15110 PRINCIPLES OF COMPUTING – EXAM 3A – FALL 2011

1	_____
2	_____
3	_____
4	_____
5	_____
TOTAL	_____

Name _____ 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. (20 pts) This question deals with random number generators.

(a) (8 pts) Recall that the Ruby `rand(n)` function returns a random integer between 0 and `n`-1. Using the `rand` function, show how to compute the following:

A random integer between 0 and 109, inclusive. _____

A random integer between 5 and 20, inclusive. _____

A random <u>even</u> integer between 2 and 20, inclusive. _____

A random string from the array `fruit` shown below: _____

```
fruit = { "apple", "orange", "banana", "peach", "pear" }
```

(b) (3 pts) Recall the linear congruential generator formula:

$$x_{i+1} = (a \times x_i + c) \text{ modulo } m$$

If a = 2, c = 3, and m = 5, and the seed x_0 is 4, what sequence does this generator produce?

(c) (1 pt) What is the period of the generator above using the constants and seed as given? _____

(c) (8 pts) A simple game is played with 2 standard 6-sided die as follows. The player starts with a total of 100 points. The player rolls the pair of dice. If the sum is 3, 6, 9 or 12, then the player earns a "zonk"; otherwise, the player adds the sum of the 2 die to the total. Once the player gets 4 zonks, the game ends.

Assume the `roll` function is specified by the specification below:

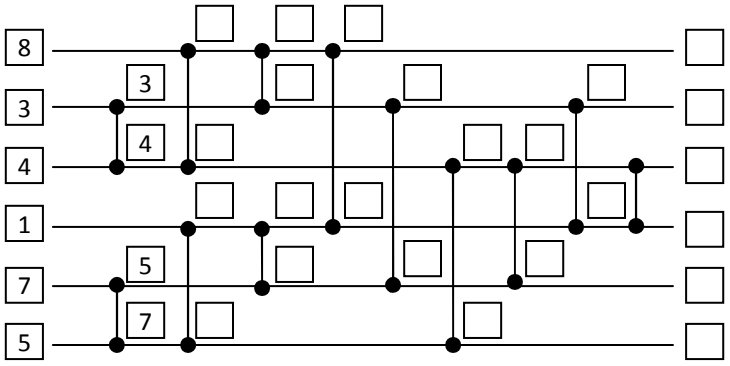
```
def roll()
```
Returns a uniformly distributed random integer between 1 and 6 for a simulated die.

Complete the Ruby function below that simulates this game using the `roll` function where appropriate.

```
def play_game()
     total = _____________
     zonks = _____________
     while ____________________________________ do
          die1 = ___________________
          die2 = ___________________
          if ________________________________________ then
               total = total + ____________________________
          else
               zonks = zonks + ____________________________
          end
     end
     return total
end
```

2. (20 pts) This problem focuses on principles of concurrency.

(a) (6 pts) Consider the following sorting network (shown as a wire diagram) that sorts 6 data values.



Show how this network sorts the values [8, 3, 4, 1, 7, 5] (as shown on the inputs of the network) by filling in each empty box in the network with its value. The first two comparisons are done for you.

(b) (4 pts) For the network shown above, assume each comparison is performed in time *t*.

How long would this sort take if each comparison is done sequentially? _____

How long would this sort take if we use concurrency to its fullest extent for this network? _____

(c) (8 pts) Manufacturing a toy requires 50 minutes in four sub-steps in the order given below:

- Glue toy piece together (10 minutes)
- Paint toy (15 minutes)
- Send toy through drying oven (20 minutes) – *only one toy can be in the drying oven at a time*
- Secure toy in package with instructions (5 minutes)

How many minutes does it take to manufacture 100 toys if we make one at a time sequentially, where we do not start the next toy until the current toy is completely finished? _____

If we used the principle of pipelining using the four stages given above, how many minutes does it take to manufacture 100 toys? _____

How is pipelining used in computers to speed up program execution?

_____

_____

(d) (2 pts) A failure or inability to proceed due to two programs or devices both requiring a response from the other before completing an operation is known by what term? _____

3. (20 pts)The following question deals with issues involving the Internet.

(a) (2 pts) Give a short one sentence definition of the term *protocol*.

_____

(b) (4 pts) Using the Transport Control Protocol (TCP), which of the following does TCP support. Answer YES or NO for each property.

Delivers an ordered stream of data even when the underlying packets are received out of order. _____

Dropped packets are not detected so streaming video can be supported. _____

A packet is acknowledged by the receiver or else the transmitter will resend the packet. _____

A duplicate packet can be detected and thrown out by the receiver. _____

(c) (4 pts) A computer is assigned the Internet Protocol (IP) address: `42.128.35.199`

Using the traditional (pre-1993) IPv4 standard, is this IP address
a class A address, class B address, or class C address? _____

How many unique IP addresses can be supported using IPv4? _____

(d) (2 pts) Suppose that ISP provider MegaNet blocks its users from seeing webpages of its competitor SuperSpeed. What commonly accepted Internet principle does this practice violate? _____

(e) (4 pts) The IETF (Internet Engineering Task Force) has a dataflow model of the internet that has four layers. Match each layer with its job.

