IT5002 Computer Systems and Applications
2024/25 Semester I
Midterm Assessment
(SOLUTIONS)

Instructions

1. You are given an OCR sheet. Shade AND write your student number on this sheet now.

2. This assessment consists of 15 questions on ??? pages. This excludes six pages (3 sheets) of rough paper at the end.

3. Each question is worth two marks, and this paper is thus worth 30 marks.

4. You are given 60 minutes to complete this assessment. Answer every question by shading the appropriate lozenge on the OCR sheet.

5. Ensure that you fully shade the lozenge. We are not responsible for incorrect marking caused by improper shading.

6. Do not communicate with each other. If you wish to ask a question, raise your hand until an invigilator attends to you.

7. Only standalone calculators are allowed. Mobile phones, tablets, laptops and other devices are not allowed.

8. This is a cheat-sheet assessment. Only a single two-sided cheat sheet is allowed.

Questions

1. Which ONE of the following is true regarding the C Programming Language?
    a. It is an interpreted language like Python or Javascript.
    b. The C compiler directly produces executable program.
    c. +The object code produced by the C compiler is linked to various library codes to produce the executable program.
    d. C is a low-level language like assembly.
    e. None of the above options a. to d. are correct.

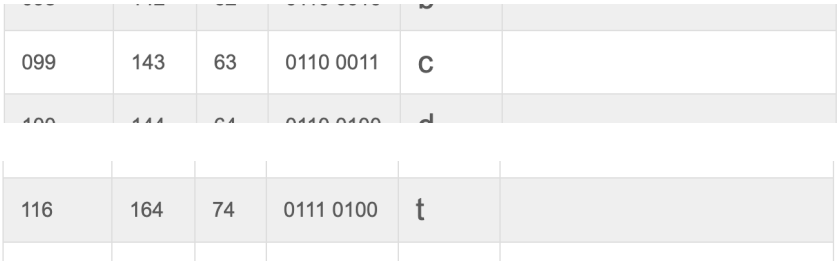
We are given the following 16-bit **binary** pattern (the "0b" prefix means binary):

0b 0110001101110110

2. If this pattern were to be interpreted as ASCII, what does it represent?

    a. +cv
    b. 6g
    c. g6
    d. ad
    e. None of the above options a. to d. are correct.

Solution:
https://www.sciencebuddies.org/science-fair-projects/references/ascii-table



099	143	63	0110 0011	c
116	164	74	0111 0100	t

3. If we interpret this value in unsigned base-8, what value does it represent?

    a. 306730_8
    b. 614323_8
    c. 652137_8
    d. +61566_8
    e. None of the above options a. to d. are correct.

Working
0b 0 110 001 101 110 110 = 061566 (Correct)
0b 011 000 110 111 011 0 = 0306730 (Wrong)

4. What is this value in unsigned base-9, if this binary pattern is unsigned?

a. 13873_9
b. $+37831_9$
c. 14324_9
d. 31898_9
e. None of the above options a. to d. are correct.

Working

$0b0110001101110110 = 25462_{10}$
$= 37831_9$

5. We consider a number system called "9's complement", which is defined in a similar way to 2's complement: $-X = 9^n - X$, where X is an n-digit base-9 number. What is $-(13421_9)$ in this number system? Assume that this is a 5-digit base-9 number.

a. $+75468_{9s}$
b. 75467_{9s}
c. 84568_{9s}
d. 84569_{9s}
e. None of the above options a. to d. are correct.

Working

$9^5 - 13421$
=

```
  100000
-  13421
-------
  75468
```

In Questions 6 to 9 consider a 12-bit fixed point number system with 5 bits used for the fraction portion and 7-bits for the integer portion. **This number is represented in 2's complement.**

Integer portion (7 bits)	Fraction portion (5 bits)

6. What is the largest positive number that this number system can represent?

a. 128.987
b. 127.987
c. 63.987
d. 64.987
e. +None of the above options a. to d. are correct.

Working:

Largest positive number is 0111111.11111_2
= 63.96875 = 63.969

7. What is the smallest positive number that this number system can represent?

   a. +0.03125
   b. 0.0625
   c. 0.125
   d. 0.25
   e. None of the above options a. to d. are correct.

   Answer: _____

   Working:

   Smallest positive number is 0000000.00001_2
   = 0.03125

8. How is -3.542 represented in this number system in hexadecimal?

   a. 0x7617
   b. 0x78F
   c. 0x3F9
   d. +0xF8F
   e. None of the above options a. to d. are correct.

   Working:

   Best representation for 3.542 = 0000011.10001_{2s}
   -3.542 = 1111100.01111_{2s}

   1111 1000 1111= 0xF8F

   This is actually -3.53125

9. What is the absolute error in representing -3.542 in this number system?

   Note: absolute error is defined as |N – X|, where N is the number we wish to represent, X is the number actually represented by our number system, and | . | is the absolute function defined as:

   | X | = X if X >=0, otherwise | X | = -X

   a. -0.108
   b. 0.452

c. 0.108
d. 0.137
e. +None of the above options a. to d. are correct.

