UNIVERSITETET I OSLO

Det matematisk-naturvitenskapelige fakultet

Examination in:	INF1100 — Introduction to programming with scientific applications
Day of examination:	Tuesday, October 7, 2008
Examination hours:	15.00 – 18.00.
This examination set consists of ?? 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.
- Your answer must be written on these exercise sheets, and not on separate sheets. In the exercises where you need to write program code we recommend that you first make some notes on a separate sheet of paper before you write down the final solution on these exercise sheets at the marked location.
- Some of the questions are multiple choice exercises. You get points for correct answer. There is only one correct answer in each multiple choice exercise. You will not get points if you do not mark any box or if you mark more than one of the boxes.
- If you have marked one box and afterwards regret your choice, you can write "ERROR" to the left of the box and mark another box.
- The maximum possible score on the exam is 25 points. Every multiple choice question (Exercises 1–6) answered correctly results in 1 point. Exercise 7 gives a maximum of 3 points, Exercise 8 gives a maximum of 4 points, Exercise 9 gives a maximum of 5 points, Exercise 10 gives a maximum of 5 points, while Exercise 11 gives a maximum of 2 points.

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Multiple choice exercises

Exercise 1

What will be the output of the `print` statement?

```
C = 22
F = 9*C/5 + 32
print F
```

☐ `71.6`
☐ `32`
☐ `68`
⊗ `71`

Exercise 2

For which values of `q` (a `float` or `int`) is the following boolean expression `True`?

```
q < -2 and q > 2
```

☐ All values in [-2,2]
⊗ None
☐ All finite values that can be represented on the computer
☐ All values in $[0,\infty)$

Exercise 3

Pick the construction that generates the same list `values` as the program below:

```
values = []
value = 0.5
end_value = 1
while value <= end_value:
    values.append(value)
    value += 0.1
```

☐ `[0.1*i for i in range(10)]`
☐ `range(0.5, 1.05, 0.1)`
☐ `[0.5+i for i in range(10)]`
☐ `[(i+1)*0.1 for i in range(10)]`
⊗ `[0.5+i*0.1 for i in range(6)]`

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Exercise 4

What will be the output of the `print` statement?

```
def f(x):
    return Q*x**p

Q = 4; p = 2; x = -1; z = 1
print '%g' % f(2*x - z)
```

☐ `4`
☐ `64`
☐ `-24`
⊗ `36`

Exercise 5

What will be printed by this program?

```
n = 5
C = []
for i in range(n):
    x = i**2
    C.append(i + x)
print C
```

☐ `[0, 2, 6, 12, 20, 30]`
⊗ `[0, 2, 6, 12, 20]`
☐ `[2, 6, 12, 20, 30]`
☐ `[2, 6, 12, 20, 30, 42]`

Exercise 6

What is the correct `numpy` syntax for allocating a one-dimensional array (or vector) with four elements?
⊗ `a = zeros(4)`
☐ `a = eye(4)`
☐ `a = array(4)`
☐ `a = linspace(4)`

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Programming exercises

Exercise 7

Make a Python function `sumk2(M,N)` for computing the sum $\sum_{j=M}^{N} j^{-4}$. Let the function return the sum. Also, examplify how you would call the function and store its return argument.

```
def sumk2(M, N):
    sum = 0
    j = M
    while j <= N:
        sum += j**-4
        j += 1
    return sum

result = sumk2(2, 10)
```

Exercise 8

An arbitrary triangle can be described by the coordinates of its three vertices: (x_1, y_1), (x_2, y_2), (x_3, y_3). The area of the triangle is given by the formula

$$A = \frac{1}{2}\left[x_2y_3 - x_3y_2 - x_1y_3 + x_3y_1 + x_1y_2 - x_2y_1\right] .$$

Write a function `area(vertices)` that returns the area of a triangle whose vertices are specified by the argument `vertices`, which is a nested list of the vertex coordinates. For example, `vertices` can be `[[0,0], [1,0], [0,2]]` if the three corners of the triangle have coordinates $(0, 0)$, $(1, 0)$ and $(0, 2)$. You do not need to examplify calling the function for this exercise.

```
def area(vertices):
    x1 = vertices[0][0]; y1 = vertices[0][1]
    x2 = vertices[1][0]; y2 = vertices[1][1]
    x3 = vertices[2][0]; y3 = vertices[2][1]
    A = 0.5*(x2*y3 - x3*y2 - x1*y3 + x3*y1 + x1*y2 - x2*y1)
    return A
```

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Exercise 9

Make a program that can plot the expression

$$e^{-(kx-\omega t)^2}\sin\left(kx-\omega t\right))$$

as a function of x on $[x_{\min}, x_{\max}]$ for given values of k, ω, and t. Let k, ω, t, $x_{\min}$, $x_{\max}$, and the number of x points in the plot be read from the command line. Notify the user of the program and exit in a proper way if there are not enough command-line arguments.

```
from scitools.std import *
try:
    k     = eval(sys.argv[1])
    omega = eval(sys.argv[2])
    t     = eval(sys.argv[3])
    x_min = eval(sys.argv[4])
    x_max = eval(sys.argv[5])
    n     = eval(sys.argv[6])
except:
    print 'Usage: %s k omega t x_min x_max n' %sys.argv[0]
    sys.exit(1)

x = linspace(x_min, x_max, n)
f = exp((-k*x - omega*t)**2)*sin(k*x - omega*t)
plot(x, f)
```

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Exercise 10

Make a function for solving the system of difference equations

$$s_j = s_{j-1} + a_{j-1}, \tag{1}$$
$$a_j = -x^2 \left((2j+1)2j\right)^{-1} a_{j-1}, \tag{2}$$

with initial conditions $s_0 = 0$ and $a_0 = x$. In the program, store only the newest two s_j and a_j values (i.e., do not store all the s_j and a_j values in arrays). The function should take two arguments, x and N, and return two values, s_N and a_N. Write a main program that writes out the value of s_{20} for $x = \pi$.

```
from math import pi

def S(x, N):
    sj_prev = 0
    aj_prev = x
    for j in range(1, N+1):
        sj = sj_prev + aj_prev
        aj = x**2/((2*j+1)*(2*j))*aj_prev
        sj_prev = sj
        aj_prev = aj
    return sj, aj

print S(pi, 20)
```

Exercise 11

Explain how you can test if the function developed in Exercise 10 works correctly (i.e., returns the correct result).

Compute three terms by hand and check the results. More evidence can be provided by investigating the convergence of the solutions towards $\sin(x)$.

END