15110 PRINCIPLES OF COMPUTING – EXAM 1B – FALL 2012

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

Name _____ Section _____

Andrew id _____

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.(14 pts total) History of computation.

(a) (4 pts) Match each item in the left column with the most relevant item in the right column.

Jacquard	_____	1. bones
Babbage	_____	2. a moth
Hopper	_____	3. a mouse
Turing	_____	4. Doubling in complexity
Moore	_____	5. Leibniz
Engelbart	_____	6.Hollerith
Pascal	_____	7. Enigma cipher
Napier	_____	8. Lovelace

(b) (6 pts) We want to use the method of finite differences to create a table of numbers for the function $f(x) = -7x^2 + 2x - 5$. Compute the necessary difference functions and the initial values for x = 0 for this machine. Then fill in the table for x values from 1 to 3.

$\Delta f(x) =$ _____ x + _____

$\Delta^2 f(x) =$ _____

x	$\Delta^2 f(x)$	$\Delta f(x)$	f(x)
0			
1			
2			
3			

(c) (2 pts) 1KB of memory is $2^{\_\_\_\_}$ or _____ (decimal number) bytes.

(d) (2 pts) In 1982 a state of the art microprocessor had 100,000 transistors. According to Moore's Law, when would you expect to see microprocessors with 200,000 transistors? Compute the correct year between 1982 and 1997, and *explain your reasoning.*

_____

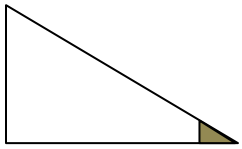
2. This problem focuses on expressions and data types.

(a) (6 pts) For each of the following Ruby expression, write down the value that would be output if the expression was evaluated in irb.

40 / 9	_____	15.0 /2	_____
2 * 2 ** 4	_____	15 % 2	_____
6 + 4 * 2 - 1	_____	2 != 2	_____

(b) (2 pts) Write a Ruby function `triangle_area` that takes two parameters `h` and `b`, respectively, for the height and base of a triangle, and returns the area of the triangle given by the formula A = ½ (height × base).

(c) (2 pts) Write a Ruby function `truncated_triangle` that takes height and base parameters (h and b) as input, and computes the area of a triangle that has the tip cut off. The tip is also a triangle; its height and base are 10% of the height and base, respectively, of the larger triangle, as shown in the figure. Use the `triangle_area` function in your solution.



(d) (2 pts)

```
def mystery1(m, n)
     i = 0
     while i <= n-1 do
       i = i + 1
       print i ** m, " "
     endfx
   end
```

The Ruby function above prints a sequence of numbers. Which of the following is the output of the function expressed in terms of m and n? Circle your answer.

1 2^m 3^m … n^m OR 1 m^2 m^3 … m^n

(e) (4 pts) If the print statement was taken outside of the while loop so that it occurred right after the while statement, as shown below, what would the function call mystery2(2, 3) print?

```
def mystery2(m, n)
  i = 0
  while i <= (n-1) do
    i = i + 1
  end
  print i ** m, " "
end
```

(f) (4 pts) Consider the following Ruby function:

```
def mystery3(m, n)
  i = 0
  result = 0
  while i <= (n-1) do
    i = i + 1
    result = result + i ** m
  end
  return result
end
```

What would the value of the variable x be after executing the following assignment statement below?

```
x = mystery3(2,4)
```

_____

(3) (20 pts total) This question focuses on the array data type and iterators.

(a) (6 pts) Assume the following list definition in Ruby using an array.

cars = [“Honda”, “Toyota”, ”Kia”, “Chrysler”, “Mercedes”]

What would be displayed in `irb` for each of the following Ruby expressions?

cars.length _____

cars.first _____

cars[1] _____

cars.include?(“Mazda”) _____

cars.include?(“KIA”) _____

cars.each { |x| print x + “*” if x > “Kia”} _____

(b) (4 pts) Assume the following list definition in Ruby using an array.

a= [1, 2, [3, 4, 5], 6]

What would be displayed in irb for each of the following Ruby expressions?

a.length _____

a.first _____

a[2] _____

a + a _____

(c) (10 pts) Assume the following list definition in Ruby using an array.

a = [2, 4, 6, 7, 8]

What would be returned in irb for if the following Ruby expressions are executed in the given order?

a.collect{ |x| x / 2 } _____

a _____

a.select{|x| x.even?} _____

a.delete_if{ |x| x % 3 == 0 } _____

Hint: delete_if is a destructive method in Ruby.

a _____

4. (20 pts total) This question focuses on looping.

(a) (8 pts) We wish to define a Ruby function `find_oddball` that takes an "almost sorted" list as input and returns the first item that is not in descending order. The function should return nil if the list is entirely in descending order. For example, `find_oddball` (24,17,5,12,1]) should return 12, since 12 is greater than the preceding item, 5. Complete the following iterative function `find_oddball`.

```
def find_oddball (list)
  index = ________
  while index < _________
    if ___________________ < ______________________ then
      return _____________
    end
  index = _____________
  end
  return __________
end
```

(b) (8 pts) Consider the following recursive algorithm for returning the first item in a list that is not in descending order, else nil. Complete the recursive definition of `find_oddball`.

1. If the list has fewer than two elements, return nil.
2. If the first element in the list is less than the second element, return the first element.
3. Otherwise return the result of a recursive call on the tail of the list (i.e., everything beyond the first element.)

```
def find_oddball (list)
  if ___________ < 2 then
    return _________
  elsif _____________ < ____________ then
    return ____________
  else
    return ____________________________
end
```

(c) (2 pts) Give an example of a six element list that would be a worst case input for `find_oddball`.

_____

(d) (2 pts) What is the big O worst case complexity of `find_oddball`?

_____

5. (20 pts) This question deals with searching and sorting.

(a) (2 pts)

What is the big O complexity of linear search? _____

What is the big O complexity of merge sort? _____

(b) (6 pts) Fill in the table below to show how binary search would locate the value "g" in the list `["a", "b", "c", "d", "e", "f", "g", "h", "i", "j", "k"]`. Use the binary search algorithm taught in the book and covered in lecture. Note: this table may contain extra rows.

Iteration	Low	High	Mid	list[mid]
1	-1	11	5	f

(c) (6 pts) For each sorting algorithm described below, give its correct name:

- For each position I in the list, find the index of the smallest item at or to the right of position I, and swap `list[i]` with `list[index_of_smallest]`.

  _____

- Organize the inputs into N groups of size 1. Systematically combine adjacent groups to form N/2 sorted groups, each of size 2. Repeat the process, combining adjacent groups of size 2 to form N/4 sorted groups of size 4. Keep going until you have one sorted group of size N.

  _____

- For each input item, find its proper position in the result list and add it at that position.

  _____

(d) (6 pts) Suppose we want to know if all the elements of a list are the same. For example, `all_same([1, 1, 1, 99, 1, 1])` returns false, but `all_same(["f","f","f","f"])` should return true. Here are two solutions. Fill in the missing elements.

```
def no_mismatch1(list)
  list.each { |x| return _______ if _______ != list[0] }
  return ______
end


def no_mismatch2 (list)
  sorted_list = list.sort
  if sorted_list[0] == sorted_list[ _______________ ] then
    return _______
  else
    return _______
  end
end
```

What is the big O complexity of no_mismatch1? _____

What is the big O complexity of no_mismatch2? _____

6. (6 pts) This question is based on your readings from the book *Blown to Bits*.

In parking garages, people with big parking bills sometimes attempt to get a second ticket at the end of their trip so that they would have to pay a smaller fee at the time of exit. What technology is used in many garages to prevent this? Give a one sentence answer.