Junaid Girkar
60004190057
SE Comps A-3

OPERATING SYSTEM
Experiment No. 8

Aim- Using the CPU-OS simulator to analyze and synthesize the following:

a. Process Scheduling algorithms.
b. Thread creation and synchronization.
c. Deadlock prevention and avoidance.

Problem Statement:

1) Install CPU-OS simulator
2) Perform the following steps

a) Process Scheduling algorithms

Loading and Compiling Program

You need to create some executable code so that it can be run by the CPU simulator under the control of the OS simulator. In order to create this code, you need to use the compiler which is part of the system simulator. This compiler is able to compile simple high-level source statements similar to Visual Basic. To do this, open the compiler window by selecting the **COMPILER…** button in the current window. You should now be looking at the compiler window.
In the compiler window, enter the following source code in the compiler's source editor window (under **PROGRAM SOURCE** frame title):

```
program LoopTest
        i = 0
        for n = 0 to 40
                i = i + 1
        next
end
```

Now you need to compile this in order to generate the executable code. To do this, click on the **COMPILE…** button. You should see the code created on the right in **PROGRAM CODE** view. Make a habit of saving your source code.

Click on the button **SHOW…** in **BINARY CODE** view. You should now see the **Binary Code for LOOPTEST** window. Study the program code displayed in hexadecimal format.

Now, this code needs to be loaded in memory so that the CPU can execute it. To do this, first we need to specify a base address (in **ASSEMBLY CODE** view): uncheck the box next to the edit box with label **Base Address**, and then enter 100 in the edit box. Now, click on the **LOAD IN MEMORY…** button in the current window. You should now see the code loaded in memory ready to be executed. You are also back in the CPU simulator at this stage. This action is equivalent to loading the program code normally stored on a disc drive into RAM on the real computer systems.

Creating processes from programs in the OS simulator.

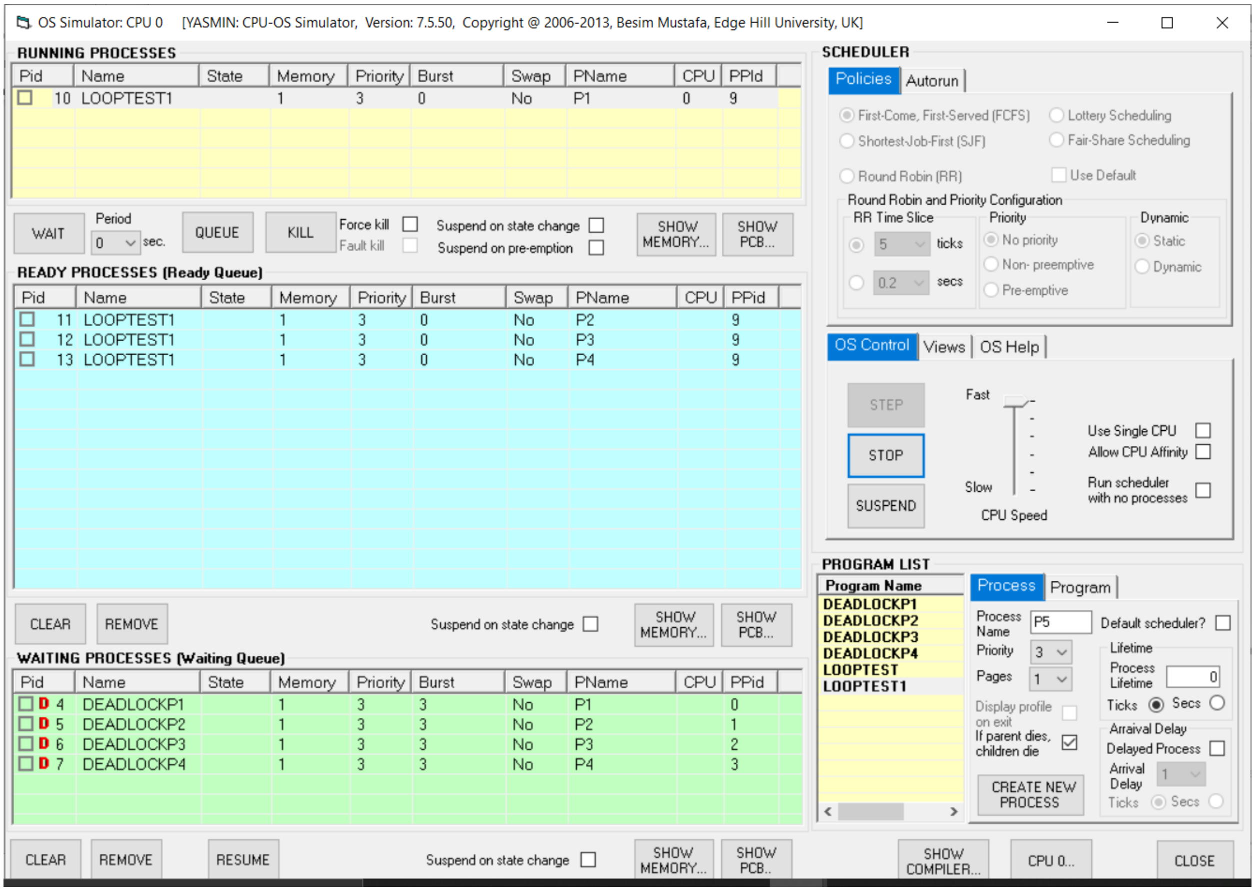
We are now going to use the OS simulator to run this code. To enter the OS simulator, click on the **OS 0…** button in the current window. The OS window opens. You should see an entry, titled **LoopTest**, in the **PROGRAM LIST** view. Now that this program is available to the OS simulator, we can create as many instances, i.e. processes, of it as we like. You do this by clicking on the **CREATE NEW PROCESS** button. Repeat this four times. Observe the four instances of the program being queued in the ready queue which is represented by the **READY PROCESSES** view.

NOTE: it is very important that you follow the instructions below without any deviation. If you do, then you must re-do the exercise from the beginning as any follow-up action(s) may give the wrong results.

Selecting different scheduling policies and run the processes in the OS simulator

Make sure the **First-Come-First-Served (FCFS)** option is selected in the **SCHEDULER/Policies** view. At this point the OS is inactive. To activate, first move the **Speed** slider to the fastest position, then click on the **START** button. This should start the OS simulator running the processes. Observe the instructions executing in the CPU simulator window. Make a note of what you observe in the box below as the processes are run (you need to concentrate on the two views: **RUNNING PROCESSES** and the **READY PROCESSES** during this period).

