Université d'Ottawa
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Technology and Engineering

ITI 1120 Winter 2009
Introduction to Computing I
Midterm Examination
Solution

Length of Examination: 80 minutes **Feb 25, 2009, 11:30**

Professors: Gilbert Arbez

Instructions: Please read carefully!

1. **Complete all sections of the identification area in ink.**
2. This is a closed-book test. **No books, papers, calculators or other electronic devices are permitted.**
3. Answer all questions on the question sheet in the area provided. **Questions answered in pencil will not be re-graded even if there is a marking error.**
4. The marks allocated to each question are indicated. Not all questions are worth the same amount, so plan your time accordingly. The midterm will be scored out of 40 marks, which represents 20% of your final grade.
5. Algorithms are to be described using the format from the lectures and the notes.
6. You can use the back of the question sheet pages, or page 9, for calculations and other work. Pages 9 and 10 can be detached as they will not be marked.
7. Les réponses en français sont acceptées.

Identification:

Name: _____

Student number: _____

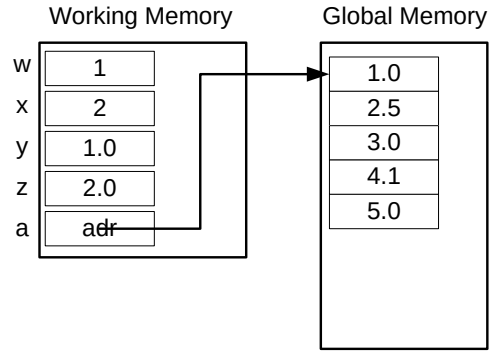
For use of grader:

Question	Marks available	Marks received
1	8	
2	10	
3	12	
4	10	
Total	40	

Question 1 (8 marks total – 4 marks for each part)

Part a)

Consider the variables found in memory as shown in the diagram to the right. Note that the variables w and x contain integer values while y, z and the array contain real values.



For each of the following expressions, write the value produced when evaluated by the computer. Be sure to indicate clearly the type of value (real values should contain a decimal point and Boolean values should be set to true or false).
Example: `x+1` 3

Expressions	Value
`w MOD x`	**1**
`a[2] ≥ z AND y ≤ a[0]`	**true**
`w + x/2`	**2**
`(a[4]+5.1) ≥ 6.5 OR a[1] ≠ y`	**true**

Part b)

The following shows the output generated during an execution of the program shown on the next page:

```
Side a
   Please give a value greater than 0: -2.1
   Please give a value greater than 0: 0
   Please give a value greater than 0: 2.5
Side b
   Please give a value greater than 0: 3.8
The hypothenuse is 4.548626
```

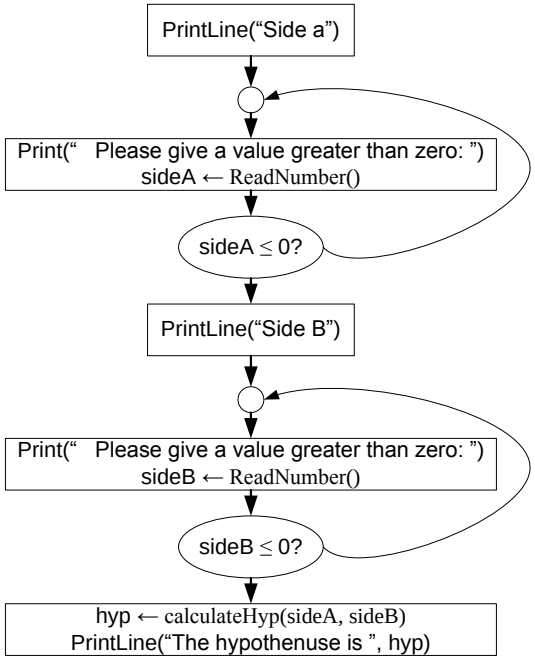
On the following page, show how the contents of the working memory are changed by the execution of the algorithm models. Show how values are passed from one algorithm model to the other using arrows. Record successive assignments to variables/parameters as follows:

