15110 PRINCIPLES OF COMPUTING – SAMPLE EXAM 3 – FALL 2013

1	
2	
3	
4	
5	
6	
7	
8	
TOTAL	

Name SOLUTIONS Section _____

Directions: Answer each question neatly in the space provided.

Please read each question carefully. You have 50 minutes for this exam. No electronic devices allowed. Good luck!

1. [12 pts] This question concerns generating random numbers in Python. Recall that the Python function `randint(0, n)` returns a random integer between 0 and n, inclusive. Using the `randint` function, show how to compute the following:

1a. [2pt] A random integer between 0 and 29, including 0 and 29.

randint (0, 29)

1b. [2pt] A random integer between 6 and 12, including 6 and 12.

randint (6, 12)

1c. [3pt] A random **odd** integer between 3 and 13, including 3 and 13.

2*randint(1,6)+1

{3,5,7,9,11,13} −1
= {2,4,6,8,10,12} /2
= {1,2,3,4,5,6}

{-4,-2,0,2}+4
= {0,2,4,6} /2
= {0,1,2,3}

1d. [3pt] A random integer from the set {-4, -2, 0, 2}. You are not allowed to use any variables or data structures. Write an expression involving `randint`. 2* randint (0,3) - 4

1e. [2pt] A random string from the array `fruits` below. fruits [randint (0,4)]
or fruits [randint (0, len(fruits)-1)]

```
fruits = ["banana", "cherry", "apple", "pear", "grape" ]
```

2. [14 pts] This question concerns writing functions that involve randomness.

2a. [8 pts] Assume that `spin()` is a function that simulates a game wheel and returns a random integer between 1 and 7. Consider a single player game where the player repeatedly spins the wheel until she gets 7, recording the value spun each time. The player wins if the sum of the values spun before the value 7 (excluding 7) is greater than or equal to 30. Fill in the blanks.

```
def game1():
    sum = 0
    value = spin()
    while  value != 7  :
        sum = sum + value
        value = spin()
    if  sum >= 30  :
        return "You won."
    else:
        return "You lost."
```

2b. [3 pts] Recall that `seed(n)` is a function that seeds a random number generator with a given seed `n`. That is, for a given seed, using the `randint(0, n)` function repeatedly leads to a unique sequence of random numbers. Consider the functions `f1(x)` and `f2(x)` below and give a value for `x` such that `f1(x)` and `f2(x)` would return different results.

Answer: x = 8 or any number greater than 7

```
def f1(x):
    seed(0)
    if randint(0, 10) > 5 and x <= 7:
        print ("First random number generated.")
    return randint(0, 10)


def f2(x):
    seed(0)
    if x <= 7:
        if randint(10) > 5:
            print ("First random number generated.")
    return randint(0, 10)
```

2d. [3 pts] Explain briefly the answer you gave in part 2c.

In f2 if x > 7, randint would only be called once therefore the value returned is the first value in the sequence generated by a random number generator.

In f1, randint gets called once regardless, therefore the value returned is the second value in the sequence.

3. [6 pts] In the *Blown To Bits* reading, you learned how Google handles a search query for the World Wide Web. Describe how a search engine such as Google gathers information and stores that information so that it can efficiently search for the answers of queries. Be specific and brief.

Google crawls the web in parallel. It analyzes the information on the page to create a page rank and to determine relevance to search queries.

4. [14 pts] This question concerns networking and the Internet.

4a. [3pts] What is the purpose of an IP address? Your answer should be at most 2 sentences.

IP address is a unique identifier of a machine/device connected to the internet or local network.

4b. [4pts] A sample IP4 address may be shown as 128.237.122.178, where each group of digits is represented by one byte. Assume that first three numbers (128, 237, 122) represent the distinct network address and last number (178) represent a machine specific to that network.

each in ___.___.___.___ represents 2^8 possibilities

(i) How many distinct network addresses are possible with this format? You don't need to simplify the answer. $2^8 * 2^8 * 2^8 = 2^{24}$

(ii) How many distinct machines can be on any one of the networks? You don't need to simplify the answer. 2^8

4c. [3 pts] A telephone network is known as a circuit switching network and the Internet is known as a packet switching network. Describe the major difference between these two types of networks and why the packet switching network idea helped the rapid development of the internet. Your answer should be about 3 sentences.

A circuit switching network creates a temporary communication link between two nodes and maintains the link as long as the two nodes are connected.

A packet switching network creates no link between any two communicating nodes but is responsible for redirecting the packets from one node to another

4d. [2pts] What is a major difference between TCP protocol and UDP protocol? In what situation that one is preferred over the other? Your sentences should be 3 sentences at most.