The first process moves from the ready processes section to the running processes. Meanwhile I can see the registers changing rapidly in another window. After about 20 seconds, Process 1 leaves the Running Processes section and Process 2 takes it place. Again 20 seconds then Process 3 and then Process 4. After that since there are no ready processes both Ready Processes and Running Processes sections remain empty



RUNNING PROCESSES

	Pid	Name	State	Memory	Priority	Burst	Swap	PName	CPU	PPId
□	10	LOOPTEST1		1	3	0	No	P1	0	9

Period 0 sec.
Force kill □ Fault kill □
Suspend on state change □
Suspend on pre-emption □

READY PROCESSES (Ready Queue)

	Pid	Name	State	Memory	Priority	Burst	Swap	PName	CPU	PPId
□	11	LOOPTEST1		1	3	0	No	P2		9
□	12	LOOPTEST1		1	3	0	No	P3		9
□	13	LOOPTEST1		1	3	0	No	P4		9

Suspend on state change □

WAITING PROCESSES (Waiting Queue)

	Pid	Name	State	Memory	Priority	Burst	Swap	PName	CPU	PPId
□	D 4	DEADLOCKP1		1	3	3	No	P1		0
□	D 5	DEADLOCKP2		1	3	3	No	P2		1
□	D 6	DEADLOCKP3		1	3	3	No	P3		2
□	D 7	DEADLOCKP4		1	3	3	No	P4		3

Suspend on state change □

SCHEDULER

Policies | Autorun

● First-Come, First-Served (FCFS) ○ Lottery Scheduling
○ Shortest-Job-First (SJF) ○ Fair-Share Scheduling
○ Round Robin (RR) □ Use Default

Round Robin and Priority Configuration
RR Time Slice: ● 5 ticks ○ 0.2 secs
Priority: ● No priority ○ Non- preemptive ○ Pre-emptive
Dynamic: ● Static ○ Dynamic

OS Control | Views | OS Help

Use Single CPU □
Allow CPU Affinity □
Run scheduler with no processes □

PROGRAM LIST

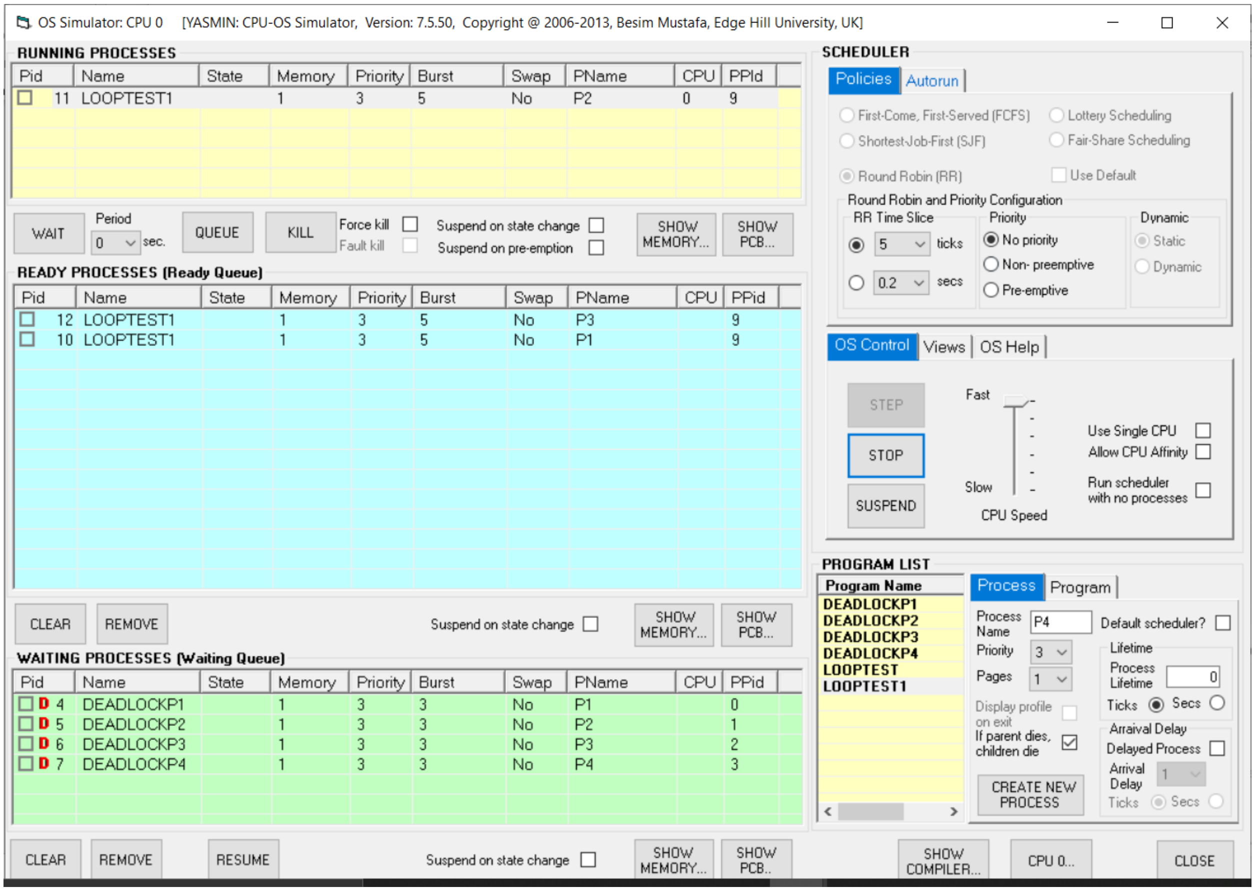
Program Name
DEADLOCKP1
DEADLOCKP2
DEADLOCKP3
DEADLOCKP4
LOOPTEST
LOOPTEST1

Process | Program

Process Name P5
Priority 3
Pages 1
Display profile on exit □
If parent dies, children die ☑
Default scheduler? □
Lifetime: Process Lifetime 0; Ticks ● Secs ○
Arraival Delay: Delayed Process □; Arrival Delay 1; Ticks ● Secs ○

When all the processes finish, do the following. Select **Round Robin (RR)** option in the **SCHEDULER/Policies** view. Then select the **No priority** option in the **SCHEDULER/Policies/Priority** frame. Create three processes. Click on the **START** button and observe the behaviors of the processes until they all complete. You may wish to use speed slider to slow down the processes to better see what is happening. Make a note of what you observed in the box below and compare this with the observation in step 1 above.

First Process 1 moves from READY to RUNNING. It it is there for a short time and we can see the General Purpose CPU registers value changing. It P1 then comes back to READY and P2 moves to RUNNING. Similar to P1, its there for some time and then comes back to READY STATE and P3 takes its place. After P3 has run for some time, it comes back to READY state and P1 moves to RUNNING again. This cycle keeps on for some time then all the three processes finish their running and both the READY and RUNNING states become empty again.


OS Simulator: CPU 0 [YASMIN: CPU-OS Simulator, Version: 7.5.50, Copyright @ 2006-2013, Besim Mustafa, Edge Hill University, UK]

RUNNING PROCESSES

	Pid	Name	State	Memory	Priority	Burst	Swap	PName	CPU	PPId
□	11	LOOPTEST1		1	3	5	No	P2	0	9

Period 0 sec.

Force kill □

Fault kill □

Suspend on state change □

Suspend on pre-emption □

WAIT
QUEUE
KILL
SHOW MEMORY...
SHOW PCB...

READY PROCESSES (Ready Queue)

	Pid	Name	State	Memory	Priority	Burst	Swap	PName	CPU	PPId
□	12	LOOPTEST1		1	3	5	No	P3		9
□	10	LOOPTEST1		1	3	5	No	P1		9

Suspend on state change □

CLEAR
REMOVE
SHOW MEMORY...
SHOW PCB...