Variable	~~2~~, ~~6~~, ~~4~~, 10

Computer Programming Model

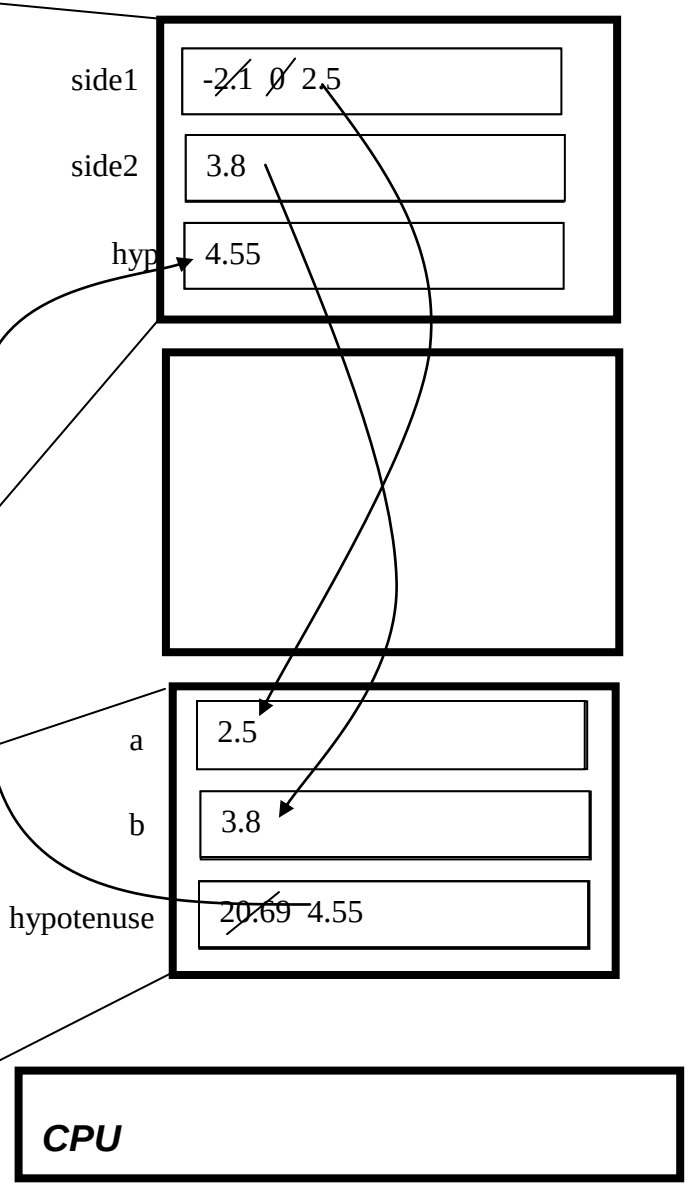
Program Memory

Intermediates:
sideA, sideB (2 sides of a right angle triangle)
hyp (hypothenuse of the triangle
Header: main
Body:



Givens: a, b (side a and side be of a right angle triangle
Results: hypotenuse (length of the hypotenuse
Assumptions: a and b are positive.
Header: hypothenuse ← calculateHyp(a, b)
Body:
hypothenuse ← a*a + b*b
hypothenuse ← $\sqrt{\text{hypotenuse}}$

Working memory



Question 2 (10 marks in total – 4+6 marks)

The following program attempts to reverse the characters inside an array. The main method obtains an array of characters from the user and then calls the method `reverse` to reverse the characters in the array. For example an array containing { ‘a’, ‘b’, ‘c’, ‘d’ } should contain { ‘d’, ‘c’, ‘b’, ‘a’ } after the call to `reverse`.

```
class Q2
{
   public static void main ( String[] args )
   {
      // DECLARE VARIABLES / DATA DICTIONARY
      char[] charArray;    // An array of characters
      int index;           // index into the array

      // Get array from the user
      System.out.print( "Enter an array of integers: " );
      charArray = ITI1120.readCharLine( );

      // Call to reverse the characters entered
      reverse(charArray);

      // PRINT the reversed list
      index = 0;
      while (index < charArray.length)
      {
         System.out.print(charArray [index] + " ");
         index = index + 1;
      }
      System.out.println();
   }
   /* Method: reverse
    * Given: list – an array of characters
    * Description: Reverses the order of characters in the array
    */
   public static void reverse(char [] list)
   {
      // Modified: list
      // Intermediates:
      char [] newList; // new array
      int ix; // index into arrays
      // No results returned
      // Body
      newList = new char[list.length];
      ix=0;
      while(ix < list.length)
      {
          newList[ix] = list[list.length - 1 - ix];
          ix = ix + 1;
      }
      list = newList;
   }
}
```