Working:

abs(-3.53125 – (-3.542)) = 0.01075 = 0.0108 (4dp)

10. We are given the following program in C:

```
X=0;
do {
        .. some code which uses X ..
        X += 2;
        } while ( X < 10)
```

Which ONE of the following MIPS assembly instructions correctly represents this C code? Assume that X is mapped to register $s0.

a.
```
        addi $s0, $zero, 0
Loop:   slti $t0, $s0, 10
        beq $t0, $zero, exit
        ... some code which uses X ...
        addi $s0, $s0, 2
        j Loop
```
b.
```
        add $s0, $zero, $zero
Loop:   ... some code which uses X ...
        addi $s0, $s0, 2
        slti $t0, $s0, 10
        beq $t0, $zero, Loop
```
c.
```
        add $s0, $zero, $zero
Loop:   slti $t0, $s0, 10
        bne $t0, $s0, exit
        ... some code which uses X ...
        addi $s0, $s0, 2
        j Loop
```
d.
```
        +add $s0, $zero, $zero
Loop:   ... some code which uses X ...
        addi $s0, $s0, 2
        slti $t0, $s0, 10
        bne $t0, $zero, Loop
```
e. None of the above options a. to d. are correct.

For questions 11 to 14 please refer to the code below. The array A has its starting address in register $s0, and the number of elements in a is in $s1.

	sll $t0, $s1, 2
	add $t1, $s0, $t0
	add $t2, $s0, $zero
	add $s3, $zero, $zero

A:	slti $t3, $t2, $t1
	beq $t3, $zero, C
	lw $t4, 0($t2)
	andi $t4, $t4, 0x1
	bne $t4, $zero, B # This instruction
	add $s3, $s3, $t4

B:	addi $t2, $t2, 4 j A
C:	…

11. Assuming that $s1 contains the value 128, what is the fewest number of instructions executed by this program?

    a. 472 instructions
    b. 796 instructions
    c. +902 instructions
    d. 1004 instructions
    e. None of the above options a. to d. are correct.

    Answer: _____

    Working:

    Outside loop: 4
    Inside loop: Fewest number means that the add $s3, $s3, $t4 is never executed. I.e. all numbers are odd.
    # of instructions in loop = 7
    # of iterations = 128
    Additional 2 instructions to exit
    So total = $4 + 128 \times 7 + 2$
    = 902 instructions

12. Assuming again that $s1 contains the value 128, what is the largest number of instructions executed by this program?

    a. 1004 instructions
    b. 1020 instructions
    c. 1024 instructions
    d. 1026 instructions
    e. +None of the above options a. to d. are correct.

Working:

Outside loop: 4
Inside loop: Largest number means that the add $s3, $s3, $t4 is always executed. I.e. all numbers are even.
# of instructions in loop = 8
# of iterations = 128
Additional 2 instructions to exit
So total = $4 + 128 \times 8 + 2$
= 1030 instructions

13. Suppose A is a 12-element array, and each element contains its own index number starting with zero (i.e. A[0]=0, A[1]=1, A[2] = 2, … A[12]=11), what is the final answer in $s3? Register $s2 contains the value 12.

    a. 10
    b. 20
    c. +30
    d. 40
    e. None of the above options a. to d. are correct.

Working:

This program sums up the even numbers. So $s3 contains 0 + 2 + 4 + 6 + 8 + 10 = 30

14. What does this program do? Pick the best answer:

    a. +It gives the sum of all the even numbered elements of A.
    b. It gives the sum of all the odd numbered elements of A
    c. It counts the number of elements of A with a 1 in the least significant bit.
    d. It counts the number of elements of A with a 1 in the most significant bit.
    e. None of the options a. to d. are correct.

15. We are given the following register values, and the short program below.

    [$2] = 15, [$3] = 23, [$4] = 15, [$5] = 42
    (Note: [r]=x means “register r contains the value x”)

	addi $3, $3, $5
	addi $6, $zero, 0
L:	slt $7, $6, $2
	beq $7, $zero, E
	beq $2, $4, S.

	addi $6, $6, 1
S:	j L # This j instruction
E:	…

Assuming that the first instruction of the program above starts at address 0xFC0, what is the instruction encoding of the "j" instruction marked "# this j instruction"?

Instruction format for "j" instruction:

Opcode (6 bits)	Target address (26 bits)
0x2	

a. **+0x80003F2**
b. 0x40003F2
c. 0x80004F0
d. 0xC1032E0
e. None of the options a. to d. above are correct.

Working:

First instruction is 0xFC0. Address of L is 0xFC8:

0000 0000 0000 0000 0000 1111 1100 1000
= 0000 0000 0000 0000 0000 1111 1100 10
= 0000 0000 0000 0000 1111 1100 10
Full encoding = 00001000000000000000001111110010
= 0000 1000 0000 0000 0000 0011 1111 0010
= 0x080003F2
= 0x80003F2