WAITING PROCESSES (Waiting Queue)

	Pid	Name	State	Memory	Priority	Burst	Swap	PName	CPU	PPId
□ D	4	DEADLOCKP1		1	3	3	No	P1		0
□ D	5	DEADLOCKP2		1	3	3	No	P2		1
□ D	6	DEADLOCKP3		1	3	3	No	P3		2
□ D	7	DEADLOCKP4		1	3	3	No	P4		3

Suspend on state change □

SCHEDULER

○ First-Come, First-Served (FCFS)
○ Lottery Scheduling
○ Shortest-Job-First (SJF)
○ Fair-Share Scheduling
● Round Robin (RR)
□ Use Default

Round Robin and Priority Configuration

RR Time Slice: ● 5 ticks ○ 0.2 secs

Priority: ● No priority ○ Non- preemptive ○ Pre-emptive

Dynamic: ● Static ○ Dynamic

Use Single CPU □

Allow CPU Affinity □

Run scheduler with no processes □

PROGRAM LIST

Program Name
DEADLOCKP1
DEADLOCKP2
DEADLOCKP3
DEADLOCKP4
LOOPTEST1

Process Name P4

Default scheduler? □

Priority 3

Pages 1

Display profile on exit □

If parent dies, children die ☑

Lifetime

Process Lifetime 0

Ticks ● Secs ○

Arraival Delay

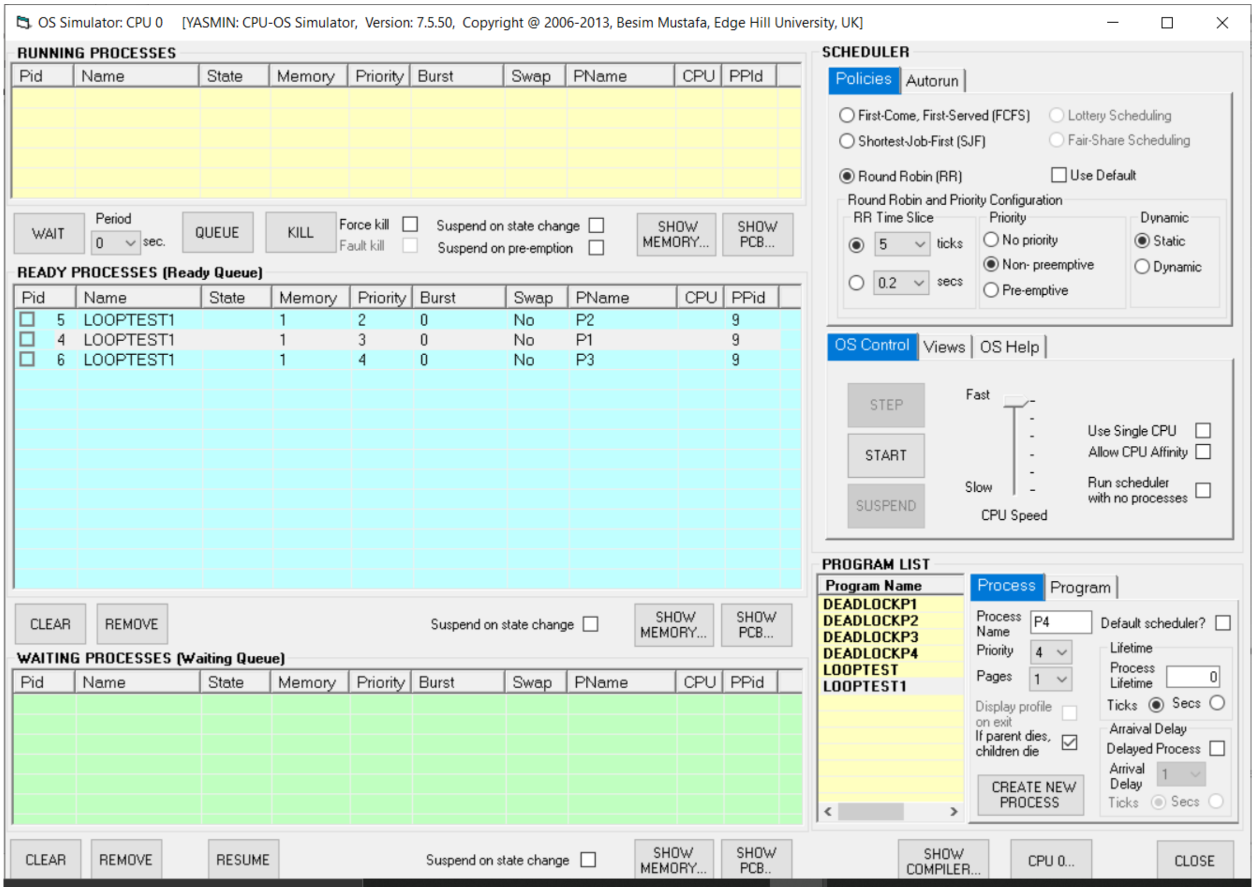
Delayed Process □

Arrival Delay 1

Ticks ● Secs ○

Then select the **Non-preemptive** priority option in the **SCHEDULER/Policies/Priority** frame. Create three processes with the following priorities: 3, 2 and 4. Use the **Priority** drop down list to select priorities. Observe the order in which the three processes are queued in the ready queue represented by the **READY PROCESSES** view and make a note of this in the box below (note that the lower the number the higher the priority is).

The 3 processes are queued in the READY PROCESSES in ascending order of priority.



OS Simulator: CPU 0 [YASMIN: CPU-OS Simulator, Version: 7.5.50, Copyright @ 2006-2013, Besim Mustafa, Edge Hill University, UK]

RUNNING PROCESSES

Pid	Name	State	Memory	Priority	Burst	Swap	PName	CPU	PPid

READY PROCESSES (Ready Queue)

Pid	Name	State	Memory	Priority	Burst	Swap	PName	CPU	PPid
□ 5	LOOPTEST1		1	2	0	No	P2		9
□ 4	LOOPTEST1		1	3	0	No	P1		9
□ 6	LOOPTEST1		1	4	0	No	P3		9

WAITING PROCESSES (Waiting Queue)

Pid	Name	State	Memory	Priority	Burst	Swap	PName	CPU	PPid

SCHEDULER

○ First-Come, First-Served (FCFS) ○ Lottery Scheduling
○ Shortest-Job-First (SJF) ○ Fair-Share Scheduling
● Round Robin (RR) □ Use Default

Round Robin and Priority Configuration
RR Time Slice: ● 5 ticks ○ 0.2 secs
Priority: ○ No priority ● Non- preemptive ○ Pre-emptive
Dynamic: ● Static ○ Dynamic

