Q1

Question Five [25 marks]

Trace the below algorithm considering the given list of number. Please note that this algorithm is designed for a one-D (one dimensional) mish parallel processing architecture. Please show all steps.

The list of numbers:

3 9 2 8 7 6 4 2

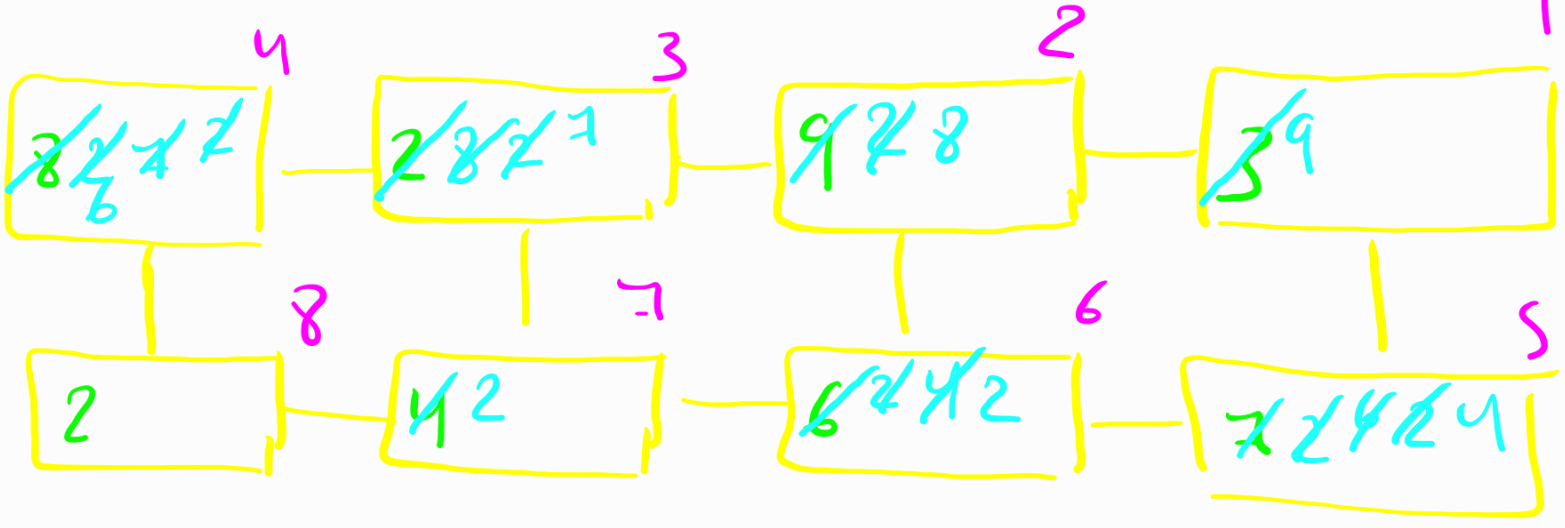
```
Procedure testCode(n)                                   // n = 8
Begin
        for i = 1 To n Do
        begin
                if i is odd then
                        for j = 0 to n/2-1 do
                            if (A2j+1 < A2j+2)
                                exchange (A2j+1, A2j+2);

                if i is even then
                        for j = 1 to n/2-1 do
                            if (A2j < A2j+1)
                                exchange (A2j, A2j+1);

        end for
end
```

1 2 3 4 5 6 7 8

Ans:- 3 9 2 8 7 6 4 2 (8)



