paper, Scissors* (https://en.wikipedia.org/wiki/Rock%E2%80%93paper%E2%80%93scissors) is a popular children's game, sometimes used by adults to determine a loser, who has to do the washing up or perform some other unpleasant task.

To play the game, two opponents simultaneously choose one of *Scissors*, or *Paper*, or *Rock*. If both opponents make the same choice, the game is tied and should be played again. Otherwise, if one player chooses *Scissors* and the other chooses *Paper*, then the player who chose *Scissors* wins. Similarly, *Paper* beats *Rock*, and *Rock* beats *Scissors*.

(The Big Bang Theory TV series proposes a variant (http://bigbangtheory.wikia.com/wiki/Rock_Paper_Scissors_Lizard_Spock) of this game.)

The following Python code allows the computer to choose one of *Scissors*, *Paper* or *Rock* at random.

```
from pylab import *

computer = randint(1,4)
if computer == 1:
    print("Computer chooses scissors")
elif computer == 2:
    print("Computer chooses paper")
else:
    print("Computer chooses rock")
```

Paste the previous code into the following Python cell , and then create a program that:

- Asks the user to input their choice of 1 (*Scissors*), 2 (*Paper*) or 3 (*Rock*)
- If the game is tied, prints out a message.
- Otherwise, identifies whether computer or the user wins the game.

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

Question (19)

Modify your program from Question (18) in the following Python cell so that the game is now played five times in succession, with a final message indicating how many games each player won, and who was the overall winner (or that the overall result was a tie).

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