Use Single CPU □
Allow CPU Affinity □
Run scheduler with no processes □

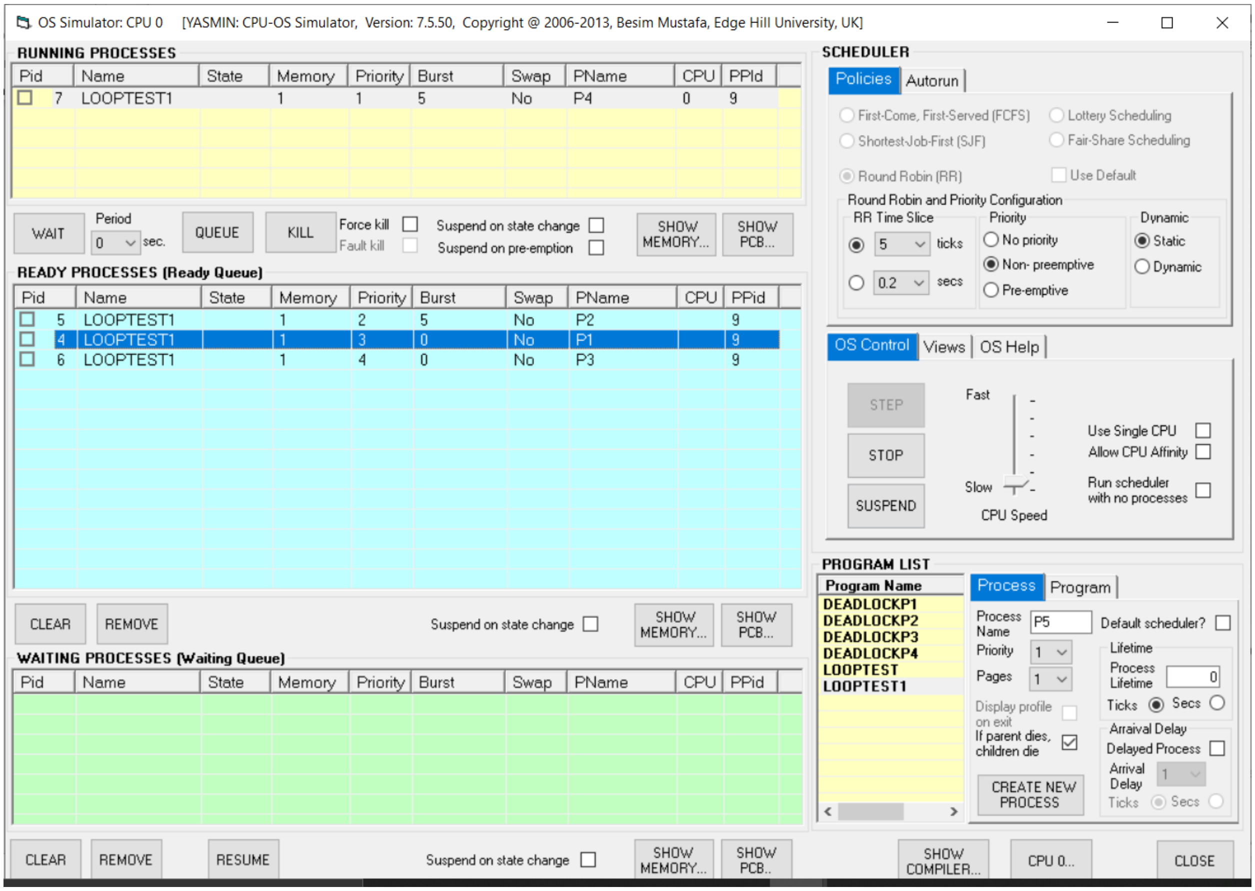
PROGRAM LIST

Program Name
DEADLOCKP1
DEADLOCKP2
DEADLOCKP3
DEADLOCKP4
LOOPTEST
LOOPTEST1

Process Name: P4
Priority: 4
Pages: 1
Default scheduler? □
Process Lifetime: 0 ● Ticks ○ Secs
Display profile on exit □
If parent dies, children die ☑
Delayed Process □

Slide the **Speed** selector to the slowest position and then hit the **START** button. While the first process is being run do the following. Create a fourth process with priority 1. Make a note of what you observe (pay attention to the **READY PROCESSES** view) in the box below.

P1 moves to the top in the READY list and soon moves to the RUNNING PROCESSES after the burst time of currently running process where it gets executed completely although with small pauses where it moves to READY and back to RUNNING. The rest of the processes occur similarly in the increasing order of their priority



OS Simulator: CPU 0 [YASMIN: CPU-OS Simulator, Version: 7.5.50, Copyright @ 2006-2013, Besim Mustafa, Edge Hill University, UK]

RUNNING PROCESSES

	Pid	Name	State	Memory	Priority	Burst	Swap	PName	CPU	PPId
□	7	LOOPTEST1		1	1	5	No	P4	0	9

Period 0 sec. Force kill □ Fault kill □ Suspend on state change □ Suspend on pre-emption □

READY PROCESSES (Ready Queue)

	Pid	Name	State	Memory	Priority	Burst	Swap	PName	CPU	PPId
□	5	LOOPTEST1		1	2	5	No	P2		9
□	4	LOOPTEST1		1	3	0	No	P1		9
□	6	LOOPTEST1		1	4	0	No	P3		9

Suspend on state change □

WAITING PROCESSES (Waiting Queue)

Pid	Name	State	Memory	Priority	Burst	Swap	PName	CPU	PPId

Suspend on state change □

SCHEDULER

○ First-Come, First-Served (FCFS) ○ Lottery Scheduling
○ Shortest-Job-First (SJF) ○ Fair-Share Scheduling
○ Round Robin (RR) □ Use Default

Round Robin and Priority Configuration
RR Time Slice: ● 5 ticks ○ 0.2 secs
Priority: ○ No priority ● Non- preemptive ○ Pre-emptive
Dynamic: ● Static ○ Dynamic