i = 1

odd → j = 0 → 3

$A_1 < A_2 = 3 < 9$ ✓ exchange

$j=1$ $A_3 < A_4 = 2 < 8$ ✓

$j=2$ $A_5 < A_6 = 7 < 6$ X

$j=3$ $A_7 < A_8 = 4 < 2$ X

$i=2$

even → $j = 1 \longrightarrow 3$

$A_2 < A_3 = 2 < 8$ ✓

$j=2$ $A_4 < A_5 = 2 < 7$ ✓

$j=3$ $A_6 < A_7 = 6 < 4$ X

$i=3$

odd → $j=0$ $A_1 < A_2 = 9 < 8$ X

$j=1$ $A_3 < A_4 = 2 < 7$ ✓

$j=2$ $A_5 < A_6 = 2 < 6$ ✓

$j=3$ $A_7 < A_8 = 4 < 2$ X

$i = 4$

even $j = 1$ $A_2 < A_3 = 8 < 7$ X

$j = 2$ $A_4 < A_5 = 2 < 6$ ✓

$j = 3$ $A_6 < A_7 = 2 < 4$ ✓

$i = 5$

odd $j = 0$ $A_1 < A_2 = 9 < 8$ X

$j = 1$ $A_3 < A_4 = 7 < 6$ X

$j = 2$ $A_5 < A_6 = 2 < 4$ ✓

$j = 3$ $A_7 < A_8 = 2 < 2$ X

$i = 6$

even $j = 1$ $A_2 < A_3 = 8 < 7$ X

$j = 2$ $A_4 < A_5 = 6 < 4$ X

$j = 3$ $A_6 < A_7 = 2 < 2$ X

$i = 7$

odd $j = 0$ $A_1 < A_2 = 9 < 8$ X

$j = 1$ $A_3 < A_4 = 7 < 6$ X

$j = 2$ $A_5 < A_6 = 4 < 2$ X

$j = 3$ $A_7 < A_8 = 2 < 2$ X

$i = 8$

even $j = 1$ $A_2 < A_3 = 8 < 7$ X

$j = 2$ $A_4 < A_5 = 6 < 4$ X

$j = 3$ $A_6 < A_7 = 2 < 2$ X

Q2

Question Five [20 marks]

1) All computer architectures can be classified into four categories. Describe these categories in details?
2) What we mean by **degree of parallelism**?
3) Parallel processing topology is the way by which the processors in parallel computers are connected. Describe in details the **Perfect Shuffle and Shuffle Exchange** topology and mention the different between Perfect Shuffle and Shuffle Exchange.

Ans:-

1)

. SISD:- Single instruction Single Data:-

* One processor persons single instruction at one data set at any given time

- MISD :- Multi instruction Single Data :-

There are multi processors each perform different instruction but on the same data set.

- SIMD :-

There are multi processors Perform the same instruction but on different data set.

- MIMD :-

There are multi processors each perform different instruction and each one performs on a different data set.

2)

degree of parallelism :-

number of processors in a multiprocessor system

3)

*Perfect shuffle :-

each processor (i) is connected to the processor (j), this topology is used only if the number of processors is a power of 2, we can determine the connections between processors by :-

$$j = \begin{cases} 2i & \text{if } 0 \le i < \frac{n}{2} \\ 2i + 1 - n & \text{if } \frac{n}{2} \le i \le n \end{cases}$$

or we can use the formula

$2i \bmod (n-1)$ except for the last processor which connects to itself.

or by using the bit representation of the processor's indices, for each bit representation of the processor's indices we shift the

binary representation one position to the left for example (001) connects with (010)

* shuffle - exchange :-

each odd processor connects with the next even node and each next even node also connects with previous odd node, in binary representation we can flip the last bit into 1 or 0

* one different between them:-

the perfect shuffle is in one direction meaning if processor 3 connects with 6, 6 is not connected with 3, however in shuffle exchange if 1 connects with 2, 2 also connects with 1, so it's 2 directional connection.

