Total time allowed: 75 minutes. **Total Marks: 60**

i) The midterm exam consists of four questions and it has four pages. Answer all questions.
ii) An instruction set sheet for the MIPS processor is allowed for your reference.
iii) Estimated time for each question is equivalent to the marks assigned to it.
iv) Your answer should be concise, to the point and in the space provided.

Q-1. Consider an application program with the following types of instructions and their frequency. A specific CPU executes the above program.

Instruction Type	Instruction Frequency	CPI
Multiply	20% 5	8
Divide	15% 10	12
Load Store	15%	5
Rest of the Instructions	50%	4

(a) What percentage of time does the CPU spend doing division operations?

(b) The hardware engineering team is suggesting an option of modifying the CPU hardware to reduce the number of cycles required for multiplication and division. The modified CPU reduces the number of cycles required for multiplication to 5 and division to 10 but it will require a 10% increase in the overall clock cycle time.

Nothing else affected, does this modification will reduce the overall execution time? Justify your answer by showing all the calculations, etc.

Marks: (4+11)

a)

$$\frac{.15\times 12}{.2\times 8 + .15\times 12 + 0.15\times 5 + .5\times 4} = \boxed{29\% \text{ on division}}$$

$\to 6.15$

4

b) $CPI_M = 5$

$CPI_D = 10$, increase in overall clock cycle Time

∴ f ↓

$5\times 0.2 + 10\times 0.15 + 0.15\times 5 + 0.5\times 4 = 5.25$

$5.25(1.1) = 5.775$

$Time_1 = \frac{6.15}{X}$

$Time_2 = \frac{5.775}{X}$

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$\frac{Time_1}{Time_2} = 1.064$

$Time1 = 1.064\, Time_2$

$\boxed{Time_2 = \frac{Time1}{1.064}}$

$\boxed{\text{b) Time will reduce by a factor of } 1.064}$

$t_0 = 2k$
$t_0 = 2t_0$
$t_0 = 2(2k)$
$t_0 = 4k+$

Q-2. Consider the following *for* loop code sequence in a C-like language:

```
for (k = 1; k < 10; k++) {
        pix[k+1] = pix[k] + i ;
        i = i + 2 ;
}
```

i k

Assume that *i* and *k* are integers stored in registers \$s3 and \$s6, base address of the *pix* array (i.e. pix[0]) is in register \$s5 and the, *pix* array is also of integer type.

(a) Write MIPS CPU assembly code for the above *for* loop with minimum number of instructions. Marks: (12)

```
loop:   addi $s6, $zero, 1       // K = 0+1 ; Since value of k is unkown
loop:   slti $t0, $s6, 10        // $t0 = 1, if k<10
        beq $t0, $zero, exit     // if $t0 = 0, exit
                                    → t0 : k≥10 exit
        add $t0, $s6, $s6        sll  4xk  sll $t0, $s6, 2
        add $t0, $t0, $t0
        add $t0, $t0, $s5        p[k] ← $t2
                                 p(k+1) ← t1
        lw $t2, 0($t0)
        add $t2, $t2, $s3
        sw 4($t0), $t2
        addi $s3, $s3, 2         i + i + 2
        addi $s6, $s6, 1
        j loop
Exit ...
```

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(Assuming all temporary registers are initized at 0)
otherwise
addi \$s6, \$zero, 1
nesseccary before loop

(b) How many memory accesses take place while executing the assembly code of part (a)? Justify your answer. Marks: (6)

~~4x(11) = 44 bytes~~

lw & sw 1 memory access each

loop runs from k=1 to k=9

loops 9 times

2x9 = 18 memory accesses or twice per loop.

4

How about code fetch from memory

Q-3. Design a tri-state buffer based single-bus datapath containing four 1-bit registers (R0, R1, R2 and R3) that facilitates all the register transfers in one or more clock cycles.