Use Single CPU □
Allow CPU Affinity □
Run scheduler with no processes □

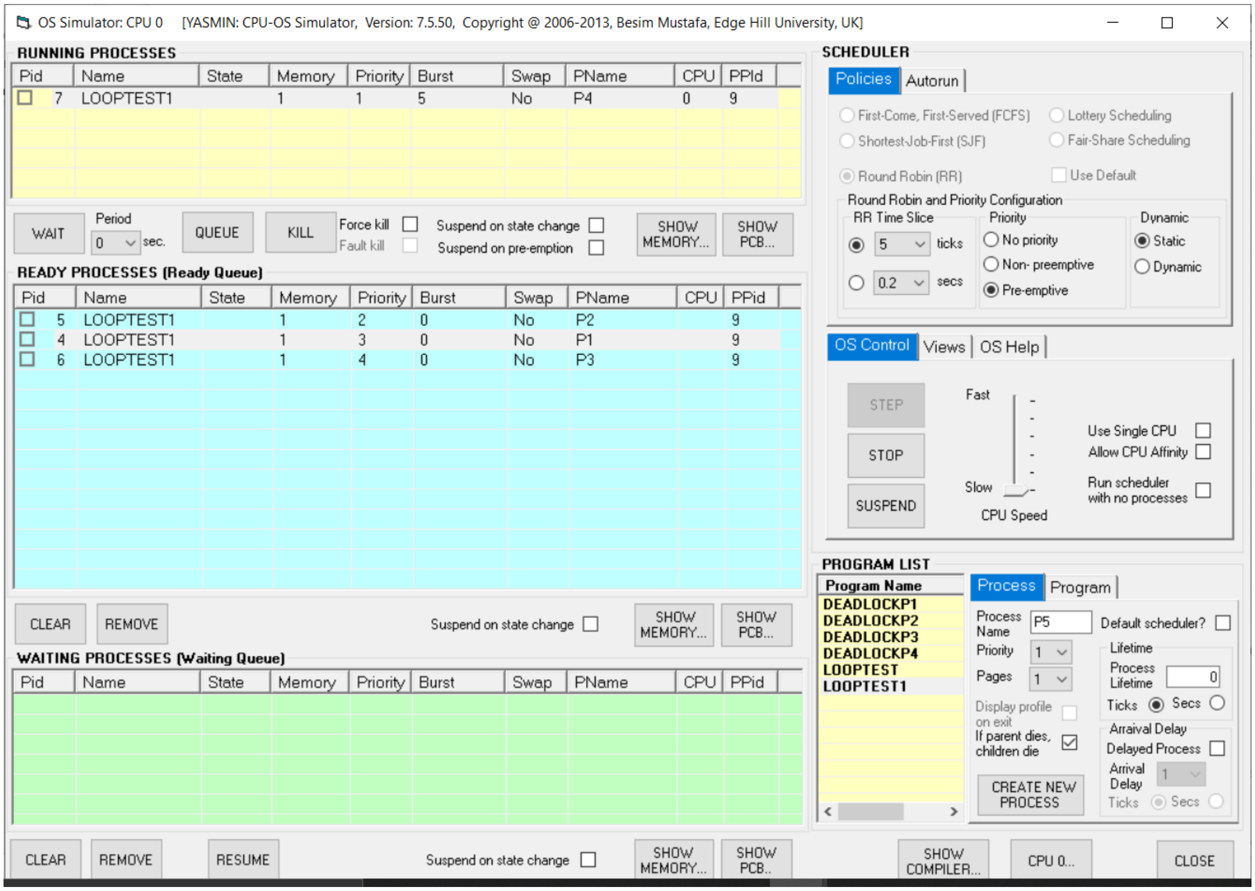
PROGRAM LIST

Program Name
DEADLOCKP1
DEADLOCKP2
DEADLOCKP3
DEADLOCKP4
LOOPTEST
LOOPTEST1

Process Name P5 Default scheduler? □
Priority 1
Pages 1
Lifetime: Process Lifetime 0, Ticks ● Secs ○
Display profile on exit □
If parent dies, children die ☑
Arraival Delay: Delayed Process □, Arrival Delay 1, Ticks ● Secs ○

Now kill all four processes one by one as they start running. Next, select the **Pre-emptive** option in the **SCHEDULER/Policies/Priority** frame. Create the same three processes as in step 3 and then hit the **START** button. While the first process is being run do the following. Create a fourth process with priority 1. Make a note of what you observe (pay attention to the **RUNNING PROCESSES** view). How is this behavior different than that in step 4 above?

P4 immediately enter RUNNING and is executed till completion. Then P2 enters and is executed till completion. This cycle continuous is ascending order of the priority



OS Simulator: CPU 0 [YASMIN: CPU-OS Simulator, Version: 7.5.50, Copyright @ 2006-2013, Besim Mustafa, Edge Hill University, UK]

RUNNING PROCESSES

	Pid	Name	State	Memory	Priority	Burst	Swap	PName	CPU	PPId
□	7	LOOPTEST1		1	1	5	No	P4	0	9

Period 0 sec. Force kill □ Fault kill □ Suspend on state change □ Suspend on pre-emption □

READY PROCESSES (Ready Queue)

	Pid	Name	State	Memory	Priority	Burst	Swap	PName	CPU	PPId
□	5	LOOPTEST1		1	2	0	No	P2		9
□	4	LOOPTEST1		1	3	0	No	P1		9
□	6	LOOPTEST1		1	4	0	No	P3		9

Suspend on state change □

WAITING PROCESSES (Waiting Queue)

Pid	Name	State	Memory	Priority	Burst	Swap	PName	CPU	PPId

Suspend on state change □

SCHEDULER

○ First-Come, First-Served (FCFS) ○ Lottery Scheduling
○ Shortest-Job-First (SJF) ○ Fair-Share Scheduling
● Round Robin (RR) □ Use Default

Round Robin and Priority Configuration
RR Time Slice: ● 5 ticks ○ 0.2 secs
Priority: ○ No priority ○ Non- preemptive ● Pre-emptive
Dynamic: ● Static ○ Dynamic

Use Single CPU □
Allow CPU Affinity □
Run scheduler with no processes □

PROGRAM LIST

Program Name
DEADLOCKP1
DEADLOCKP2
DEADLOCKP3
DEADLOCKP4
LOOPTEST
LOOPTEST1

Process Name: P5 Default scheduler? □
Priority: 1
Pages: 1
Display profile on exit □
If parent dies, children die ☑
Lifetime: Process Lifetime 0, Ticks ● Secs ○
Arraival Delay: Delayed Process □, Arrival Delay 1, Ticks ● Secs ○

Thread creation and synchronization.

Loading and Compiling a Program

In the compiler window enter the following source code:

```
program ThreadTest1
     sub thread1 as thread
          writeln("In thread1")
          while true
          wend
     end sub
     sub thread2 as thread
          call thread1
          writeln("In thread2")
          while true
          wend
     end sub
     call thread2
     writeln("In main")
     do
```

```
            loop
        end
```

Compile the above source and load the generated code in memory.

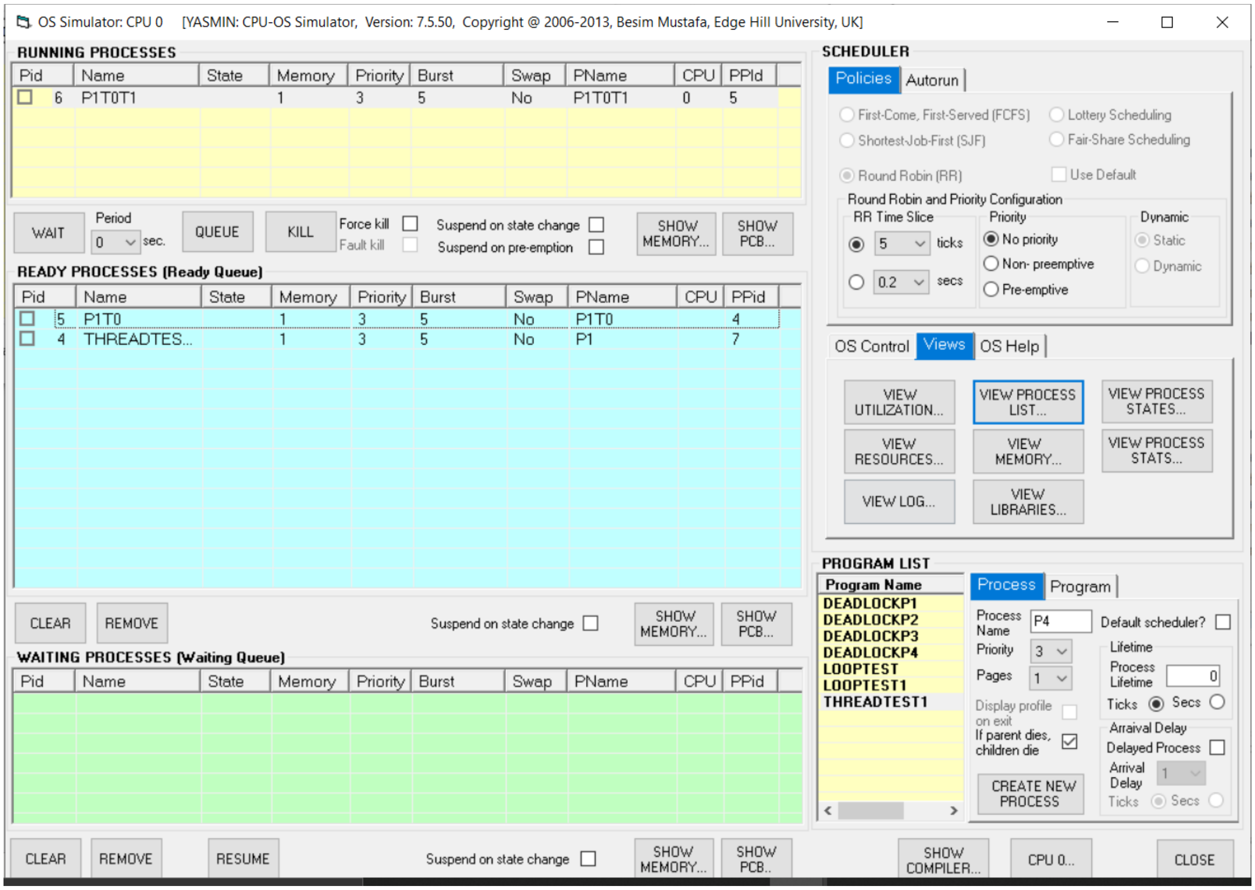
Make the console window visible by clicking on the **INPUT/OUTPUT…** button. Also make sure the console window stays on top by checking the **Stay on top** check box.