$i = 0, j = 0$

$d = 1 \quad 2d = 2$

$2^{i+2} = 4 < 2$

$i = 1 \quad j = 1$

$d = 2 / 2d = 4$

$2^{i+2} = 8 < 4$

$i = 1 \quad j = 0 \quad d = 1, 2d = 2$

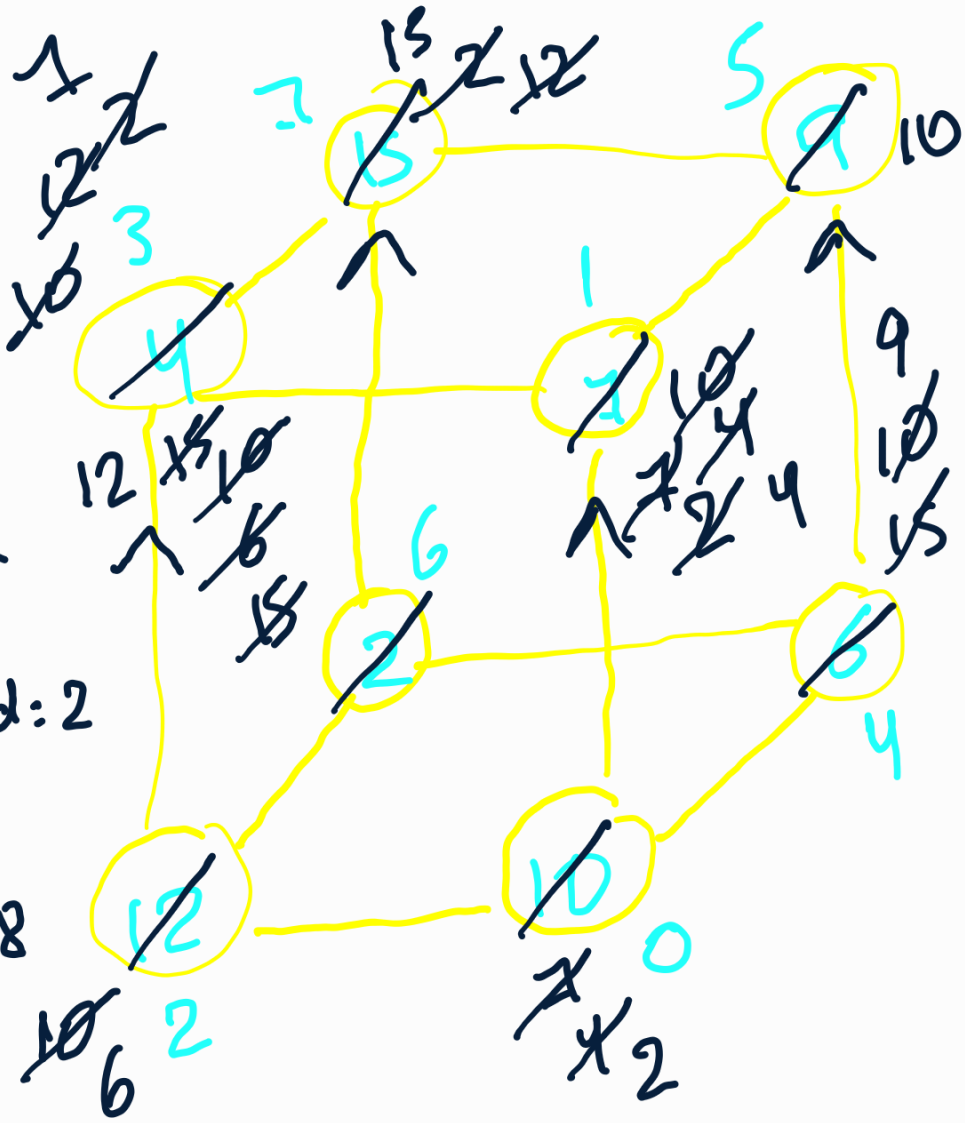
$2^{i+2} = 8 < 4$

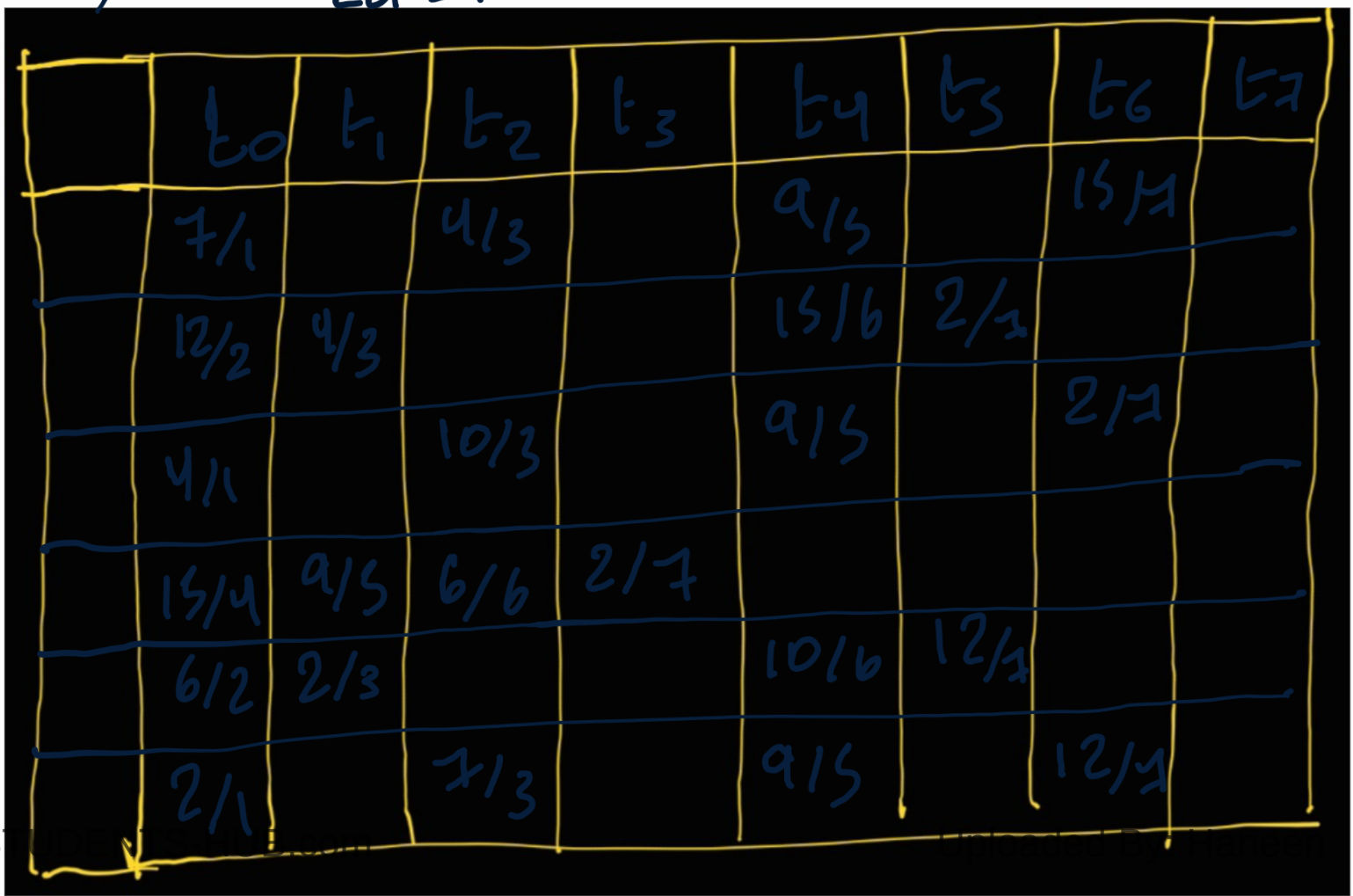
$i = 2 \quad j = 2 \quad d = 4/8$

