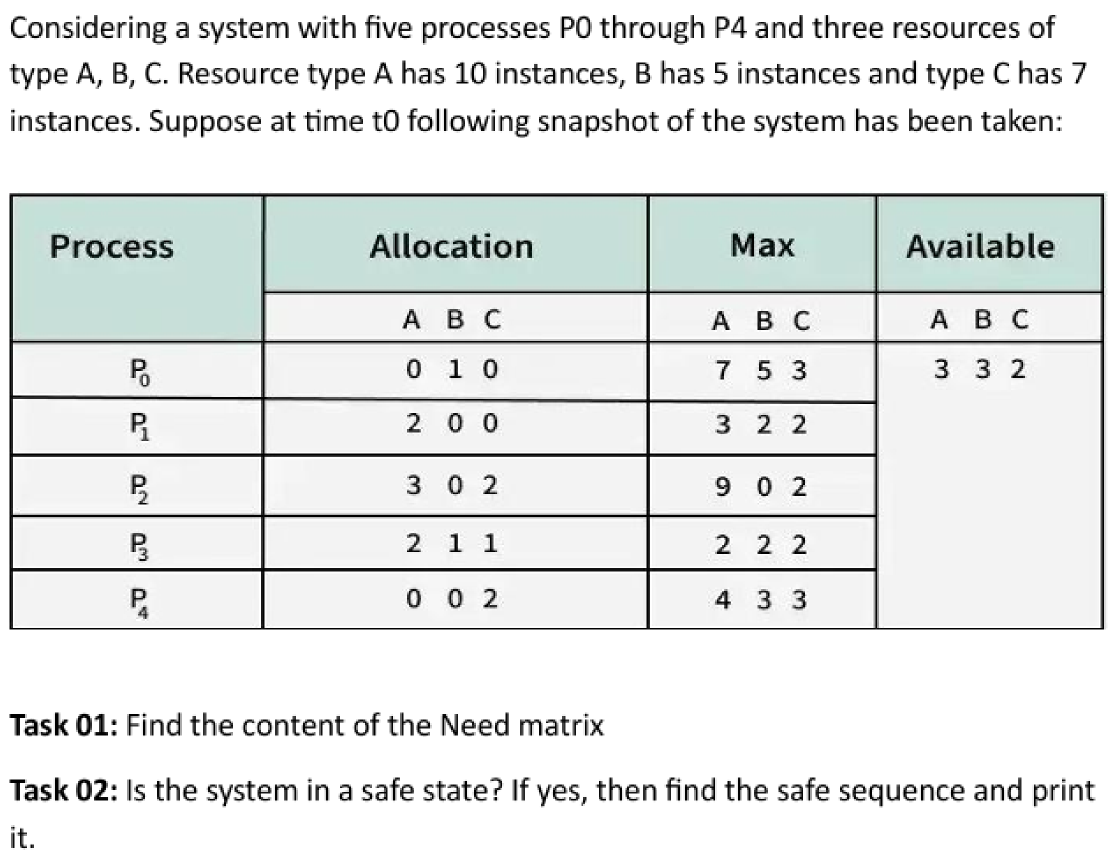


Considering a system with five processes P0 through P4 and three resources of type A, B, C. Resource type A has 10 instances, B has 5 instances and type C has 7 instances. Suppose at time t0 following snapshot of the system has been taken:

Process	Allocation	Max	Available
	A B C	A B C	A B C
P_0	0 1 0	7 5 3	3 3 2
P_1	2 0 0	3 2 2	
P_2	3 0 2	9 0 2	
P_3	2 1 1	2 2 2	
P_4	0 0 2	4 3 3	