Now, go to the OS simulator window (use the **OS…** button in the CPU simulator window) and create a single process of program *ThreadTest1* in the program list view. For this use the **CREATE NEW PROCESS** button.

Make sure the scheduling policy selected is **Round Robin** and that the simulation speed is set at maximum.

Hit the **START** button and at the same time observe the displays on the console window.
Briefly explain your observations and the no. of processes created in the box below.

Total 3 processes get created having the same priority as the main. One is the main program and the remaining two are threads. All 3 are executed partially in a cycle such that they finish at the same time one after the other.



OS Simulator: CPU 0 [YASMIN: CPU-OS Simulator, Version: 7.5.50, Copyright @ 2006-2013, Besim Mustafa, Edge Hill University, UK]

RUNNING PROCESSES

Pid	Name	State	Memory	Priority	Burst	Swap	PName	CPU	PPId
□ 6	P1T0T1		1	3	5	No	P1T0T1	0	5

Period 0 sec.

Force kill □ Fault kill □ Suspend on state change □ Suspend on pre-emption □

READY PROCESSES (Ready Queue)

Pid	Name	State	Memory	Priority	Burst	Swap	PName	CPU	PPId
□ 5	P1T0		1	3	5	No	P1T0		4
□ 4	THREADTES...		1	3	5	No	P1		7

Suspend on state change □

WAITING PROCESSES (Waiting Queue)

Pid	Name	State	Memory	Priority	Burst	Swap	PName	CPU	PPId

Suspend on state change □

SCHEDULER

Policies | Autorun

○ First-Come, First-Served (FCFS) ○ Lottery Scheduling
○ Shortest-Job-First (SJF) ○ Fair-Share Scheduling
● Round Robin (RR) □ Use Default

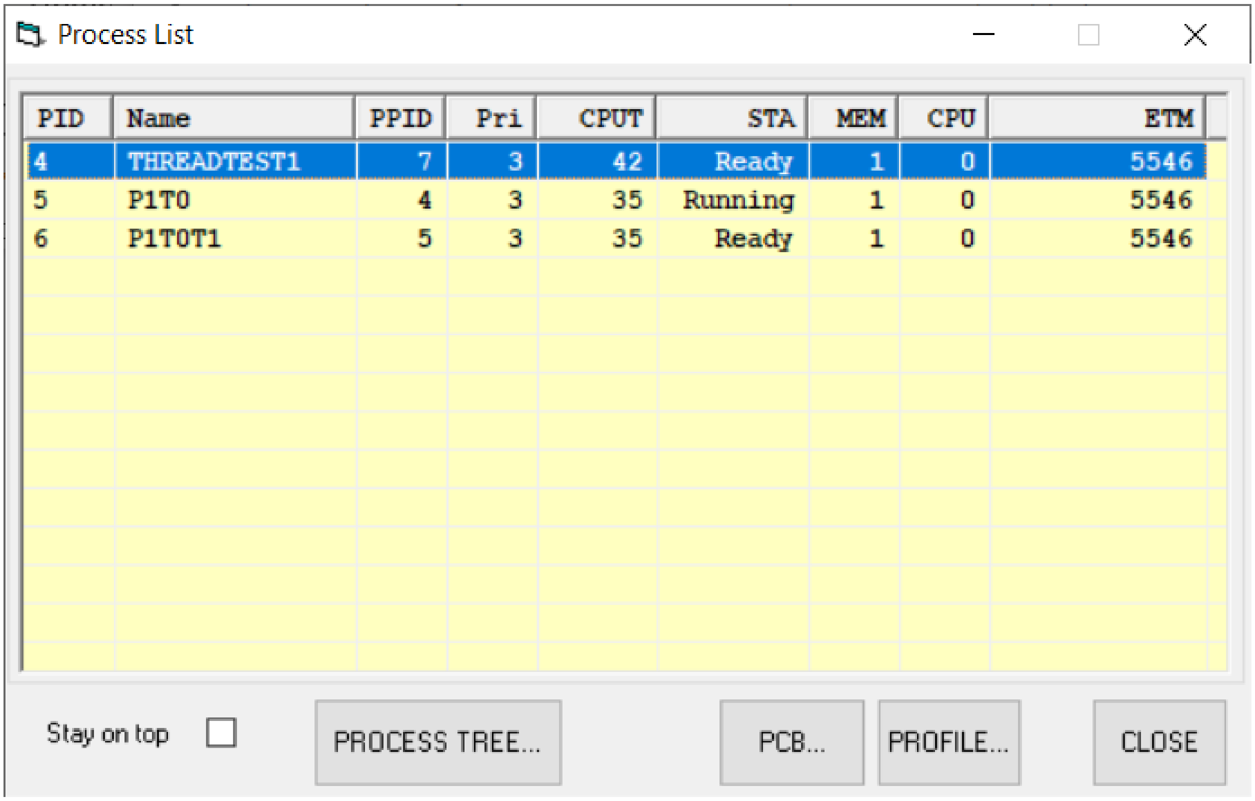
Round Robin and Priority Configuration
RR Time Slice: ● 5 ticks ○ 0.2 secs
Priority: ● No priority ○ Non- preemptive ○ Pre-emptive
Dynamic: ● Static ○ Dynamic

PROGRAM LIST

Program Name
DEADLOCKP1
DEADLOCKP2
DEADLOCKP3
DEADLOCKP4
LOOPTEST
LOOPTEST1
THREADTEST1

Process | Program

Process Name: P4
Default scheduler? □
Priority: 3
Pages: 1
Display profile on exit □
If parent dies, children die ☑
Lifetime: Process Lifetime 0 Ticks ● Secs ○
Arraival Delay: Delayed Process □ Arrival Delay 1 Ticks ● Secs ○



PID	Name	PPID	Pri	CPUT	STA	MEM	CPU	ETM
4	THREADTEST1	7	3	42	Ready	1	0	5546
5	P1T0	4	3	35	Running	1	0	5546
6	P1T0T1	5	3	35	Ready	1	0	5546

Now, click on the **Views** tab and click on the **VIEW PROCESS LIST…** button. Observe the contents of the window now displaying.