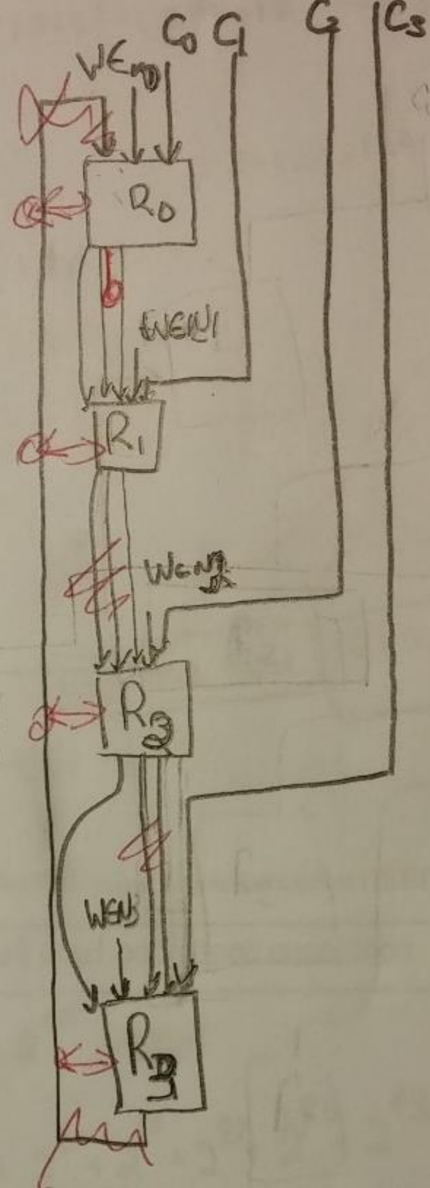
(a) Draw the datapath circuit and show all the control signals at the control points of your datapath.

(b) Identify the control signal and their values for the following register transfers in one clock cycle.
R0 <= R1, R2 <= R1

Marks: (11+5)

$R_0 <= R_1$

$R_2 <= R_1$



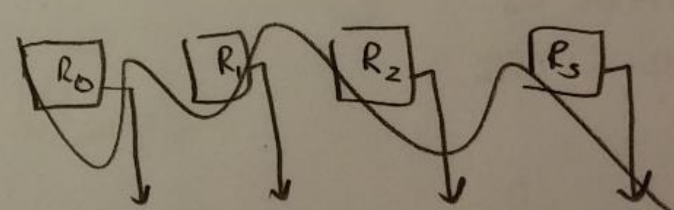
where is your single BUS

7+1

b) WEN = 0101

C = 0010

5



Q-4. **(a)** Determine a single precision, IEEE 754 floating-point standard representation of $20/3 = (6.666666)_{10}$

Marks: (7)

$6_{10} \rightarrow 110$

$6.66_{10} \rightarrow 110.10101000111101011100010 \rightarrow 1.1010101000111101011100010 \times 2^2$

$.66 \times 2 = 1$
$.32 \times 2 = 0$
$.64 \times 2 = 1$
$.28 \times 2 = 0$
$.56 \times 2 = 1$
$.12 \times 2 = 0$
$.24 \times 2 = 0$
$.48 \times 2 = 0$
$.96 \times 2 = 1$
$.92 \times 2 = 1$
$.84 \times 2 = 1$
$.68 \times 2 = 1$
$.36 \times 2 = 0$
$.72 \times 2 = 1$
$.44 \times 2 = 0$

$0.88 \times 2 = 1$
$.76 \times 2 = 1$
$.52 \times 2 = 1$
$.04 \times 2 = 0$
$.08 \times 2 = 0$
$.06 \times 2 = 0$
$.32 \times 2 = 0$
$.64 \times 2 = 1$
$.28 \times 2 = 0$

$2 + 127 = 129$
$\rightarrow 1000\ 0001$

0	1000 0001	10101010001111010111000

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(b) Determine the decimal value of the following single precision (IEEE 754 Standard) floating point number.

Marks: (4)

E

0	1101 1001	011 0101 0000 0000 0000 0000

Positive

$1.011\ 0101 \times 2^{90}$

$\rightarrow 2^{90} + 2^{88} + 2^{87} + 2^{85} + 2^{83}$

$\boxed{1.75 \times 10^{27}}$

4

$1101\ 1001 \rightarrow 217$

$217 - 127 = 90$

$E = exp + 127$

$217 - 127 = exp$