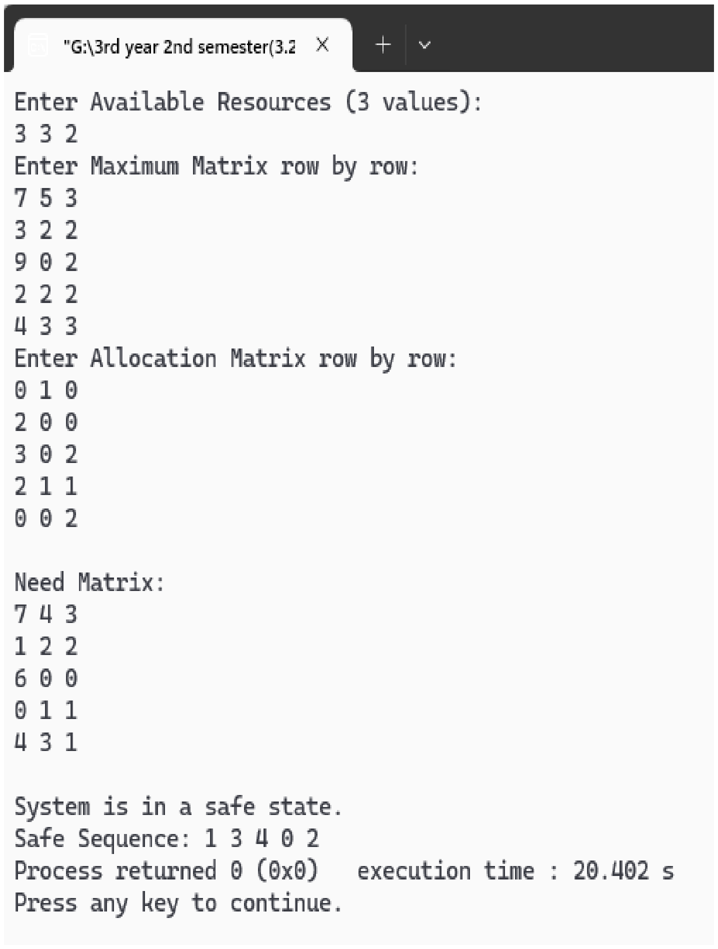
Task 01: Find the content of the Need matrix

Task 02: Is the system in a safe state? If yes, then find the safe sequence and print it.

1,2:Find the Need Matrix And Safe sequence:

```
#include<iostream>

using namespace std;


const int p = 5;

const int r = 3;


void needcalc(int need[p][r], int maxm[p][r], int allot[p][r]) {

   for (int i = 0; i < p; i++)

      for (int j = 0; j < r; j++)

         need[i][j] = maxm[i][j] - allot[i][j];

}


bool safe(int avail[r], int maxm[p][r], int allot[p][r]) {

   int need[p][r], work[r], seq[p], cnt = 0;

bool done[p] = {0};


needcalc(need, maxm, allot);


cout << "\nNeed Matrix:\n";

for (int i = 0; i < p; i++) {

   for (int j = 0; j < r; j++)

      cout << need[i][j] << " ";

   cout << endl;

}


for (int i = 0; i < r; i++) work[i] = avail[i];


while (cnt < p) {

   bool ok = 0;

   for (int i = 0; i < p; i++) {
```

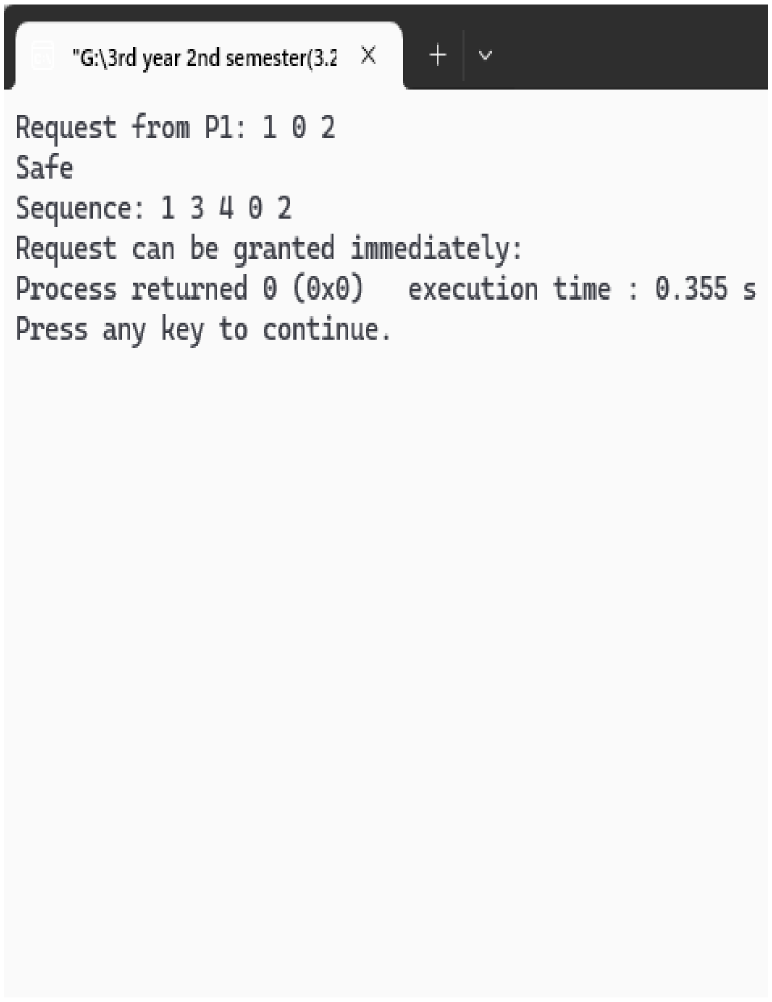
```
            if (!done[i]) {
                int j;
                for (j = 0; j < r; j++)
                    if (need[i][j] > work[j]) break;
                if (j == r) {
                    for (int k = 0; k < r; k++)
                        work[k] += allot[i][k];
                    seq[cnt++] = i;
                    done[i] = 1;
                    ok = 1;
                }
            }
        }
        if (!ok) {
            cout << "\nSystem is not in a safe state.";
            return 0;
        }
    }

    cout << "\nSystem is in a safe state.\nSafe Sequence: ";
    for (int i = 0; i < p; i++) cout << seq[i] << " ";
    return 1;



int main() {
    int avail[r], maxm[p][r], allot[p][r];

    cout << "Enter Available Resources (" << r << " values):\n";
    for (int i = 0; i < r; i++)
        cin >> avail[i];

    cout << "Enter Maximum Matrix row by row:\n";
    for (int i = 0; i < p; i++)

        for (int j = 0; j < r; j++)
            cin >> maxm[i][j];

    cout << "Enter Allocation Matrix row by row:\n";
    for (int i = 0; i < p; i++)
        for (int j = 0; j < r; j++)
            cin >> allot[i][j];

    safe(avail, maxm, allot);
    return 0;
}
```



```
Enter Available Resources (3 values):
3 3 2
Enter Maximum Matrix row by row:
7 5 3
3 2 2
9 0 2
2 2 2
4 3 3
Enter Allocation Matrix row by row:
0 1 0
2 0 0
3 0 2
2 1 1
0 0 2

Need Matrix:
7 4 3
1 2 2
6 0 0
0 1 1
4 3 1

System is in a safe state.
Safe Sequence: 1 3 4 0 2
Process returned 0 (0x0)   execution time : 20.402 s
Press any key to continue.
```