$2^{i+2} = 16 < 8.$

$d = 0 / j = 1 \quad d = 2$

$2d = 4$





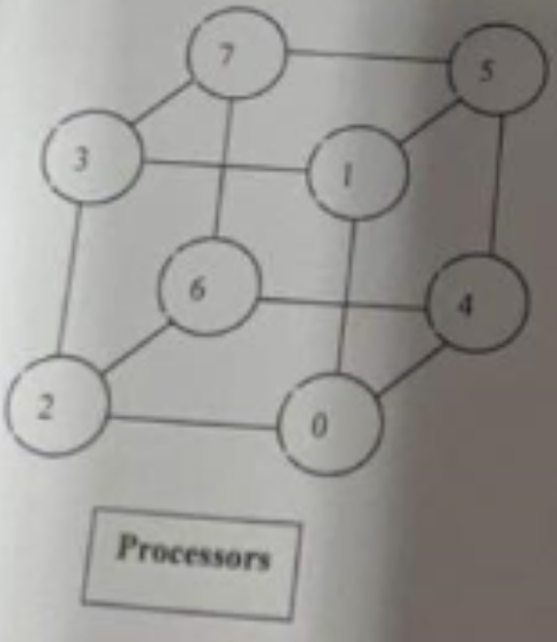
Q4

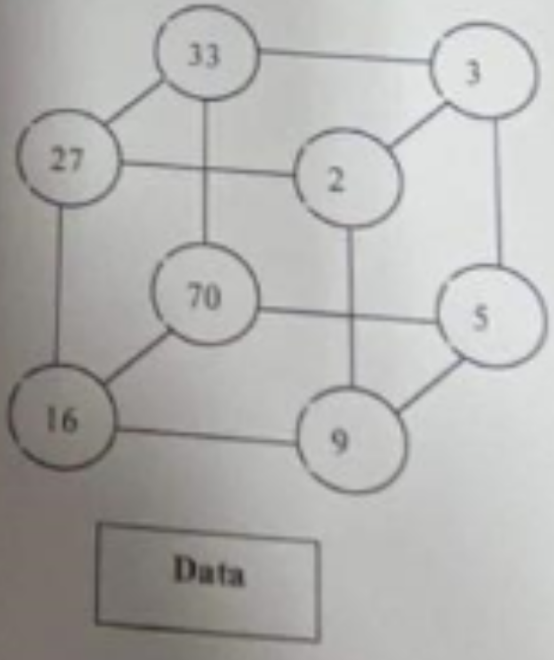
Question Four [25 marks]

Perform a Bitonic sort of the following list of numbers, using a SIMD-CC model, into ascending order:

