UNIVERSITETET I OSLO
Det matematisk-naturvitenskapelige fakultet

Examination in:	INF1100 — Introduction to programming with scientific applications
Day of examination:	Thursday, October 13, 2011
Examination hours:	15.00 − 19.00.

This examination set consists of 5 pages.

Appendices:	None.
Permitted aids:	None.

Make sure that your copy of the examination set is complete before you start solving the problems.

- Read through the complete exercise set before you start solving the individual exercises. If you miss information in an exercise, you can provide your own reasonable assumptions as long as you explain that in detail.

- The maximum possible score on the exam is 25 points. The maximum number of points is listed for each exercise (a correct answer of a subquestion ((a), (b), etc.) gives 1 point).

Exercise 1 (10 points)

What will be the output of the `print` statement in the programs below?

(a)

```
q = -0.17
print '%.1f' % q
```

(b)

```
for i in range(-2, 6, 3):
    print i-1
```

(c)

```
a = 11
b = 10/a + 1
print b
```

(Assume Python version 2.x, e.g., version 2.7.)

(d)

```
A = [-1, 1, 5] + ['plot1.eps', "plot2.png"]
del A[1]
print A
```

(e)

```
A = [-1, 9, 2, 5, 19, 21, 33]
print A[3:-2]
```

(f)

```
integers = []
value = 0
stop = 1
increment = 1
while value <= stop:
    integers.append(value)
    value += increment
for v in integers:
    print v
```

(g)

```
print [0.2*(i+1) for i in range(2)]
```

(h)

```
from math import sqrt

def f(x):
    return a*sqrt(x)

x = 6; a = -2
print '%g' % f(x + a)
```

(i)

```
for i in range(2, 4):
    for j in range(i-1, i+2):
        if i != j:
            print i, j+1
```

(j)

```
def func1(x, y):
    if x > 0:
        print 'quadrant I or IV'
    if y > 0:
        print 'quadrant I or II'

def func2(x, y):
    if x > 0:
        print 'quadrant I or IV'
    elif y > 0:
        print 'quadrant II'

for x, y in (-1, 1), (1, 1):
    func1(x,y)
    func2(x,y)
```

Exercise 2 (3 points)

The following formula finds the time t it takes (in seconds) for the center of the yolk in an egg to reach the temperature T_y (in Celsius degrees):

$$t = \frac{M^{2/3}c\rho^{1/3}}{K\pi^2(4\pi/3)^{2/3}} \ln\left[0.76\frac{T_o - T_w}{T_y - T_w}\right].$$

The symbols M, ρ, c, and K reflect physical properties of the egg (mass, density, specific heat capacity, and thermal conductivity, respectively.). Relevant values are $M = 47$ g for a small egg, $M = 57$ g for a medium-sized egg, and $M = 67$ g for a large egg; $\rho = 1.038$ g cm^{-3}; $c = 3.7$ J g^{-1} K^{-1}; and $K = 5.4 \cdot 10^{-3}$ W cm^{-1} K^{-1}. Furthermore, T_w is the temperature (in C degrees) of the boiling water ($T_w = 100$ C), and T_o is the original temperature (in C degrees) of the egg before it is put in the boiling water.

Implement the formula for t in a Python function `egg(M, To=20, Ty=70)`. Insert a doc string in the function for explaining the purpose of the calculation, what the arguments are, and what is returned. You do not need to call the `egg` function in this exercise.

Exercise 3 (3 points)

Write a program that prints out a nicely formatted table of t values, computed by the `egg` function in Exercise 2, for all combinations of the following parameters:

- M for small, medium-sized, and large egg

- T_o as 4, 12, 20, and 30 degrees Celsius

- T_y as 63 and 70 degrees Celsius (corresponding to a soft and hard boiled egg, respectively)

Exclude the combination of a soft boiled egg and $T_o = 25$ C or $T_o = 30$ C. Hint: Use nested `for`-loops with an `if`-test.

Exercise 4 (4 points)

The sine function can be approximated by a polynomial according to the following formula:

$$\sin x \approx S(x; n) = \sum_{j=0}^{n} (-1)^j \frac{x^{2j+1}}{(2j+1)!} . \tag{1}$$

The expression $(2j+1)!$ is the factorial and can be computed by the `factorial` function in the `math` module.

Write a Python function `S(x, n)` that computes and returns the value of $S(x; n)$. Show how you can verify the implementation by comparing the result of `S(x, n)` with the known expressions x and $x - \frac{1}{6}x^3$ for $n = 0$ and $n = 1$.

Exercise 5 (2 points)

Plot $\sin x$ on $[0, 4\pi]$ together with the approximations $S(x; 1)$, $S(x; 2)$, $S(x; 3)$, $S(x; 6)$, and $S(x; 12)$, where $S(x; n)$ is defined and implemented in Exercise 4. Make sure each curve is identified with a proper label. Let the y axis cover the interval $[-2, 2]$.

Exercise 6 (3 points)

Make a function for solving the system of difference equations

$$\begin{align} p_j &= p_{j-1} + q_{j-1}, \tag{2} \\ q_j &= -x^2 \left((2j+1)2j\right)^{-1} q_{j-1}, \tag{3} \end{align}$$

with initial conditions $p_0 = 0$ and $q_0 = x$. In the function, store only the newest two p_j and q_j values (i.e., do not store all the p_j and q_j values in arrays). The function should take two arguments, x and n, and return the two values p_n and $|q_n|$. Write a main program that prints out the value of p_{20} for $x = \pi$.

END