Q1: [Marks = 3+3+2+2]

a) Figure A illustrates a task dependency graph for finding the minimum number in the sequence {4, 9, 1, 7, 8, 11, 2, 12}. Each node in the tree represents the task of finding the minimum of a pair of numbers. Write a pseudo code (a recursive program) for finding the minimum in an array of numbers A of length n.
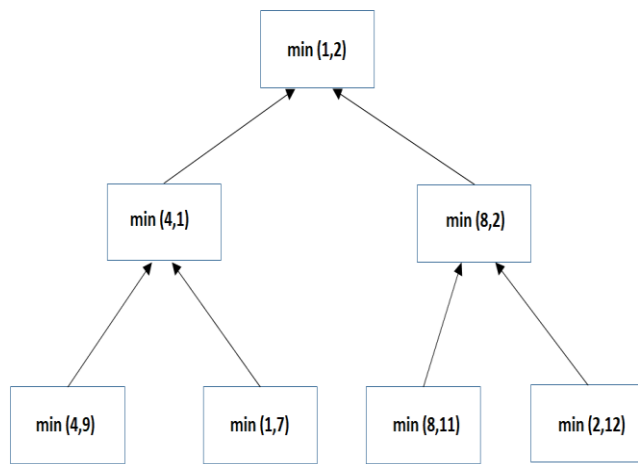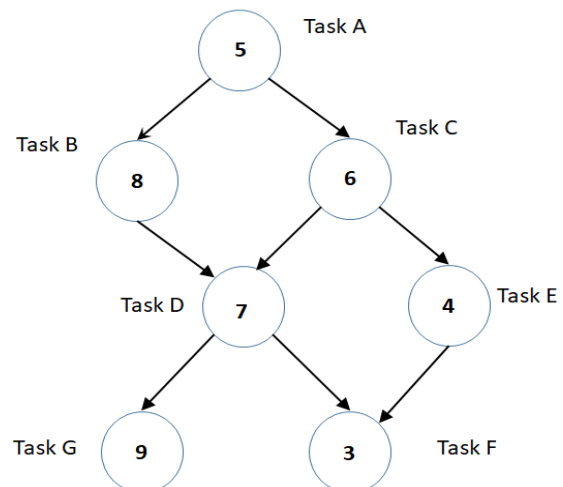

Figure A

Figure B

b) We have two matrices $\begin{bmatrix} X_{1,1} & X_{1,2} \\ X_{2,1} & X_{2,2} \end{bmatrix}$ and $\begin{bmatrix} Y_{1,1} & Y_{1,2} \\ Y_{2,1} & Y_{2,2} \end{bmatrix}$ their product is represented by $\begin{bmatrix} R_{1,1} & R_{1,2} \\ R_{2,1} & R_{2,2} \end{bmatrix}$. Use Data decomposition technique and show two variations of calculating the product for the given two matrices.

c) Consider the following task dependency graph in figure B. Calculate the critical path length and average degree of concurrency.

d) Explain the role of checkpoint node in Hadoop distributed file system in 3 sentences.

Q2: [Marks=2+3]

a) Consider the following piece of code where process 0 sends two messages with different tags to process 1, and process 1 receives them in the reverse order. MPI_Send is implemented by blocking. Identify the problem and describe in two sentences.

```
int a[10], b[10], myrank;
MPI_Status status;
...
 MPI_Comm_rank(MPI_COMM_WORLD, &myrank);
if (myrank == 0) {
    MPI_Send(a, 10, MPI_INT, 1, 1, MPI_COMM_WORLD);
    MPI_Send(b, 10, MPI_INT, 1, 2, MPI_COMM_WORLD);
}
else if (myrank == 1) {
    MPI_Recv(b, 10, MPI_INT, 0, 2, MPI_COMM_WORLD);
    MPI_Recv(a, 10, MPI_INT, 0, 1, MPI_COMM_WORLD);
}
```

b) Write a MPI C program that will find the sum of the given two matrices using 3 processes with scatter and gather operations.

a
1	2	3
1	2	3
1	2	3

b
1	1	1
2	2	2
3	3	3