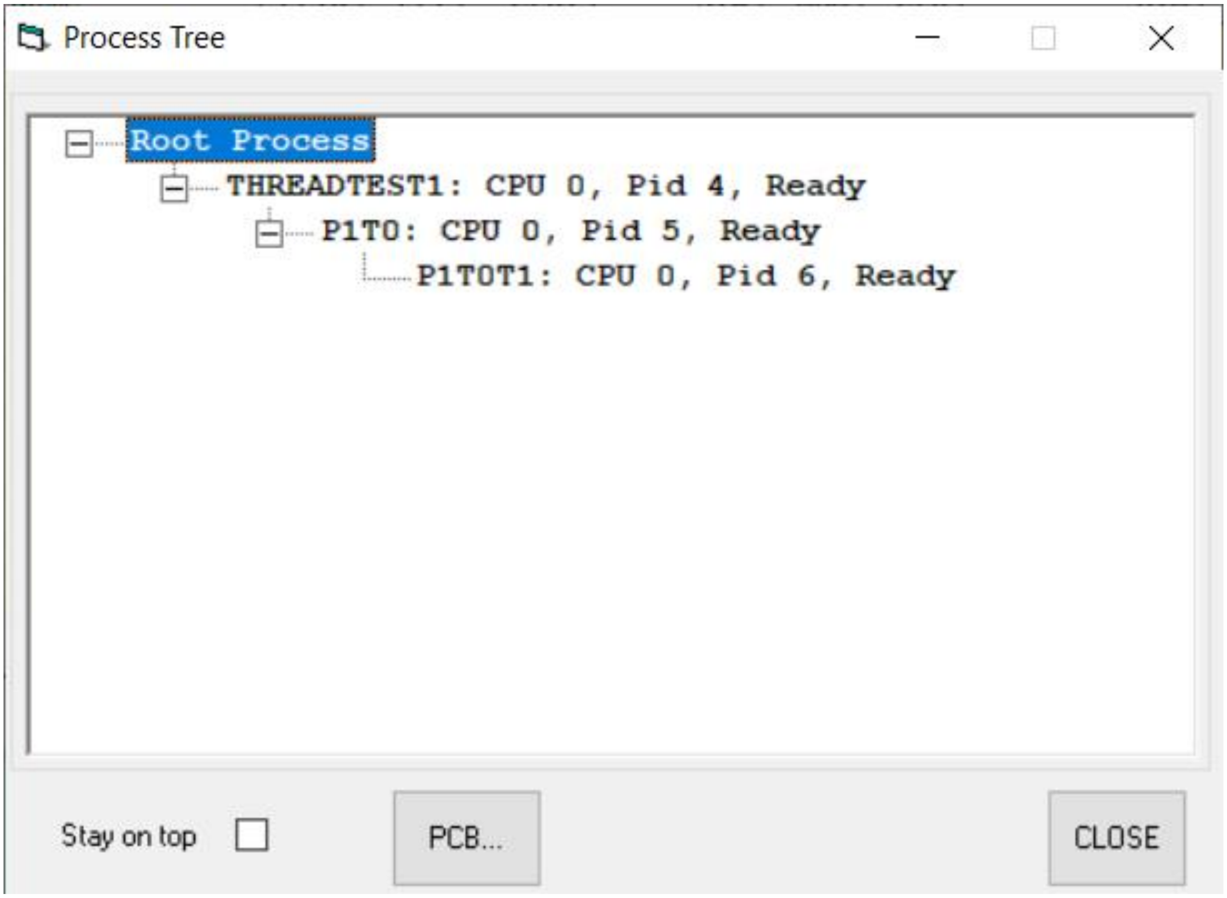
In the Process List window hit the **PROCESS TREE…** button. Observe the contents of the window now displaying.

Briefly explain your observations in the box below:

How are the parent/child process relationships represented?
The parent/child process are represented in the form of a tree with the main parent [Root] at the top and the smallest child process at the bottom [P1T0T1]

Identify the parent and the children processes:

The main parent is Root Process. Our program ThreadTest1 is its child. Its state keeps changing from ready to running and back.
ThreadTest1's child is named P1T0 whose state also keeps fluctuating.
P1T0's child is P1T0T1 who state also keeps fluctuating.



```
Root Process
    THREADTEST1: CPU 0, Pid 4, Ready
        P1T0: CPU 0, Pid 5, Ready
            P1T0T1: CPU 0, Pid 6, Ready
```

Stop the running processes by repeatedly using the **KILL** button in the OS simulator window.

Synchronization

Loading and Compiling a Program

In the compiler window, enter the following source code in the compiler source editor area (under **PROGRAM SOURCE** frame title). Make sure your program is exactly the same as the one below (best to use copy and paste for this).

```
program CriticalRegion1
     var g integer
     sub thread1 as thread
          writeln("In thread1")
          g = 0
          for n = 1 to 20
               g = g + 1
          next
          writeln("thread1 g = ", g)
          writeln("Exiting thread1")
     end sub
     sub thread2 as thread
          writeln("In thread2")
```

```
            g = 0
            for n = 1 to 12
                 g = g + 1
            next
            writeln("thread2 g = ", g)
            writeln("Exiting thread2")
        end sub

        writeln("In main")

        call thread1
        call thread2

        wait
        writeln("Exiting main")
    end
```

The above code creates a main program called *CriticalRegion1*. This program creates two threads thread1 and thread2. Each thread increments the value of the global variable **g** in two separate loops.

- Compile the above code using the **COMPILE…** button.
- Load the CPU instructions in memory using the **LOAD IN MEMORY** button**.**
- Display the console using the **INPUT/OUTPUT…** button in CPU simulator.
- On the console window check the **Stay on top** check box.