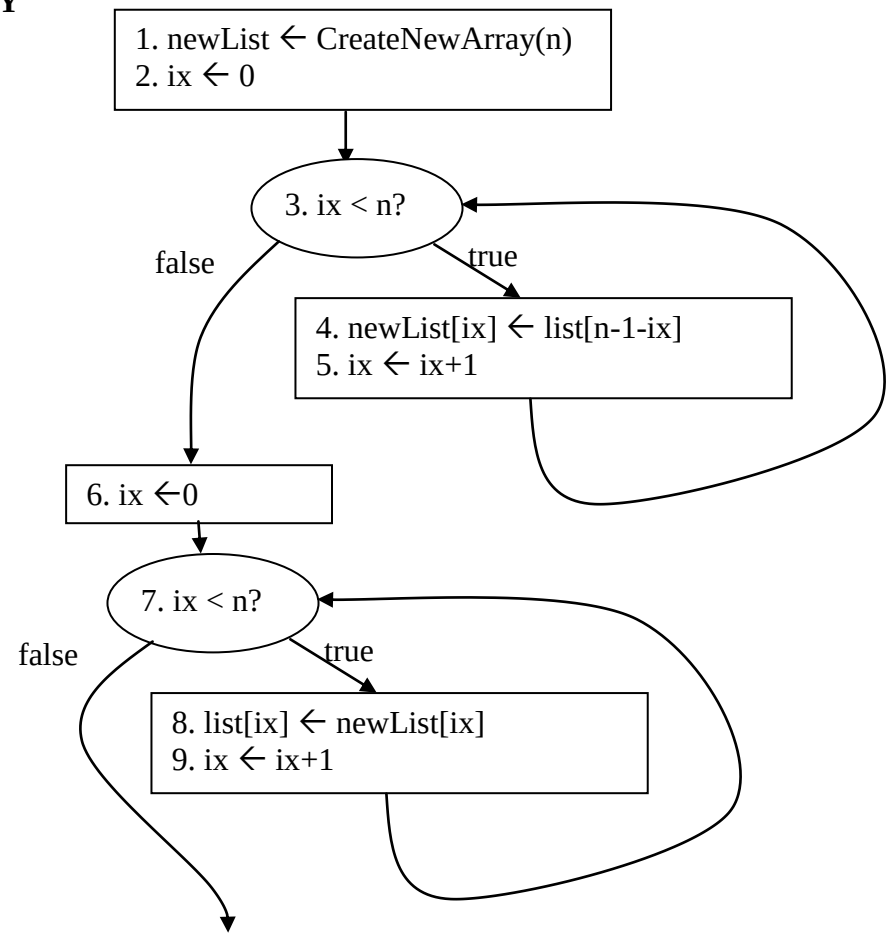
Part a) The above program does not work, explain why?

The method reverse creates a new array into which the characters are copied in reversed from the array received, which means that the array created in the main method is unaffected. Assigning newList to list does not change the charArray reference variable in main.

Part b) Develop an **algorithm model** for "*reverse*" to correct the logic error presented in part a). DO NOT give a Java method.

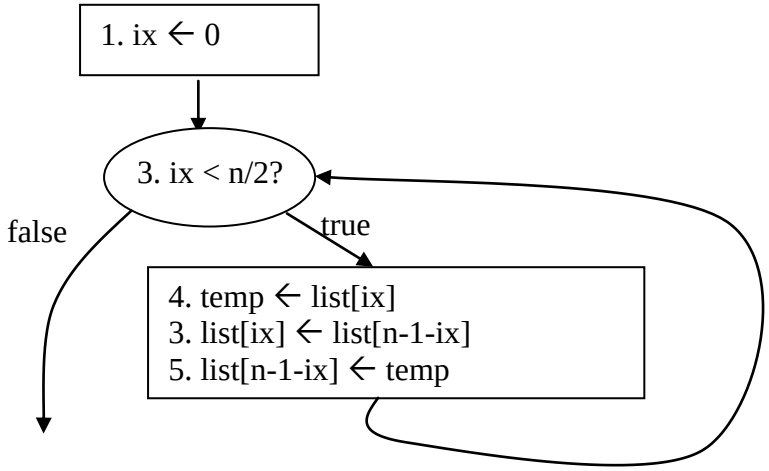
A number of approaches can be used:
1) Create the new array, and after copying the contents in reverse order, copy the contents back to the array referenced by list. Shown below.

