JOHN MONASH SCIENCE SCHOOL

VICTORIAN CERTIFICATE OF EDUCATION

2016

STUDENT NAME:

ALGORITHMICS (HESS)

Practice Exam 1

2016

Reading Time: 15 minutes
Writing time: 120 minutes

QUESTION AND ANSWER BOOK

Structure of book

Section	*Number of questions*	*Number of questions to be answered*	*Number of marks*
A	20	20	20
B	12	12	80
		Total	100

- Students are permitted to bring into the test room: pens, pencils, highlighters, erasers, sharpeners, rulers and one scientific calculator.
- Students are NOT permitted to bring into the examination: blank sheets of paper and/or correction fluid/tape.

Materials supplied

- Question and answer book of 23 pages.
- Answer sheet for multiple-choice questions.

Instructions

- Write your name in the space provided above on this page.
- All written responses must be in English.

At the end of the examination

- Place the answer sheet for multiple-choice questions inside the front cover of this book.

Students are NOT permitted to bring mobile phones and/or any other unauthorised electronic devices into the examination room.

SECTION A – Multiple-choice Questions

Instructions for Section A

Answer **all** questions in pencil on the answer provided for multiple-choice questions.
Choose the response that is **correct** or that **best answers** the question.
A correct answer scores 1, an incorrect answer scores 0.
Marks will **not** be deducted for incorrect answers.
No marks will be given if more than one answer is completed for any question.

Question 1

Which of the following is not an example of an algorithm design pattern?

A. Brute Force

B. Greedy

C. Black Box

D. Transform and Conquer

Question 2

The most appropriate algorithm to use when determining the length of the shortest path from a single node to any other node in a given graph is:

A. Bellman-Ford Algorithm

B. Dijkstra's Algorithm

C. Prim's Algorithm

D. Floyd-Warshall Algorithm

Question 3

```
S.push(2)
S.push(3)
S.pop()
S.push(2)
S.pop()
S.push(3)
```

Given an empty stack, S, what does S look like after the operations above?

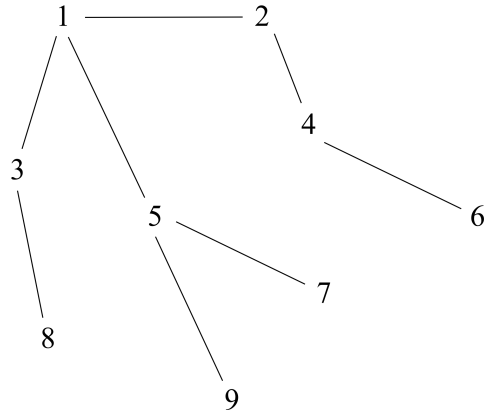
A. 2, 3, 3

B. 2, 2

C. 2, 3

D. 2, 3, 2, 3

Use the following information to answer Questions 4 and 5



Question 4

The first 6 nodes visited in a Depth-First Search, starting at node 1, could be

A. 1, 2, 5, 3, 4, 8,

B. 1, 2, 3, 5, 4, 8

C. 1, 2, 3, 4, 5, 6

D. 1, 2, 4, 6, 3, 8

Question 5

The first 6 nodes visited in a Breadth-First Search, starting at node 1, could be

A. 1, 2, 5, 3, 4, 8,

B. 1, 2, 3, 5, 4, 8

C. 1, 2, 3, 4, 5, 6

D. 1, 2, 4, 6, 3, 8

Question 6

A loop invariant is:

A. a condition that holds true at the beginning, during and at the end of each iteration of a loop

B. a condition that holds true at the beginning and end of each iteration of a loop

C. a condition that holds true at the beginning and end of each iteration of a loop until the termination condition for the loop is met

D. an algorithm design pattern that does not use nested loops

Question 7

Which of the following is **NOT** an example of a Black-Box Testing technique?

A. Pair-Wise Testing

B. Error Testing

C. Path Coverage

D. Edge Case Testing

Question 8

The PageRank Algorithm is used for:

A. Ranking the importance of a page from a Harry Potter book to the progression of the overall story

B. Estimating the importance of a node in a digraph based on the number of nodes it connects to

C. Estimating the importance of a node in a digraph based on the number of nodes connecting to it

D. Estimating the importance of a node in a digraph based on the number and importance of the nodes connected to it

Question 9

The minimal spanning tree of a graph is best described as:

A. The set of edges with minimal weightings that result in all vertices of the graph being connected such that a path exists between them.

