10.009 The Digital World

Term 3. 2017

Problem Set 2 (for Week 2)

Last update: January 12, 2017

Due dates:

- **Problems: Cohort sessions**: Following week: Monday 11:59pm.
- **Problems: Homework**: Same as for the cohort session problems.
- **Problems: Exercises**: These are practice problems and will not be graded. You are encouraged to solve these to enhance your programming skills. Being able to solve these problems will likely help you prepare for the midterm examination.

Objectives:

1. Learn to write and use functions.
2. Learn basic techniques for program debugging.
3. Learn to input data from the keyboard and handle user input.

Note: Solve the programming problems listed below using your favourite text editor. Make sure you save your programs in files with suitably chosen names, **and try as much as possible to write your code with good style (see the style guide for python code)**. In each problem find out a way to test the correctness of your program. After writing each program, test it, debug it if the program is incorrect, correct it, and repeat this process until you have a fully working program. Show your working program to one of the cohort instructors.

Problems: Cohort sessions

1. *Functions: Temperature conversion:* Write a function named `farenheit_to_celsius`. This function takes a fahrenheit value as input and returns its centigrade equivalent. Recall: If C denotes the centigrade value and F its fahrenheit equivalent, then $F = C * 9/5 + 32$. For example:

```
>>>print fahrenheit_to_celsius(32)
0.0
>>>print fahrenheit_to_celsius(-40)
-40.0
>>>print fahrenheit_to_celsius(212)
100.0
```

2. *Functions: multivalued:* Recall the following equation that gives the height of a ball at time t when it is thrown with an initial velocity of v_0.

$$y(t) = v_0 t - \frac{1}{2} g t^2$$

Write a function named `position_velocity()` that takes v_0 and t as inputs and returns $y(t)$ and $y'(t)$, where $y'(t)$ is the first derivative of $y(t)$ with respect to t. Use your knowledge of calculus to find the formula to calculate $y'(t)$. Think of the appropriate place where you will define the gravitational constant g. Round the output to two decimal number using `round(n,d)`. Use $g = 9.81\ m\ s^{-2}$.

```
>>>print position_velocity(5.0, 10.0)
(-440.5, -93.1)
>>>print position_velocity(5.0, 0.0)
(0.0, 5.0)
>>>print position_velocity(0.0, 5.0)
(-122.62, -49.05)
```

3. *Functions: Number of years and days:* Write a function `minutes_to_years_days` that takes in minutes as its input parameter, and returns the number of years and days for the minutes. For simplicity, assume a year has 365 days. For example,

```
>>>print minutes_to_years_days(1000000000)
(1902, 214)
>>>print minutes_to_years_days(2000000000)
(3805, 63)
```

Test the function by writing a test program that prompts the user using `raw_input` to enter the minutes and print the output of the functions. Here is a sample run:

```
Enter the number of minutes: 1000000000
1000000000 minutes is approximately 1902 years and 214 days.
```

4. *Functions: Area of a Triangle:* Write a function that takes in the three points (x1,y1), (x2,y2), and (x3,y3) of a triangle and returns its area. The formula for computing the area of a triangle is

$$\begin{aligned} s &= (side_1 + side_2 + side_3)/2 \\ area &= \sqrt{s(s - side_1)(s - side_2)(s - side_3)} \end{aligned}$$

where $side_n$ is the length of one of the sides of a triangle. The three points are of the type Coordinate defined as:

```
class Coordinate(object):
  x=0
  y=0
```

To test the function, you can use the following code:

```
print "Test Case 1"
p1=Coordinate()
p1.x=1.5
p1.y=-3.4
p2=Coordinate()
p2.x=4.6
p2.y=5
p3=Coordinate()
p3.x=9.5
p3.y=-3.4

ans=area_triangle(p1,p2,p3)
print ans

print "Test Case 2"
p1=Coordinate()
p1.x=2.0
p1.y=-3.4
p2=Coordinate()
p2.x=4.6
p2.y=5
p3=Coordinate()
p3.x=9.5
p3.y=-1.4

ans=area_triangle(p1,p2,p3)
print ans

print "Test Case 3"
p1=Coordinate()
p1.x=1.5
p1.y=3.4
p2=Coordinate()
p2.x=4.6
p2.y=5
p3=Coordinate()
p3.x=-1.5
p3.y=3.4

ans=area_triangle(p1,p2,p3)
print ans
```

```
print "Test Case 4"
p1=Coordinate()
p1.x=-1.5
p1.y=3.4
p2=Coordinate()
p2.x=4.6
p2.y=5
p3=Coordinate()
p3.x=4.3
p3.y=-3.4

ans=area_triangle(p1,p2,p3)
print ans
```

The expected output should be:

```
Test Case 1:
33.6
Test Case 2:
28.9
Test Case 3:
2.4
Test Case 4:
25.38
```

Write a test program that prompts the user to enter the coordinates of the three sides and display the area. Here is a sample run:

```
Enter x coordinate of the first point of a triangle: 1.5
Enter y coordinate of the first point of a triangle: -3.4
Enter x coordinate of the second point of a triangle: 4.6
Enter y coordinate of the second point of a triangle: 5
Enter x coordinate of the third point of a triangle: 9.5
Enter y coordinate of the third point of a triangle: -3.4
The area of the triangle is 33.6
```

Tutor Submission: Submit only the function definition without the test program.