TCP protocol assures reliable communications of packets and ensures nothing was lost during transmission.

UDP does not assure reliability so packet loss is possible but its main goal is to support synchronous communication.

4e. [2pts] We often say that the Internet is made up of core and edges. Explain briefly what this means to you. Identify one hardware element in the core and one hardware element on the edge.

The core of the internet is made up of routers, servers, and other hardware / software components. The edges are the individual computers and local networks.

5.[10 pts] This question concerns security.

5a. [2pts] What is **not** public in "public key encryption"? Circle one answer:

(a) The product of the two prime numbers used to generate the keys.
(b) The public key.
(c) The decryption algorithm.
(d) The two prime numbers used to generate the keys.

5b. [4pts] Alice and Bob want to use public key encryption to send a secret message. Assume Alice's public key is e_A and her private key is d_A, Bob's public key is e_B and his private key d_B. They both know a function `encrypt(plaintext, key)` that can be used to encrypt a message, and a corresponding function `decrypt(ciphertext, key)` to decrypt it.

Write an expression involving the `encrypt` function and the appropriate key to show how Alice would securely send the message "ready" to Bob.

encrypt ("ready", e_B)

Write an expression involving the `decrypt` function to show how Bob would decrypt the message he received from Alice. You can assume that Alice's encrypted message is stored in the variable M.

from previous q

M = encrypt("ready", e_B) · decrypt(M, d_B)

5c. [2pts] The RSA public key encryption algorithm is believed to be secure because **what** is believed to take time that is exponential in the length (number of digits) of the input?

Factoring a number

5d.[2 pts] Which of the following properties describe a one-way function. Circle one answer.

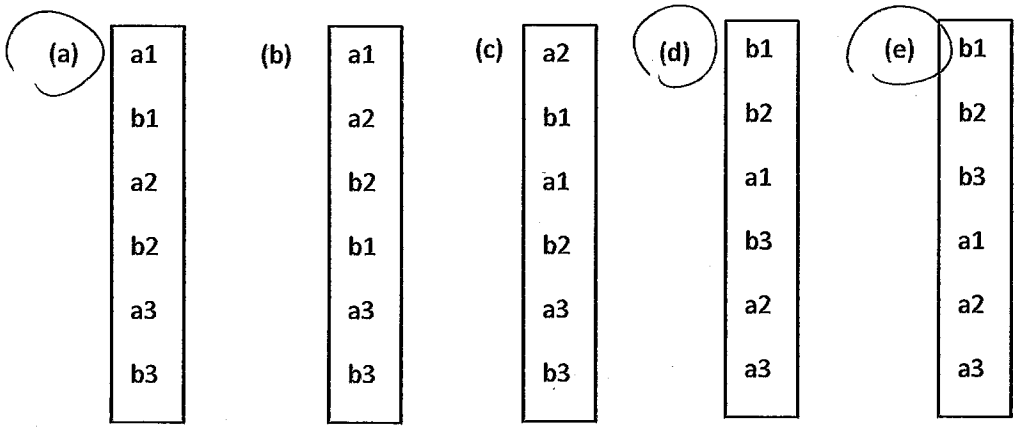
(a) It can be computed efficiently.
(b) Its inverse can be computed efficiently.
(c) Its inverse cannot be computed efficiently.
(d) Both (a) and (b)
(e) Both (a) and (c)

6. [20 pts] This question concerns concurrency.

6a. [6 pts] Consider the two sequential programs given below that are run concurrently on a single processor. The steps of the first program are written as a1, a2, and a3, and the steps of the second program are written as b1, b2, and b3.

Program 1:	Program 2:
a1	b1
a2	b2
a3	b3

Which of the following sequences of actions can arise from interleaving the steps of the two programs on a single processor? There are multiple correct answers among the 5 options. Circle all of them.



6b. [2 pts] For those answers that you did NOT circle, state briefly why they cannot arise from the two given programs.

Each program is executed sequentially so any sequence in which a1 a2 a3's and b1 b2 b3's relative ordering is not respected cannot be valid.

6c. [2 pts] Suppose that the following are the steps for executing **one instruction** on a processor and that each of these steps take 1 milliseconds to complete.

F. Fetch instruction from memory
D. Decode the instruction and fetch operands
E. Execute the instruction
W. Write the result into registers or memory

How long would it take to execute 5 instructions, one after another on a single processor?

4ms · 5 = 20 ms

6d. [2 pts] How long would it take to execute 5 instructions on 5 different processors running in parallel if we assume that all instructions start their execution at the same time?