B. The set of edges that result in the shortest path between the start and end node of the graph

C. The set of edges that result in the shortest Hamiltonian-Path around the graph

D. The set of edges with minimal weightings that result in all nodes being connected by a Eulerian-Path

Question 10

A certain algorithm has a recurrence relation given by:

$$T(n) = \begin{cases} O\left(n^2\right) + 3T\left(\frac{n}{2}\right) & , \quad n > 1 \\ O(1) & , \quad n = 1 \end{cases}$$

Which one of the following is the time complexity of this algorithm?

A. $O(1)$

B. $O\left(n^2\right)$

C. $O\left(n^2 \log(n)\right)$

D. $O\left(n^{\log_2(3)}\right)$

Question 11

A Turing Machine is best described as:

A. A hypothetical machine that can solve any problem

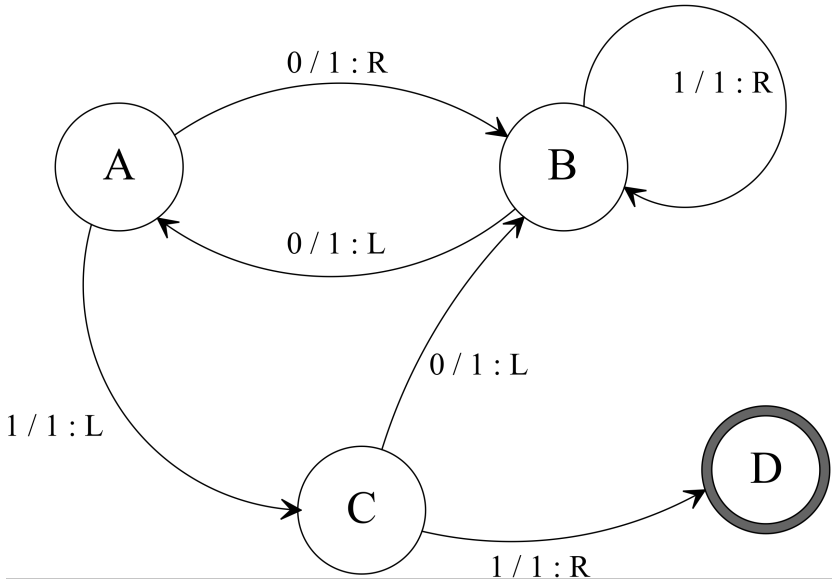
B. A hypothetical machine that can follow a set of predefined rules which allow it to compute any computable problem

C. A hypothetical machine that consists of a reader, writer and infinitely long piece of tape with 1's and 0's on it, which can be used to compute any problem

D. A hypothetical machine that can't spell but is part of a band that has had a song reach number one on the country's music charts

Use the following information to answer Questions 11 and 12

A Turing Machine is configured with the instructions represented in the state diagram below.



Each edge is labelled i / j : k, where:

- i is the input
- j is the output
- k is the direction the head moves (L = left, R = right) after the output.

The machine starts in state A.

The machine is given the following tape. For this machine, the tape remains stationary while the head moves. The arrow shows the starting point of the head.

	0	0	0	0	0	0	0	0	

Question 12

After the fourth step, the Turing Machine will be in:

A. In state C and the head will be one position to the left

B. In state A and the head will be three positions to the left

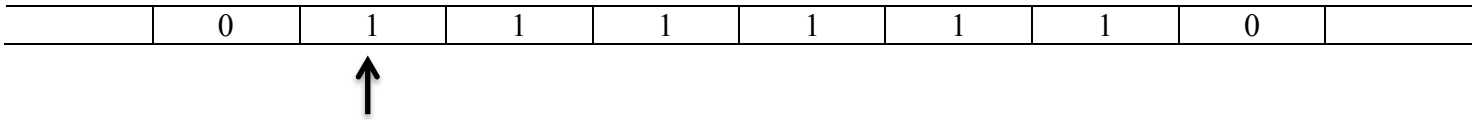
C. In state B and the head will be two positions to the left

D. In state B and the head will be one position to the right

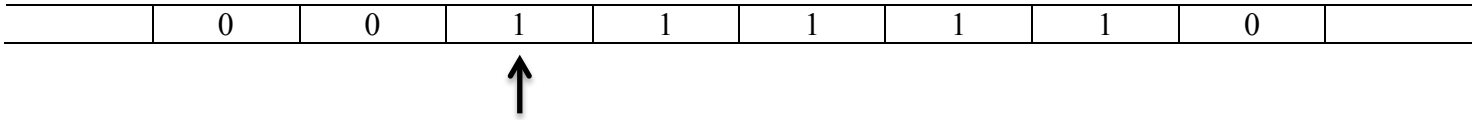
Question 13

Which one of the following best represents the tapes appearance and the position of the head when the Turing Machine halts?