9 2 16 27 5 3 70 33

```
Bitonic Merge_Sort (SIMD-CC)
Begin
    for i = 0 To m-1 Do
        for j = i DownTo 0 Do
            d = 2^j
            for all P_k where 0<= k <= 2^m - 1 Do
                if (k mod 2d < d ) Then
                    t_k = a_k+d
                    if (k mod 2^(i+1) < 2^(i+1) ) Then
                        b_k = min(t_k , a_k)
                        a_k = max(t_k , a_k)
                    else
                        b_k = max(t_k , a_k)
                        a_k = min(t_k , a_k)
                    endif
                endif
            endfor
        endfor
    endfor
end.
```





9 12 16 27 5 3 70 33

$i = 0, j = 0$

$d = 1 \quad 2d = 2$

$2^{i+2} = 4 < 2$

$i = 1 \quad j = 1$

$d = 2 \;/\; 2d = 4$

$2^{i+2} = 8 < 4$

$i = 1 \quad j = 0 \quad d = 1, 2d = 2$

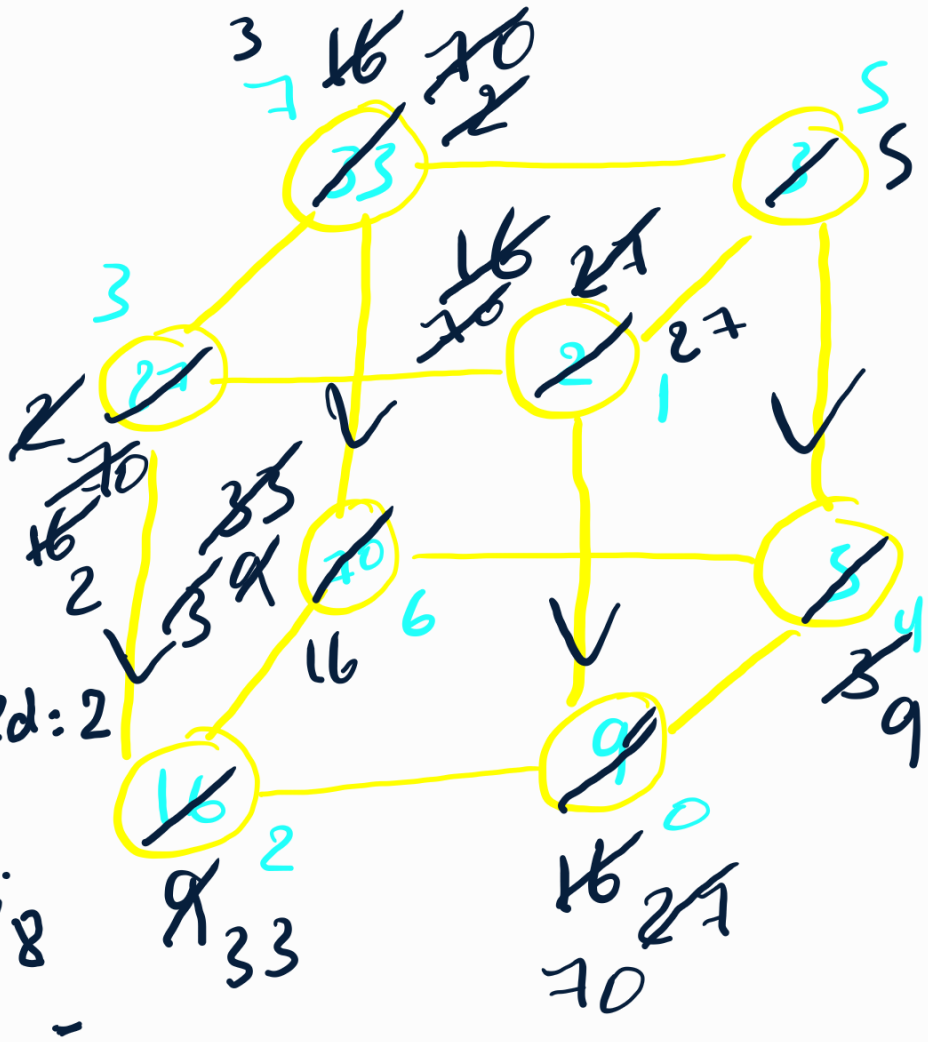
$2^{i+2} = 8 < 4$

$i = 2 \quad j = 2 \quad d = 4/8$

$2^{i+2} = 16 < 8.$

$d = 0 / j = 1 \quad d = 2$

$2d = 4$



t_0	t_1	t_2	t_3	t_4	t_5	t_6	t_7
2/1		27/3		3/5		33/7	
16/2	27/3			33/6	70/7		
27/1		2/3		3/5		70/7	
3/4	5/5	33/6	70/7				
33/2	70/3			9/6	27		
70/1		33/3		5/5		2/7	