<u>Task 03: Suppose now process P1 requests one additional instance of resource type A and two instances of resource type C, can the request be granted immediately? If granted, then print the sequence.</u>

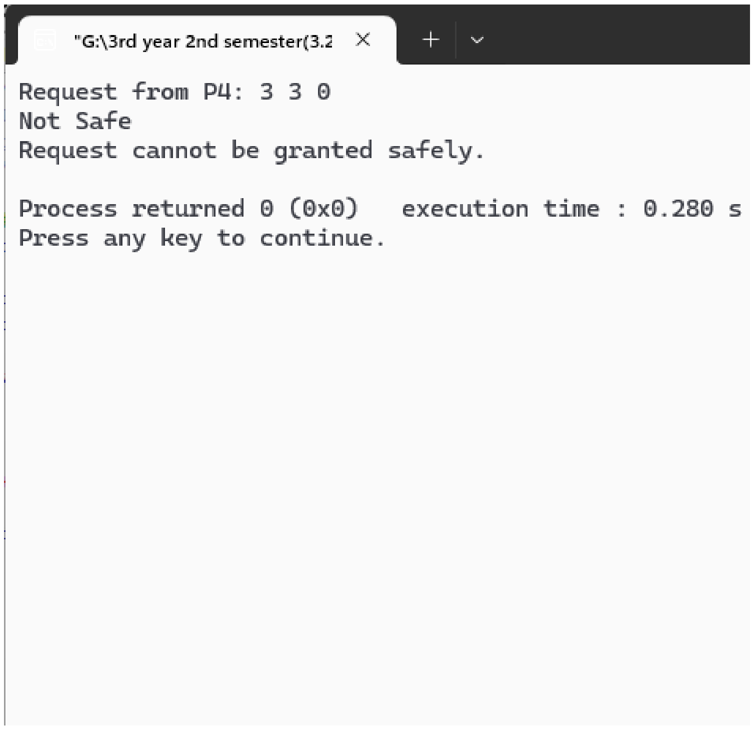
```
#include<iostream>

using namespace std;


const int p = 5;

const int r = 3;


void needcalc(int need[p][r], int maxm[p][r], int
allot[p][r]) {

   for (int i = 0; i < p; i++)

      for (int j = 0; j < r; j++)

         need[i][j] = maxm[i][j] - allot[i][j];

}


bool safe(int avail[r], int maxm[p][r], int allot[p][r]) {

   int need[p][r], work[r], seq[p], cnt = 0;

   bool done[p] = {0};

   needcalc(need, maxm, allot);

   for (int i = 0; i < r; i++) work[i] = avail[i];


   while (cnt < p) {

      bool ok = 0;

      for (int i = 0; i < p; i++) {

         if (!done[i]) {

            int j;

            for (j = 0; j < r; j++)

               if (need[i][j] > work[j]) break;

            if (j == r) {

               for (int k = 0; k < r; k++)

                  work[k] += allot[i][k];

               seq[cnt++] = i;

                done[i] = 1;

                ok = 1;

            }

         }

      }

      if (!ok) {

         cout << "Not Safe";

         return 0;

      }

   }

   cout << "Safe\nSequence: ";

   for (int i = 0; i < p; i++) cout << seq[i] << " ";

   return 1;

}


int main() {

   int avail[r] = {3, 3, 2};


   int maxm[p][r] = {

      {7, 5, 3},

      {3, 2, 2},

      {9, 0, 2},

      {2, 2, 2},

      {4, 3, 3}

   };


   int allot[p][r] = {

      {0, 1, 0},

      {2, 0, 0},

      {3, 0, 2},
      {2, 1, 1},
      {0, 0, 2}
   };

   int req[r] = {1, 0, 2};

   int need[p][r];
   needcalc(need, maxm, allot);

   cout << "Request from P1: ";
   for (int i = 0; i < r; i++) cout << req[i] << " ";
   cout << endl;

   bool canGrant = true;
   for (int i = 0; i < r; i++) {
      if (req[i] > need[1][i] || req[i] > avail[i]) {
         canGrant = false;
         break;
      }
   }

   if (!canGrant) {
      cout << "Cannot be granted immediately.";
      return 0;
   }

   for (int i = 0; i < r; i++) {
      avail[i] -= req[i];
      allot[1][i] += req[i];
      need[1][i] -= req[i];
   }

   if (safe(avail, maxm, allot))
      cout << "\nRequest can be granted immediately:";
   else
      cout << "\nRequest cannot be granted safely:";

   return 0;
}
```



```
Request from P1: 1 0 2
Safe
Sequence: 1 3 4 0 2
Request can be granted immediately:
Process returned 0 (0x0)   execution time : 0.355 s
Press any key to continue.
```