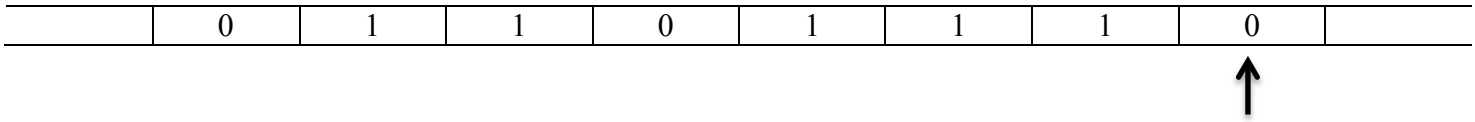
A.



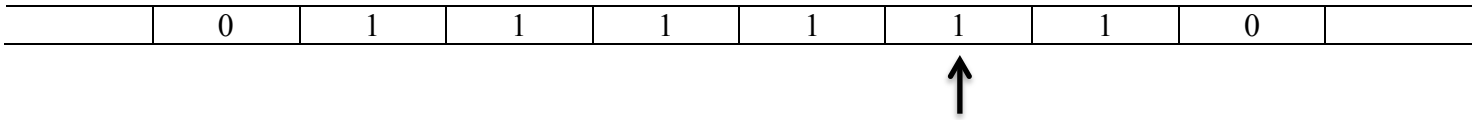
B.



C.



D.



Question 14

Consider the following pseudocode.

```
num_days = n
num_apples = 100
num_worms = 1
for i = 0 to i = n
        if num_apples > 0
            num_apples = num_apples - num_worms
            num_worms = num_worms * 2
        else
            break
return num_apples
return num_days
```

The run time is best described as:

A. $O(n)$

B. $O(1)$

C. $O(n^2)$

D. $O(\log(n))$

Question 15

Mergesort is an example of a:

A. Backtracking algorithm

B. Dynamic Programming algorithm

C. Transform and Conquer algorithm

D. Divide and Conquer algorithm

Question 16

Hilbert's program was an attempt to:

A. find a solution to the Halting Problem using Turing Machines

B. define the nature of what is computable and what is not

C. create a finite set of axioms that were consistent and could form the basis of all mathematical theory

D. write down an infinite set of axioms that were consistent and that could describe all existing and future mathematical theory

Question 17

Which of the following is **NOT** an example of an NP problem?

A. Finding the optimum solution to the travelling salesman problem with *n* nodes

B. Finding all possible arrangements of *n* people in a photograph

C. Finding the maximum sized elephant in an unordered list of *n* elephants

D. Finding the best way to colour in a map of a fictional set of *n* countries so that no two adjoining countries are the same colour and so that you use the least amount of colours possible

Question 18

If a program is said to be Turing Complete then:

A. anything that the program can do can also be done by a Turing Machine in finite time and space

B. anything that the program can do can also be done by a Turing Machine (although the Turing Machine might require infinite time and/or space to do so)

C. it can complete/solve any problem in polynomial time

D. It is known that for all inputs, the program will halt

Question 19

For which of the following games would the use of the Minimax Algorithm not be appropriate?

A. Tic-Tac-Toe

B. Connect Four

C. Checkers

D. Scrabble

Question 20

John Searle's Chinese Room Argument suggests:

A. that computers are not, nor will ever be, capable of understanding

B. that computers are capable of understanding

C. that understanding is only possible if you can read and speak Chinese

D. that only Michael understands Algorithmic

END OF SECTION A
TURN OVER

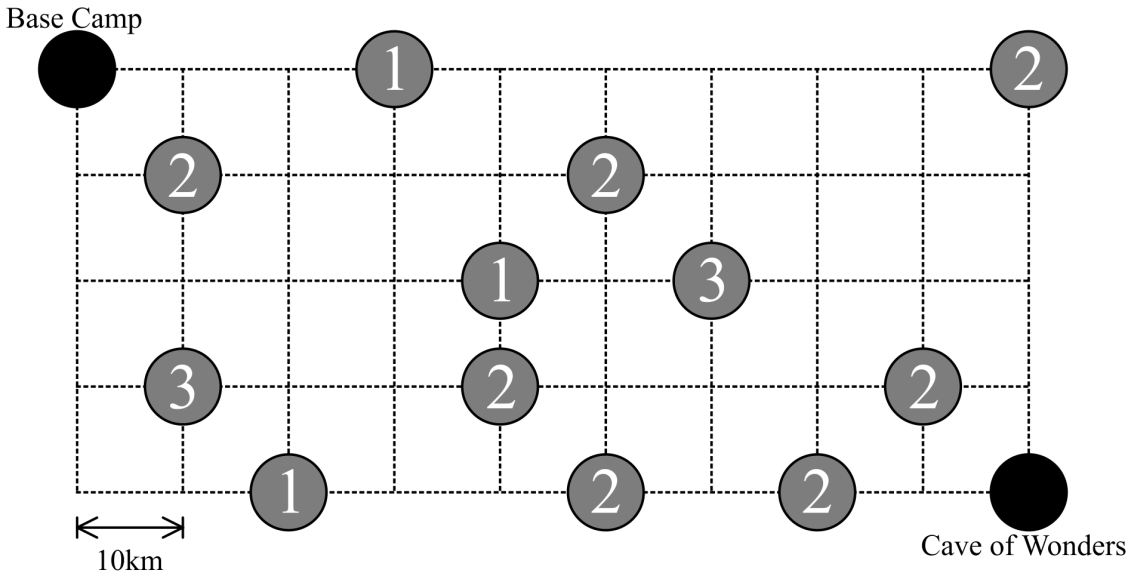
SECTION B

Instructions for Section B
Answer **all** questions in the spaces provided

Question 1 (4 marks)

Bartholomew Highlander is on an adventure to find the long lost golden sphinx of Antarctica. In order to find the golden sphinx, he has to travel from his base camp to the 'Cave of Wonders' which is located in the middle of the Antarctic Desert.

Petrol stations are scarce in the Antarctic Desert so Bartholomew needs to plan his trip carefully. The diagram below shows the location of the few petrol stations in the Antarctic Desert as well as a number that represents how much fuel, in litres, they can provide to Bartholomew.



Bartholomew starts his journey across the Antartic Desert with 3 Litres of fuel in his snow speeder. The snow speeder uses 1 Litre per 10 kilometers.

As shown in the diagram, each grid line is 10 kilometers in height and in width. Assume that Bartholomew can only travel along the grid lines and that he can store as much fuel as he can pick up along the way.

Describe an algorithm that could be used to help Bartholomew determine the path he should take to get from his base camp to the 'Cave of Wonders' if he wishes to use the minimum amount of fuel possible (he's environmentally aware). In your answer, explain how the algorithm would meet Bartholomew's needs.

Question 2 (11 marks)

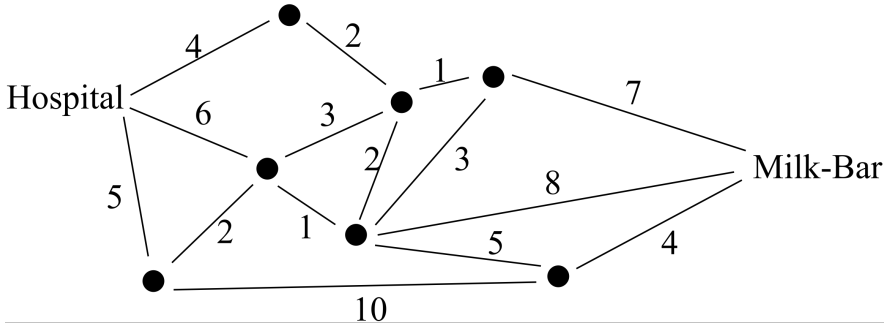
Nisura dislikes mornings immensely, and will often skip breakfast because he sleeps in. On his way to school he passes by a local milk-bar where he usually likes to buy a Big-M.

One day, whilst he is waiting in line to buy his Big-M, Nisura contemplates how he could use ADTs to model the customers waiting to be served in the milk-bar. There are two people serving customers in the milk-bar and every customer can have a variety of items that they are wishing to purchase.

a. Which ADT could be used for modelling this scenario and why? 2 marks

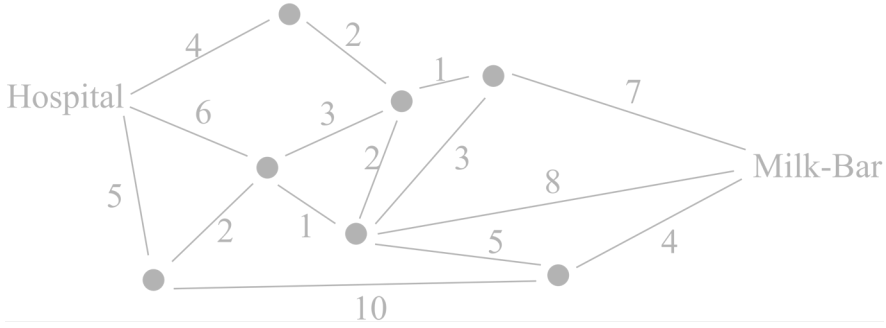
Whilst day-dreaming about ADTs, Nisura slips and knocks his head. An ambulance is called to collect Nisura and take him to hospital. For some reason, Aaron and Jack are in charge of giving directions to the ambulance.

They have the following map in front of them showing the roads from the hospital to the milk-bar. The weightings on the roads indicate the time it will take the ambulance to travel along that road.



Aaron suggests that they use a minimal spanning tree to find the shortest path to the milk-bar.

b. On the diagram below, draw the minimal spanning tree for this graph. 1 mark



SECTION B - continued

c. Explain why the minimal spanning tree does not provide a good solution to the problem Aaron and Jack are trying to solve. 2 marks

Jack proposes that they use either Dijkstra's Algorithm, The Bellman-Ford Algorithm or Floyd-Warshall's Algorithm to solve their problem

d. In the space below, compare the suitability of each of these algorithms to the problem that is being solved and justify which algorithm Aaron and Jack should use. 6 marks

Question 3 (3 marks)

Joel and Michael want to test an algorithm that they have written which takes the following inputs:

{Fast, Medium, Slow}
{1, 2, 3, 4, 5}
{Water, Not Water}

What are the minimum number of pair-wise tests that they would need to do to test these inputs? List a possible combination of pair-wise tests that would satisfy testing all pairs.

Question 4 (4 marks)

Turing Machines are an abstract model of computation.

Outline 4 key characteristics of a Turing Machine.

Question 5 (9 marks)

a. In the space below describe the context of John Searle's Chinese Room Argument, including a description of the Chinese Room thought experiment and John Searle's interpretation of it's meaning. 6 marks

b. Provide and explain in detail a commonly used counter argument to John Searle's Chinese Room. 3 marks

Question 6 (8 marks)

Eugenia and Mathen are having an argument about the meaning of the Church-Turing Thesis.

Mathen states
"The Church-Turing Thesis says that a Turing Machine can compute anything but it might take infinite time and resources to do it."

Eugenia retorts with
"You're confused Mathen! The Church-Turing Thesis is simply a definition for what computability means. It says that anything that is computable must be capable of being done on a Turing Machine with finite time and resources"

In the space below, discuss the accuracies and inaccuracies of each student's statements and provide a statement of your own regarding the meaning of the Church-Turing Thesis.

Question 7 (9 marks)

Ben and Kavindu are getting sick and tired of Deep eavesdropping on their conversations. In order to stop him, they decide to start sending coded messages to one another.

In a simplified version of their code, a message consisting of a string of As, Bs, Cs and Ds undergoes a final transformation before being transmitted.

- each A is replaced by 1 0 1
- each B is replaced by 1 1 0 0
- each C is replaced by 0 1 1 0
- each D is replaced by 1 1 0

The transmitted message was:

{1 1 0 0 1 1 0 0 1 1 0 1 1 0 1 0 1 1 1 0 0 1 0 1 1 0 1 1 1 0 0 0 1 1 0 1 1 0 1 1 0 1 1 0 1 1 0}

Not wanting to be left out, Deep decides to try and write an algorithm that can decipher the code. In the space provided, write an algorithm, in pseudocode, which can determine all the possible messages that could result in a transmitted message like the one above.

Question 8 (8 marks)

SECTION B - continued

Ever since learning about DNA computing in class, Sebastian has become quite paranoid that Finn is going to be able to use DNA computing to hack into his computer.

Explain whether DNA computing is actually a threat to computer security. In your answer, include a discussion of NP completeness.

Question 9 (6 marks)

Gabe is keen to solve the Travelling Salesman Problem so that he can become the world's greatest door-to-door Encyclopedia Salesman. He decides to use Randomised Heuristics to help him solve the problem.

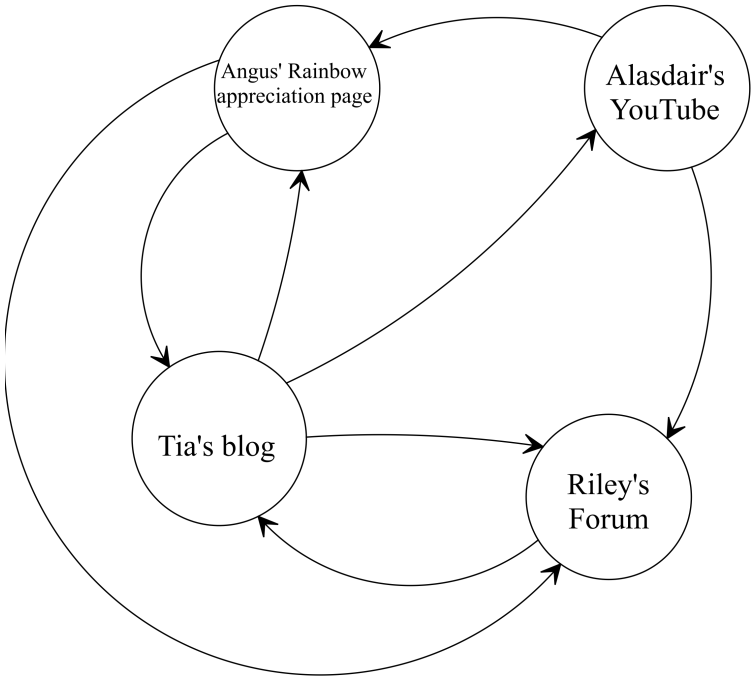
Explain how Randomised Heuristics might help Gabe find a solution to the Travelling Salesman Problem. Include in your answer a discussion on the quality of the solution that he will get from using this approach.

Question 10 (5 marks)

Riley wants to start up a rival search engine to Google which he will call Booschle. He doesn't want to come up with his own algorithm, though, so he decides to use PageRank to rank pages on Booschle. Consider the 4 webpages depicted below. Each directed edge indicates which webpage is referenced by another (depicted by an arrow going from the webpage that is referencing the other webpage, to the webpage that is being referenced).

Use PageRank to determine the ranking that would be assigned to each webpage after the second iteration of PageRank.

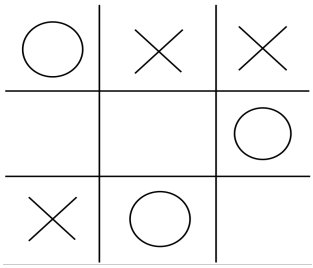
For the purposes of this question, you can use a dampening factor of 0.5.



Question 11 (8 marks)

Annoyed by Riley's ranking system, Tia decides to challenge Riley to a game of Tic-Tac-Toe. Riley, being a confident Tic-Tac-Toe'r accepts and they start playing. After 3 turns the board is in the state as shown in the diagram below and it is now Tia's (O's) turn.

Show, in the space provided, how the minimax algorithm could be used to determine the next move that Tia should make.



Question 12 (5 marks)

Angus, whilst appreciating the natural beauty of a rainbow, is inspired to start converting an iterative algorithm that he knows into a recursive one.

The iterative algorithm, 'sum_iter' that Angus knows is defined in pseudocode below:

```
Function sum_iter(x)
      running_total = 0
      while x is not equal to 0
            running_total = running_total + x
            x = x - 1
      return running_total
```

In the space provided, convert the iterative pseudocode for 'sum_iter' into a tail recursive algorithm.

END OF QUESTION AND ANSWER BOOK