5. *Functions: Compound value:* Suppose you save $100 each month into a saving account with an annual interest rate of 5%. Therefore, the monthly interest rate is 0.05/12=0.00417. After the first month, the value in the account becomes

   $100 * (1 + 0.00417) = 100.417$

   After the second month, the value in the account becomes

   $(100 + 100.417) * (1 + 0.00417) = 201.252$

After the third month, the value in the account becomes

$(100 + 201.252) * (1 + 0.00417) = 302.507$

and so on.

```
>>>print compound_val_sixth_months(100,0.05)
608.811017706
>>>print compound_val_sixth_months(100,0.03)
605.27192977
>>>print compound_val_sixth_months(200,0.05)
1217.62203541
>>>print compound_val_sixth_months(200,0.03)
1210.54385954
```

Write a function that takes in a monthly saving amount and an annual interest rate, and returns the account value after the sixth month. Write a test program that prompts the user the monthly saving amount and displays the account value. Here is a sample run.

```
Enter the monthly saving amount: 100
Enter annual interest rate: 0.05
After the sixth month, the account value is 608.81
```

Tutor Submission: Submit only the function definition without the test program.

6. **Checkoff** Get a checkoff from an instructor by showing your test programs for Q 3, 4, and 5.

Problems: Homework

1. *Functions: Temperature conversion:* Write a function named `celsius_to_fahrenheit` that returns the fahrenheit equivalent of a centigrade value input as an argument.

```
>>>print celsius_to_fahrenheit(0)
32.0
>>>print celsius_to_fahrenheit(-40)
-40.0
>>>print celsius_to_fahrenheit(100)
212.0
```

2. *Functions: Volume of a cylinder* Write a function that takes in the radius and the length of a cylinder and returns the area and volume using the following formulas:

$$area = radius * radius * \pi$$

$$volume = area * length$$

For example,

```
>>>print area_vol_cylinder(1.0,2.0)
(3.141592653589793, 6.283185307179586)

>>>print area_vol_cylinder(2.0,2.3)
(12.566370614359172, 28.902652413026093)

>>>print area_vol_cylinder(1.5,4)
(7.0685834705770345, 28.274333882308138)

>>>print area_vol_cylinder(2.2,5.0)
(15.205308443374602, 76.02654221687301)
```

3. *Functions: Wind-chill temperature* How cold is outside? The temperature alone is not enough to provide the answer. Other factors including wind speed, relative humidity, and sunshine play important roles in determining coldness outside. In 2001, the National Weather Service (NWS) implemented the new wind-chill temperature to measure the coldness using temperature and wind speed.

$$t_{wc} = 35.74 + 0.6215t_a - 35.75v^{0.16} + 0.4275t_a v^{0.16}$$

where t_a is the outside temperature measured in Fahrenheit and v is the speed measured in miles per hour. t_{wc} is the wind-chill temperature.

Write a function that takes in a temperature between $-58°$F and $41°$F and a wind speed greater than or equal to 2 and returns the wind-chill temperature.

```
>>>print wind_chill_temp(5.3,6)
-5.56706845588

>>>print wind_chill_temp(2.2,4)
-6.34646224199
```

Write a test program that prompt the user to key in the temperature and the wind speed as follows.

```
Outside temperature in Fahrenheit: 5.3
Wind speed in  miles per hour: 6
wind chill index: -5.56707
```

Tutor Submission: Submit only the function definition without the test program.

4. *Functions: BMI:* Write a function that takes in your weight in pounds and your height in inches, and returns the Body Mass Index (BMI) of the person. The BMI can be calculated by taking the weight in kilograms and dividing it by the square of your height in meters. Note that one pound is 0.45359237 Kg and one inch is 0.0254 meters. For example:

```
>>>print bmi(120,60)
23.4356526546
>>>print bmi(100,50)
28.1227831856
>>>print bmi(200,80)
21.9709243637
>>>print bmi(95.5,50)
26.8572579422
```

Write a test program that request for weight and height from a user as follows.

```
Weight in pounds: 95.5
Height in inches: 50
BMI: 26.8573
```

Tutor Submission: Submit only the function definition without the test program.

5. *Functions: Future investment value:* Write a function that takes in an investment amount, the annual interest rate, and the number of years, and returns the future investment value using the following formula:

$$futureInvestmentValue = investmentAmount \times (1 + monthlyInterestRate)^{numberOfMonths}$$

For example:

```
>>>print investment_val(1000,4.25,1)
1043.34
>>>print investment_val(1500,3.25,2)
1600.6
>>>print investment_val(1000,2.25,0.5)
1011.3
>>>print investment_val(2000,4.25,3)
2271.46
```

Round the answer to two decimal places.

Write a test program that keys in the investment amount, annual interest rate, and the number of years. Here is a sample run:

```
Enter investment amount: 1000
Enter annual interest rate (%): 4.25
Enter number of years: 1
Accumulated value is 1043.33
```

Tutor Submission: Submit only the function definition without the test program.

End of Problem Set 2.