____ Application	A. Handles the task of sending packets across one or more networks.
____ Transport	B. Handles the physical transfer and reception of bits.
____ Internet	C. Handles splitting messages into packets for delivery.
____ Link	D. Handles requests from the user for data on the Internet.

(f) (2 pts) For each of the following protocols, identify to which of the four layers it belongs.

UDP _____ HTTP _____

(g) (2 pts) Based on the principle of *abstraction*, if a new link layer protocol were introduced, programs at the applications layer would not have to be reprogrammed to work with this new protocol. Why?

_____

_____

4. (20 pts) The following question involves cryptography. For your convenience, the Vigenère table is given below.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
A	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z
B	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A
C	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B
D	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C
E	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D
F	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E
G	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F
H	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G
I	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H
J	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I
K	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J
L	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K
M	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L
N	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M
O	O	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N
P	P	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
Q	Q	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
R	R	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
S	S	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R
T	T	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
U	U	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T
V	V	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U
W	W	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
X	X	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W
Y	Y	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X
Z	Z	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y

(a) (4 pts) Decode the following word that was encoded using a Caesar cipher. (HINT: The first letter decodes to a vowel.)

J U P X A R C Q V

___ ___ ___ ___ ___ ___ ___ ___ ___

(b) (4 pts) Encode the message `TURING` using the Vigenère table with a key of `LIST`.

T U R I N G

___ ___ ___ ___ ___ ___

(c) (4 pts) Recall that strings can be treated as arrays in Ruby. For example, the following code prints out the ASCII code of each letter in the given message:

```
message = "ABCDE"
for i in 0..message.length-1 do
    print message[i], " "
end
print "\n"
```

```
65 66 67 68 69
```

Complete the following function that applies a Caesar shift to a message. You may assume that `message` contains only lowercase letters and that `shift_amount` is an integer between 1 and 25, inclusive.

```
def caesar(message, shift_amount)

      for i in 0..message.length-1 do

            message[i] = message[i] - 65

            message[i] = _____________________________________________

            message[i] = message[i] + 65

      end

      return message

end
```

(d) (8 pts) Alice and Bob want to communicate by encrypting messages using the RSA algorithm. Alice chooses the following values for her messages: d = 2753, e = 17, n = 3233. Suppose Bob wants to send the numerical message `2011` to Alice using RSA. Eve is trying to eavesdrop.

Which value(s) does Alice make public? _____

What formula does Bob compute to create the encrypted message to send to Alice? (You do not have to compute the numerical value of this formula.) _____

What formula does Alice compute to decrypt Bob's message? (Again, you do not have to compute the numerical value of this formula.) _____

If Eve gets a copy of Bob's encrypted message, which value does she need to factor into the product of two primes in order to determine Alice's decryption formula? _____

5. (20 pts) This question deals with cellular automata, simulation, and AI.

(a) (8 pts) Complete the following Ruby function to implement a cellular automata for **Rule 165**.
(Recall the powers of 2 are: 1, 2, 4, 8, 16, 32, 64, 128, …)

```
def apply_rule(automaton)

  new_automaton = Array.new(automaton.length)

  for i in 0..automaton.length-1 do

    middle = automaton[i]

    if _____________________________________________ then

        left = 0
    else
        left = automaton[i-1]
    end

    if _____________________________________________ then

        right = 0
    else
        right = automaton[i+1]
    end

    if    left==1 && middle==1 && right==1 then new_automaton[i] = _______

    elsif left==1 && middle==1 && right==0 then new_automaton[i] = _______

    elsif left==1 && middle==0 && right==1 then new_automaton[i] = _______

    elsif left==1 && middle==0 && right==0 then new_automaton[i] = _______

    elsif left==0 && middle==1 && right==1 then new_automaton[i] = _______

    elsif left==0 && middle==1 && right==0 then new_automaton[i] = _______

    elsif left==0 && middle==0 && right==1 then new_automaton[i] = _______

    elsif left==0 && middle==0 && right==0 then new_automaton[i] = _______

    end

  end

  return new_automaton

end
```

(b) (8 pts) Recall the simulation for the spread of a virus in a population. In the simulation, a code of 6 represented an individual who got the virus and is no longer contagious.

Was this simulation *time-stepped* or *event-driven*? _____

Was this simulation *grid-based* or *mesh-free*? _____

Was this simulation *deterministic* or *stochastic*? _____

Suppose that the programmer tests for the end of the simulation using the following Ruby function:

```
def done(matrix)
      for i in 0..matrix.length-1 do
            for j in 0..matrix[0].length-1 do
                  return false if matrix[i][j] != 6
            end
      end
      return true
end
```

Will this always work? Why or why not? _____

_____

(c) (4 pts) A simple MARS program to compute 3 * 8 is shown below.

```
      y     DAT #8
      x     DAT #3
      acc   DAT #0
      mult  ADD x, acc       ; add x to acc
            SUB #1, y        ; subtract 1 from y
            JMN mult, y      ; jump to mult if y != 0
            DAT #0
            end mult
```

Show how the program would be stored in the computer by filling in the missing blanks below.
HINT: MARS uses the computational principle of *relative addressing*.

```
      0000: DAT #0 #8
      0001: DAT #0 #3
      0002: DAT #0 #0

      0003: ADD _______, _______

      0004: SUB  #1   , _______

      0005: JMN _______, _______

      0006: DAT #0 #0
```