1.4 Data Types, Data Structures and Boolean Algebra: Test Pack

Total Marks

OCR H446 · Calculators not allowed · about 35 minutes

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 This question is about primitive data types and number base conversions.

(a) State the most appropriate primitive data type for each of the following items of data: (i) a customer's age in whole years (ii) the price of an item in pounds and pence (iii) whether a user is currently logged in (iv) the initial letter of a person's surname. **(4)**

(b) Convert the denary integer 214 into an 8-bit unsigned binary number. Show your working. **(2)**

(c) Convert your answer to part (b) into hexadecimal. **(2)**

(d) Convert the hexadecimal value 2F into an 8-bit binary number, and state its denary value. **(2)**

(Total for Question 1 is 10 marks)

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2 A program uses the following pseudocode to process a set of 5 test scores stored in an array:

```
DECLARE scores : ARRAY[0:4] OF INTEGER
scores[0] <- 12
scores[1] <- 45
scores[2] <- 8
scores[3] <- 45
scores[4] <- 19
total <- 0
FOR i <- 0 TO 4
    total <- total + scores[i]
NEXT i
average <- total / 5
OUTPUT average
```

Use this pseudocode to answer parts (a) to (d).

(a) State the name of the data structure declared by the line 'DECLARE scores : ARRAY[0:4] OF INTEGER', and state the data type of each element it stores. **(1)**

(b) Complete a trace table for the FOR loop, showing the values of i, scores[i] and total for each of the 5 iterations. **(5)**

(c) State the value that will be output by the program. **(1)**

(d) Rewrite the line 'average <- total / 5' so that integer (whole-number) division is used instead of real division, and state the new value that would be output. **(2)**

(Total for Question 2 is 9 marks)

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3 A security system triggers an alarm (ALARM) if the front door sensor (D) is open AND the system is armed (S), OR if the motion sensor (M) is triggered while the system is armed (S), regardless of the door.

(a) Write a Boolean expression for ALARM in terms of D, S and M. **(2)**

(b) Using the distributive law, simplify your expression from part (a) so that it uses only one AND gate involving S. **(2)**

(c) Describe the simplified logic circuit needed to implement ALARM = S AND (D OR M), stating the gates required and their inputs. **(2)**

(d) Complete a truth table for ALARM = S AND (D OR M), showing the output for all 8 combinations of S, D and M (using the standard ordering 000 to 111). **(4)**

(e) State the number of rows in the truth table where ALARM = 1, and explain what this means for the behaviour of the security system. **(2)**

(Total for Question 3 is 12 marks)

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Mark scheme · 1.4 Data Types, Data Structures and Boolean Algebra: Test Pack

Question 1

(a) INTEGER for age **B1**

(a) REAL (oe fixed-point/currency type) for price **B1**

(a) BOOLEAN for logged-in status **B1**

(a) CHAR for the initial letter **B1**

(a) Answer: INTEGER, REAL, BOOLEAN, CHAR

(b) correct place values identified, e.g. 128+64+16+4+2=214, or equivalent method shown **M1**

(b) 11010110 cao **A1**

(b) Answer: 11010110

(c) binary split into two 4-bit nibbles: 1101 and 0110 **M1**

(c) D6 cao **A1**

(c) Answer: D6

(d) 2=0010 and F=1111 correctly identified **M1**

(d) 00101111 and denary value 47, both correct (oe) **A1**

(d) Answer: 00101111 = 47

Question 2

(a) a one-dimensional array (of 5 elements), storing INTEGER data (both parts needed for the mark) **B1**

(a) Answer: A one-dimensional array of INTEGER values.

(b) i=0, scores[i]=12, total=12 **B1**

(b) i=1, scores[i]=45, total=57 **B1**

(b) i=2, scores[i]=8, total=65 **B1**

(b) i=3, scores[i]=45, total=110 **B1**

(b) i=4, scores[i]=19, total=129 **B1**

(b) Answer: total after each iteration: 12, 57, 65, 110, 129

(c) 25.8 cao **B1**

(c) Answer: 25.8

(d) average <- total DIV 5 (or equivalent correct use of DIV) **M1**

(d) 25 cao **A1**

(d) Answer: average <- total DIV 5, output 25

Question 3

(a) correctly identifies that ALARM is true when (D AND S) is true, or when (M AND S) is true **M1**

(a) ALARM = (D AND S) OR (M AND S) (oe, any equivalent correct expression) **A1**

(a) Answer: ALARM = (D AND S) OR (M AND S)

(b) S correctly factorised out of both terms **M1**

(b) ALARM = S AND (D OR M) cao **A1**

(b) Answer: ALARM = S AND (D OR M)

(c) an OR gate with inputs D and M **B1**

(c) the output of the OR gate, together with input S, are connected to an AND gate, whose output is ALARM **B1**

(c) Answer: OR gate (inputs D, M) feeding into an AND gate together with S; the AND gate output is ALARM.

(d) S=0 rows (all 4 combinations of D,M): ALARM=0 in every case, since S=0 **B1**

(d) S=1,D=0: M=0 gives ALARM=0; M=1 gives ALARM=1 **B1**

(d) S=1,D=1: M=0 gives ALARM=1; M=1 gives ALARM=1 **B1**

(d) full table correct and consistent with S AND (D OR M) (cao) **B1**

(d) Answer: ALARM values (S,D,M from 000 to 111): 0, 0, 0, 0, 0, 1, 1, 1

(e) 3 rows **B1**

(e) the alarm only ever sounds when the system is armed (S=1) and at least one of the sensors (D or M) is triggered; when the system is disarmed (S=0) the alarm never sounds, regardless of the sensors **B1**

(e) Answer: 3 rows; the alarm only sounds when the system is armed and at least one sensor is triggered - it never sounds while disarmed.

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