4ms

6e. [4 pts]Pipelining is used in computers to speed up execution of instructions. If a 4-staged pipeline is used for executing an instruction on a single processor, how long would it take to have 5 instructions completed? Show your work.

1 2 3 4 5 6 7 8
F D E W
F D E W
F D E W
F D E W
F D E W

8ms

6f. [4 pts] Consider three programs running simultaneously, each wanting access to the same three databases. When a program accesses one database, it locks it so another program cannot use it. Once the program is done using the database, it unlocks the database. If a program tries to access a database and it is locked, it waits until it is unlocked. Explain how deadlock can occur for these three programs.

Program A	Program B	Program C
1. Lock DB1	1. Lock DB2	1. Lock DB3
2. Lock DB2	2. Lock DB3	2. Lock DB #1
3. Lock DB3	3. Lock DB1	3. Lock DB #2
4. Do Stuff	4. Study IIO	4. Sleep
5. Unlock DB3	5. Unlock DB1	5. ~~Loc~~ Unlock DB2
6. Unlock DB2	6. Unlock DB3	6. Unlock DB1
7. Unlock DB1	7. Unlock DB2	7. Unlock DB3

Execution Seq.

A1
B1
C1
Deadlock!

7. [16 pts] This question concerns simulation.

In a simulation of the spread of a flu virus among a population of 500 individuals, information about individuals' health is stored as integers in a 25x20 matrix using 4 for healthy (but not immune), 3 for infected (but not yet contagious), 1 or 2 for contagious, and 0 for immune. There

are functions defined to test what state an individual is in. For example, `healthy(matrix, i, j)` test if the individual at (i, j) in the matrix is healthy. For the individual at column `j` of row `i`, the following code is used during each update to determine if the person becomes infected:

```
if healthy(matrix, i, j):
    k = 0
    while k < 4:
        # contact a random person in the matrix
        if contagious(matrix, rand(25), rand(20)):
            newmatrix[i][j] = 3
        k = k + 1
```

7a. [2 pts] Based on the code given above, how does a healthy (but not immune) person get infected? Circle your answer:

(a) If at least one of four random individuals is contagious, the individual gets infected.
(b) If exactly one of four random individuals is contagious, the individual gets infected.
(c) If exactly four random individuals are contagious, the individual gets infected.
(d) None of the above.

7b. [2 pts] Based on the code given above, can a healthy individual get infected by contacting himself? Explain your answer briefly.

No, even if ~~he can~~ he/she contacts him/herself, it would not pass the contagious check.

7c. [4 pts] Define a Python function `contagious(matrix, i, j)` that returns true if and only if the individual in row `i` and column `j` is contagious. Assume `i` and `j` are valid matrix indices.

```
def contagious(matrix, i, j):
    if matrix[i][j] == 1 or matrix[i][j] == 2:
        return True
    return False
```

7d. [4 pts] Complete the following statement that sets an individual in the matrix at row `i` column `j` to immune with a probability of 25%.

```
if randint(0, 3 ) < 1 :
    newmatrix[i][j] = 0
```

7e. [4 pts] A new feature of this simulation is assigning a score to a person to indicate how healthy the surrounding neighbors are. The neighbors are the people immediately to the north, south, east and west of the person being scored. Suppose we compute this score as follows for the person in the matrix at row `i` column `j`:

```
score = matrix[i-1][j] + matrix[i+1][j] + matrix[i][j-1] +
matrix[i][j+1]
```

For what value(s) of `i` and for what value(s) of `j` does this computation fail for a matrix of people of size 25 X 20?

i: 0, 24

j: 0, 19

8. [8 pts] This question concerns AI and game trees.

Consider a game that is played by two players taking turns to choose a number between 1 and 9. A number that has previously been chosen by any player cannot be repeated. The game is won by the player who has chosen 3 numbers that sum up to 15. For example, suppose that the game unfolds by two players choosing the following numbers by taking turns. The underlined numbers in bold face are the choices of player 1 and the rest are the choices of player 2. This game has been won by player 1:
6 2 **4** 5 **8** 1 **3**. The player 1 wins because 4 + 8 + 3 = 15 and she is the first player to have chosen 3 numbers that sum up to 15.

8a. [1 pt] How many possible moves are there for player 1 in her first turn?

9

8b. [2 pts] How many possible moves are there for player 2 in her first turn?

8

8c. [5 pts] How many possible different games are there if we assume that every game ends only after all 9 numbers have been chosen? You don't need to simplify the answer.

9!