GIVENS: list (array to reverse)
n (number of items in the array)
MODIFIED: list
INTERMEDIATE: newList (working array)
ix (index)
RESULTS: none
HEADER: reverse(list, n)
BODY



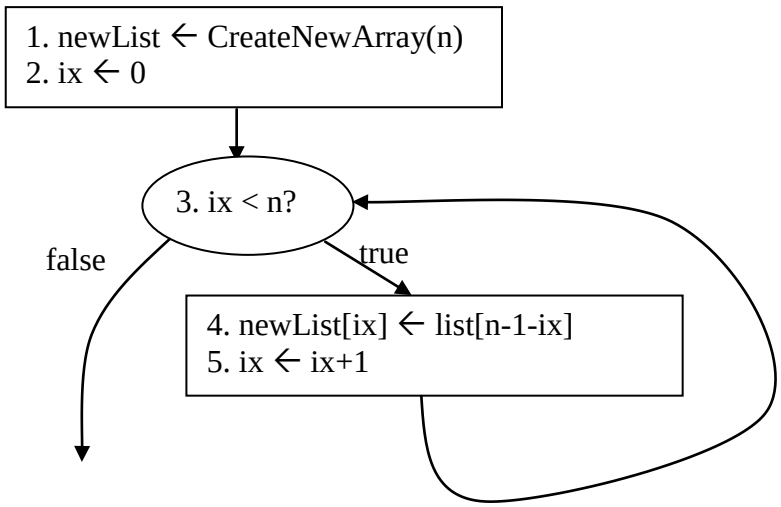
2) Reverse the contents without creating a new array (this is more challenging although the most efficient).

GIVENS: list (array to reverse)
n (number of items in the array)
MODIFIED: list
INTERMEDIATE: ix (index)
RESULTS: none
HEADER: reverse(list, n)
BODY



3) Can return the reference to the new array (the calling algorithm needs to be change to save the returned reference).

GIVENS: list (array to reverse)
n (number of items in the array)
INTERMEDIATE: ix (index)
RESULTS: newList (references new array with reversed values)
HEADER: newList ← reverse(list, n)
BODY



Question 3 (12 marks)

Translate the algorithm found in appendix A on page 10 to a Java program by completing the partially filled `main( )` method below and on the next page. You do not need to add an identification section to the program.

```
import java.util.Scanner;
class Q3
{
  public static void main(String [] args)
  {
    // setup the input
    Scanner keyboard = new Scanner(System.in);
    // Declare variables
    int num;  // number of lockers/students
    boolean isInvalidFlag;  // true when input is invalid
    int [] lockerArray;  // array of lockers
    int index;  // index for printing array
    // Constraints:  user must enter min of 10
    // Get num from the user
    do
    {
       System.out.print("Number of lockers please: ");
       num = keyboard.nextInt();
       if(num < 10)
       {
         System.out.print("Number must be at least 10: ");
         isInvalidFlag = true;
       }
       else
       {
         isInvalidFlag = false;
       }
    }
    while(isInvalidFlag);
    // Call the lockerPuzzle method
    lockerArray = lockerPuzzle(num);
    // Print the results
    for(index = 0 ; index < num ; index++)
    {
      System.out.println("Locker "+(index+1)+": "+lockerArray[index]);
    }
  }
```

```
  public static int [] lockerPuzzle(int n)
  {
     // Givens: n - number of lockers/students
     // Results
     int [] lockersArr;  // reference to an array
     // Intermediates
     int lockNum;  // locker number
     int stdntNum;  // student number
     // Body
     lockersArr = new int[n]; // creates the array
     // zero the contents of the array
     for(lockNum = 0 ; lockNum < n ; lockNum++)
       lockersArr[lockNum] = 0;
     // Have students come in
     stdntNum = 0;
     while(stdntNum < n)
     {
       // student now changes the lockers
       for(lockNum = stdntNum ; lockNum < n ; lockNum = lockNum+stdntNum+1)
       {
          lockersArr[lockNum]++;
       }
       stdntNum = stdntNum+1;  // next student
     }
     // return results
     return(lockersArr);
  }
}
```

Question 4 (10 marks)
The value of e can be approximated using the following series:

$$e = 1 + \frac{1}{1!} + \frac{1}{2!} + \frac{1}{3!} + .. + \frac{1}{i!} + ... \frac{1}{n!}$$

Develop an algorithm model that receives *n* (i.e. defines the number of terms used to compute *e*) and returns a value for *e*. Note that the term 1/*i*! is simply 1/*i*(*i*-1)!, that is the i^{th} term can be computed from the $(i-1)^{th}$ term simply by dividing it by *i*.

Given: n (defines number of terms used to compute e)
Result: e (a value for e)
Intermediate: i (used to compute n terms)
term (for computing terms)
Header: e← compute_e(n)
Body: