1 (a) Describe the effect of changing the allocation of bits used for the mantissa and for the exponent in a floating-point number with a fixed total number of bits.

- Increasing bits in the mantissa increases precision/accuracy.
- Increasing bits in the exponent increases the range of representable numbers.

[2]

(b) Real numbers are stored in a computer, using floating-point representation with:

- 12 bits for the mantissa
- 4 bits for the exponent
- Two's complement form for both the mantissa and exponent.

Calculate the normalised floating-point representation of `+54.8125` in this system.

Show your working.

54.8125

110110.1101

0.1101101101 x 2^6

0 1101101101 0110

- Working:
  - Convert 54.8125 to binary:
    54.8125 = 110110.1101
  - Exponent = 6 (Move binary point 6 places)
    0.11011011010 x 2 ^ 6
  - Normalised form:
    - Mantissa: 011011011010
    - Exponent: 0110

Mantissa											
0	1	1	0	1	1	0	1	1	0	1	0

Exponent			
0	1	1	0

[3]

2 (a) Outline why protocols are essential for communication between computers.

- Protocols ensure data is sent/received using the same standards/rules/formats.
- They allow communication between devices on different platforms, making communication independent of software and hardware.

[2]

(b) State the names of two different protocols associated with the sending and receiving of emails between computers.

- Sending: SMTP
- Receiving: POP3 or IMAP

[2]

(c) Explain the meaning of the phrase: BitTorrent protocol provides peer-to-peer file sharing.

- BitTorrent allows file sharing between thousands of users connected over the internet.
- It supports more users sharing files compared to a traditional peer-to-peer network.
- Users share files directly with each other without a central server.

[3]

3(a) Explain what is meant by the term non-composite data type and give an example of a non-composite data type.

- A non-composite data type is defined without referencing another user-defined data type.
- It can be a primitive or user-defined type.
- Example: Enumerated data type, pointer data type.

[3]

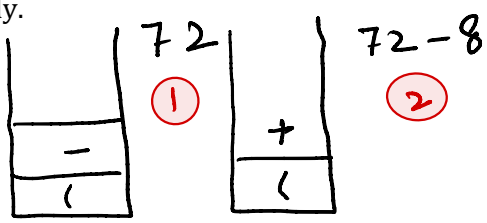
(b) Write pseudocode statements to declare the set data type EvenNumbers to hold this set of even numbers between 2 and 12:

```
2, 4, 6, 8, 10, 12
```

TYPE Numbers = SET OF INTEGER
DEFINE EvenNumbers (2, 4, 6, 8, 10, 12) : Numbers

[4]

Sheila has a customer called Fred. Fred wants to send Sheila a confidential document as part of a transaction. Explain how Fred uses asymmetric encryption to send his document securely.



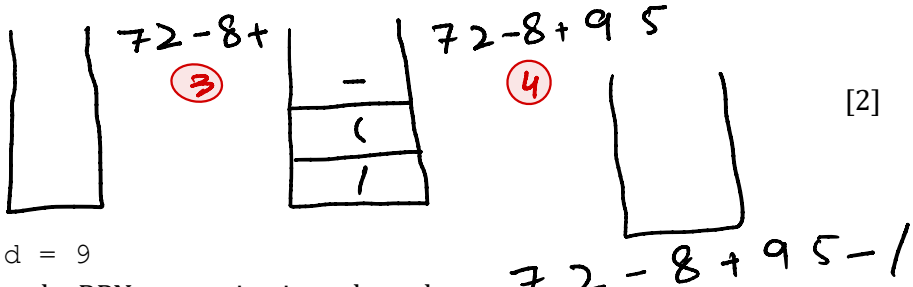
- Sheila's computer generates a pair of keys (private and public).
- Sheila's computer sends Sheila's public key to Fred.
- Fred encrypts the document using Sheila's public key to create cipher text.
- Fred sends the cipher text to Sheila.
- Sheila decrypts the cipher text using her private key.

[4]

5 (a) Write this infix expression in Reverse Polish Notation (RPN):

```
(7 - 2 + 8) / (9 - 5)
```

- Answer: 7 2 - 8 + 9 5 - /



[2]

(b) Evaluate this RPN expression:

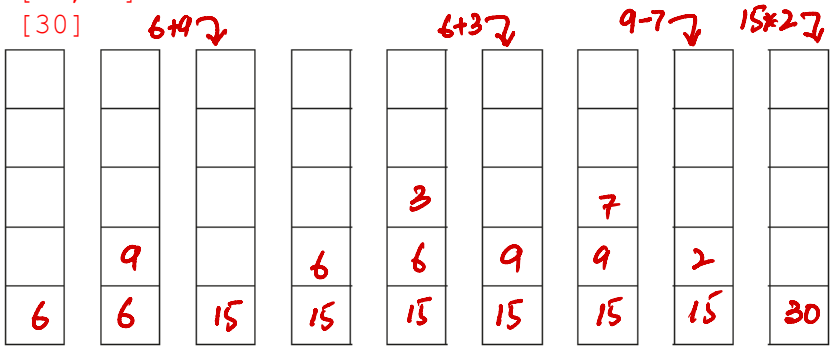
```
a d + a b + c - *
```

when

```
a = 6, b = 3, c = 7 and d = 9
```

Show the changing contents of the stack as the RPN expression is evaluated.

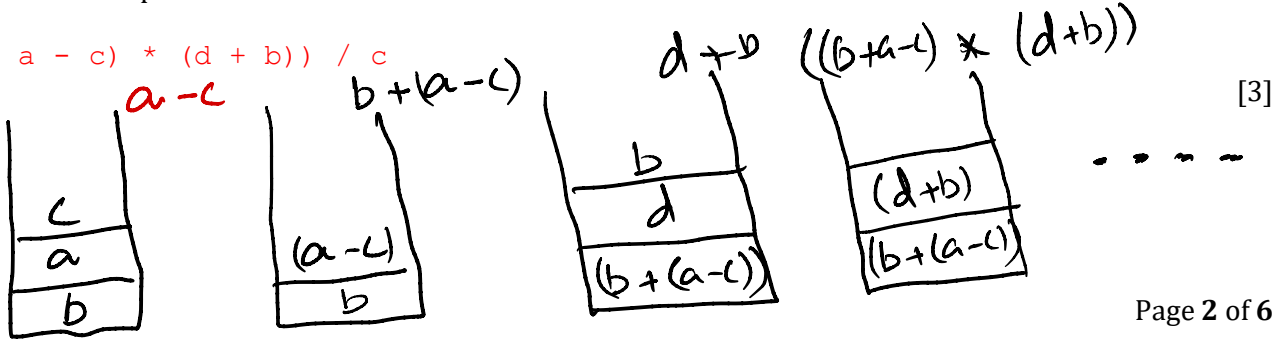
- Stack changes:
  - Push 6, 9 → [6, 9]
  - Add → [15]
  - Push 6, 3 → [15, 6, 3]
  - Add → [15, 9]
  - Push 7 → [15, 9, 7]
  - Subtract → [15, 2]
  - Multiply → [30]



[4]

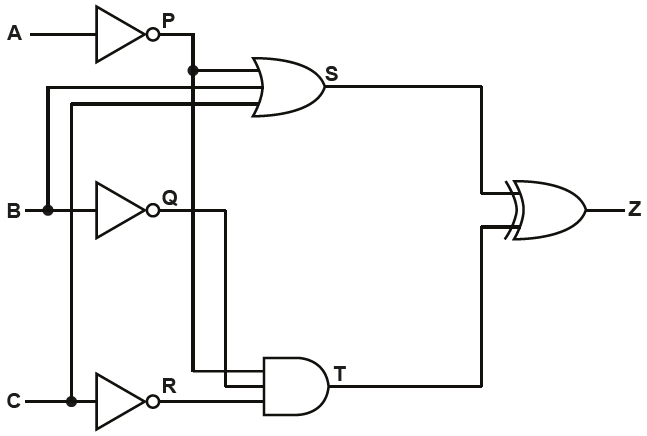
(c) Write this RPN expression in infix form: b a c - + d b + * c /

((b + a - c) * (d + b)) / c



[3]

6 The diagram shows a logic circuit.



(a) Complete the truth table for the given logic circuit. Show your working.

A	B	C	P	Q	R	S	T	Z	MINTERMS
0	0	0	1	1	1	1	1	0	
0	0	1	1	1	0	1	0	1	$\bar{A}\bar{B}C$
0	1	0	1	0	1	1	0	1	$A\bar{B}\bar{C}$
0	1	1	1	0	0	1	0	1	$\bar{A}BC$
1	0	0	0	1	1	0	0	0	
1	0	1	0	1	0	1	0	1	$A\bar{B}C$
1	1	0	0	0	1	1	0	1	$AB\bar{C}$
1	1	1	0	0	0	1	0	1	ABC

[3]

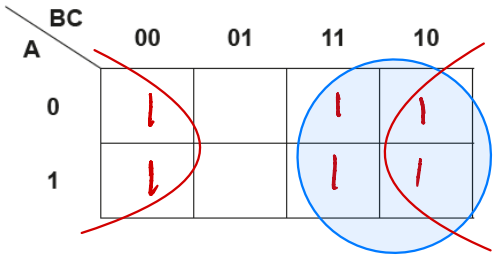
(b) Write the Boolean expression that corresponds to the logic circuit as a sum-of-products.

$Z = \bar{A}.\bar{B}.C + \bar{A}.B.\bar{C} + \bar{A}.B.C + A.\bar{B}.C + A.B.\bar{C} + A.B.C$

[2]

(c) (i) Complete the Karnaugh map (K-map) for this Boolean expression:

$\bar{A}.\bar{B}.\bar{C} + \bar{A}.B.\bar{C} + \bar{A}.B.C + A.\bar{B}.\bar{C} + A.B.\bar{C} + A.B.C$



[2]

(ii) Draw loop(s) around appropriate group(s) in the K-map to produce an optimal sum-of-products. [2]

(iii) Write the Boolean expression from your answer to part c(ii) as a simplified sum-of-products.

$B + \bar{C}$

[1]

7 (a) Outline what is meant by direct access as a method of file access.

- Direct access allows a record to be found without reading other records.
- Records are located using the key field.

[2]

(b) Explain how direct access is used to locate a specific record in sequential files and random files.

(i) Sequential files:
- An index of all key fields is kept.
- The index is searched for the address of the target record.

[2]

(ii) Random files:
- A hashing algorithm is used on the key field.
- The address of the target record is calculated using the hashing algorithm.

[2]

8 (a) Complete the pseudocode to find an item in a 1D array Widgets of type STRING, using a linear search.

```
DECLARE Widgets : ARRAY[1:50000] OF STRING
DECLARE TopOfList : INTEGER
DECLARE EndOfList : INTEGER
DECLARE Count : INTEGER
DECLARE ToFind : STRING
DECLARE Found : BOOLEAN
DECLARE NotInList : BOOLEAN
TopOfList ← 1
EndOfList ← 50000
OUTPUT "Enter the name of the item you wish to find "
INPUT ToFind
Found ← FALSE
NotInList ← FALSE
Count ← TopOfList
WHILE Found = FALSE AND NotInList = FALSE
   IF ToFind = Widgets[Count] THEN
      Found ← TRUE
   ENDIF
   Count ← Count + 1
   IF Count > EndOfList THEN
      NotInList ← TRUE
   ENDIF
ENDWHILE
IF Found = TRUE THEN
   OUTPUT "Item found at position " Count - 1 " in array"
ELSE
   OUTPUT "Item not in array"
ENDIF
```

[4]

(b) Compare the methods used by the linear and binary search algorithms to find an item in an array. Refer to Big O notation in your answer.

- Linear search:
  - Sequentially checks each element until a match is found or end of array.
  - Time complexity: `O(n)`

- Binary search:
  - Repeatedly divides the search interval in half.
  - Time complexity: `O(log n)`

[4]

9 (a) Outline two benefits and two limitations of a virtual machine.

- Benefits:
1. The guest operating system has no effect on the host machine or other virtual machines.
2. Applications incompatible with the host OS can run on the virtual machine.

- Limitations:
1. Performance is lower compared to running on its own compatible machine.
2. Building and maintaining virtual machines can be expensive and complex.

[4]

(b) Explain the roles of the host operating system and the guest operating system as used in a computer system running a virtual machine.

- Host Operating System:
- Normal OS of the host machine.
- Controls all resources and runs the virtual machine software.

- Guest Operating System:
- Runs within the virtual machine.
- Controls the virtual hardware and accesses physical resources through the host OS.

[3]

10 A declarative programming language is used to allow clients to choose daily activities at the beach.

```
01 activity(paddleboarding).
02 activity(sailing).
03 activity(rowing).
04 activity(kayaking).
05 activity(jetskiing).
06 client(stevie).
07 client(antonio).
08 client(henry).
09 client(eliza).
10 client(rebeka).
11 client(danny).
12 client(erik).
13 client(simone).
14 client(petra).
15 client(frankie).
16 choice(petra, rowing).
17 choice(frankie, sailing).
18 choice(erik, sailing).
19 choice(eliza, rowing).
20 choice(stevie, jetskiing).
21 choice(henry, sailing).
22 done(henry, jetskiing).
23 done(rebeka, jetskiing).
24 done(antonio, kayaking).
```

These clauses have the meanings:

Clause	Meaning
01	Paddle boarding is an activity.
06	Stevie is a client.
16	Petra has chosen rowing.
22	Henry has already done jet skiing.

(a) Jane is a client who would like to choose the activity surfing and she has already done sailing. Write additional clauses to represent this information.

```
25 client(jane).
26 activity(surfing).
27 choice(jane, surfing).
28 done(jane, sailing).
```

[4]

(b) Using the variable List, the goal:

today(List, rowing)

returns

List = petra, eliza

Write the result returned by the goal:

today(List, sailing)

List = `frankie, erik, henry`

[1]

(c) C is a client who would like to choose A if A is an activity and C has not already done A. Write this as a rule:

may_choose_activity(C, A)

```
IF  client(C),
    activity(A),
    not(done(C, A)).
```

[4]

11 Explain what is meant by Reinforcement Learning in relation to Artificial Intelligence.

- Reinforcement learning is a machine learning technique based on feedback.
- An agent learns to behave in an environment by performing actions and seeing the results.
- Good actions receive positive feedback/reward, bad actions receive negative feedback/punishment.
- The agent learns automatically using feedback without any labeled data.

[3]

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