Task 04: Again, a request for (3,3,0) by P4 happened. Now, can the request be granted immediately?

```
#include<iostream>

using namespace std;


const int p = 5;

const int r = 3;


void needcalc(int need[p][r], int maxm[p][r], int allot[p][r]) {

    for (int i = 0; i < p; i++)

        for (int j = 0; j < r; j++)

            need[i][j] = maxm[i][j] - allot[i][j];

}


bool safe(int avail[r], int maxm[p][r], int allot[p][r]) {

    int need[p][r], work[r], seq[p], cnt = 0;

    bool done[p] = {0};

    needcalc(need, maxm, allot);

    for (int i = 0; i < r; i++) work[i] = avail[i];


    while (cnt < p) {

        bool ok = 0;

        for (int i = 0; i < p; i++) {

            if (!done[i]) {

                int j;

                for (j = 0; j < r; j++)

                    if (need[i][j] > work[j]) break;

                if (j == r) {

                    for (int k = 0; k < r; k++)

                        work[k] += allot[i][k];

                    seq[cnt++] = i;

                    done[i] = 1;

                    ok = 1;

                }

            }

        }

        if (!ok) {

            cout << "Not Safe";

            return 0;

        }

    }

    cout << "Safe\nSequence: ";

    for (int i = 0; i < p; i++) cout << seq[i] << " ";

    return 1;

}


int main() {

    int avail[r] = {3, 3, 2};


    int maxm[p][r] = {

        {7, 5, 3},

        {3, 2, 2},

        {9, 0, 2},

        {2, 2, 2},

        {4, 3, 3}

    };
    int allot[p][r] = {
        {0, 1, 0},
        {2, 0, 0},
        {3, 0, 2},
        {2, 1, 1},
        {0, 0, 2}
    };

    int req[r] = {3, 3, 0}; // Request by P4 (process index 4)

    int need[p][r];
    needcalc(need, maxm, allot);

    cout << "Request from P4: ";
    for (int i = 0; i < r; i++) cout << req[i] << " ";
    cout << endl;

    bool canGrant = true;
    for (int i = 0; i < r; i++) {
        if (req[i] > need[4][i] || req[i] > avail[i]) {
            canGrant = false;
            break;
        }
    }

    if (!canGrant) {
        cout << "Cannot be granted immediately.";
        return 0;
    }

    for (int i = 0; i < r; i++) {
        avail[i] -= req[i];
        allot[4][i] += req[i];
        need[4][i] -= req[i];
    }

    if (safe(avail, maxm, allot))
        cout << "\nRequest can be granted immediately.\n";
    else
        cout << "\nRequest cannot be granted safely.\n";

    return 0;
}
```



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```
Request from P4: 3 3 0
Not Safe
Request cannot be granted safely.

Process returned 0 (0x0)   execution time : 0.280 s
Press any key to continue.
```