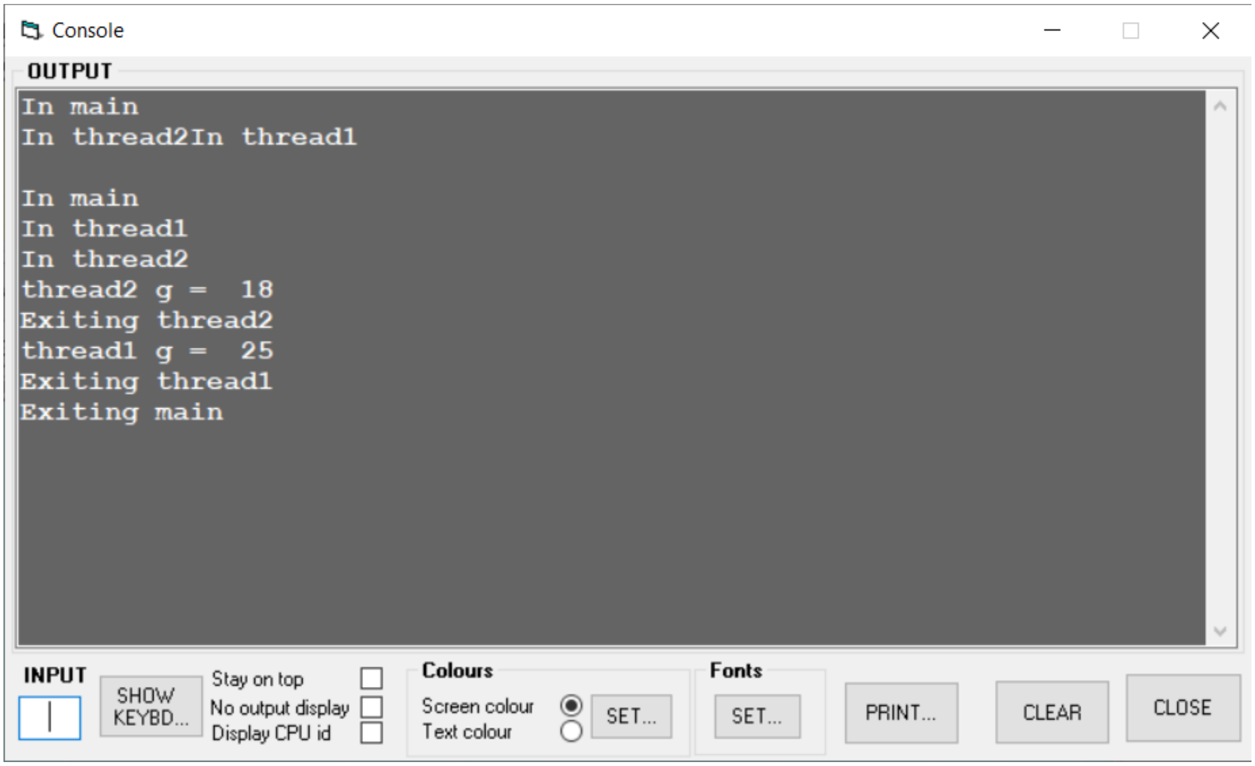
Running the above code

- Enter the OS simulator using the **OS 0…** button in CPU simulator.
- You should see an entry, titled *CriticalRegion1*, in the **PROGRAM LIST** view.
- Create an instance of this program using the **NEW PROCESS** button.
- Select **Round Robin** option in the **SCHEDULER/Policies** view.
- Select **10 ticks** from the drop-down list in **RR Time Slice** frame.
- Make sure the console window is displaying (see above).
- Move the **Speed** slider to the fastest position.
- Start the scheduler using the **START** button.

Now, follow the instructions below without any deviations:

When the program stops running, make a note of the two displayed values of **g**. Are these values what you were expecting? Explain if there are any discrepancies.

Thread1 = 25
Thread2 = 18
No, these are not what I expected.



```
In main
In thread2In thread1

In main
In thread1
In thread2
thread2 g =  18
Exiting thread2
thread1 g =  25
Exiting thread1
Exiting main
```

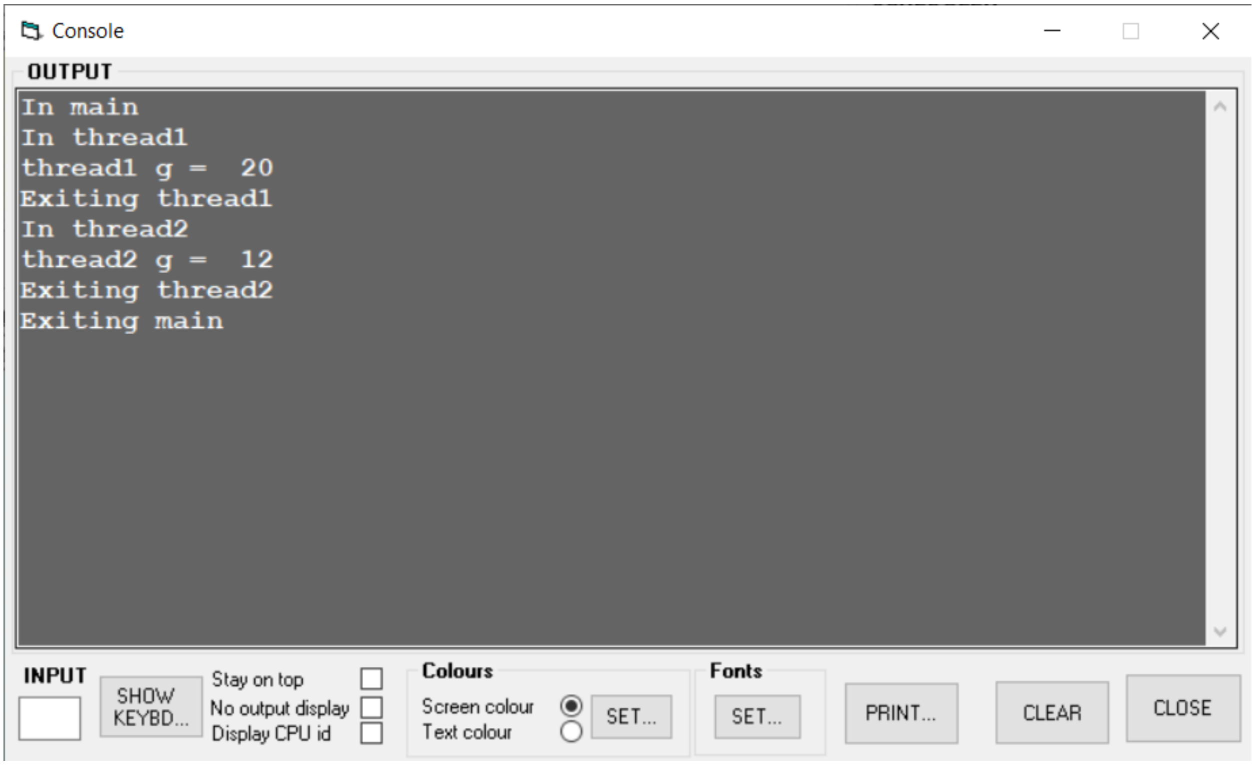
Modify this program as shown below. The changes are in bold and underlined. Rename the program *CriticalRegion2*.

```
program CriticalRegion2
     var g integer
sub thread1 as thread synchronise

          writeln("In thread1")
          g = 0
          for n = 1 to 20
               g = g + 1
          next
          writeln("thread1 g = ", g)
          writeln("Exiting thread1")
     end sub
     sub thread2 as thread synchronise
          writeln("In thread2")
          g = 0
          for n = 1 to 12
               g = g + 1
          next
          writeln("thread2 g = ", g)
          writeln("Exiting thread2")
```

```
        end sub

        writeln("In main")

        call thread1
        call thread2

        wait
        writeln("Exiting main")
    end
```

Compile the above program and load in memory as before. Next, run it and carefully observe how the threads behave. Make a note of the two values of variable **g**.

Thread 1 = 20
Thread 2 = 12



```
In main
In thread1
thread1 g =  20
Exiting thread1
In thread2
thread2 g =  12
Exiting thread2
Exiting main
```

Modify this program for the second time. The new additions are in bold and underlined. Remove the two **synchronise** keywords. Rename it *CriticalRegion3*.

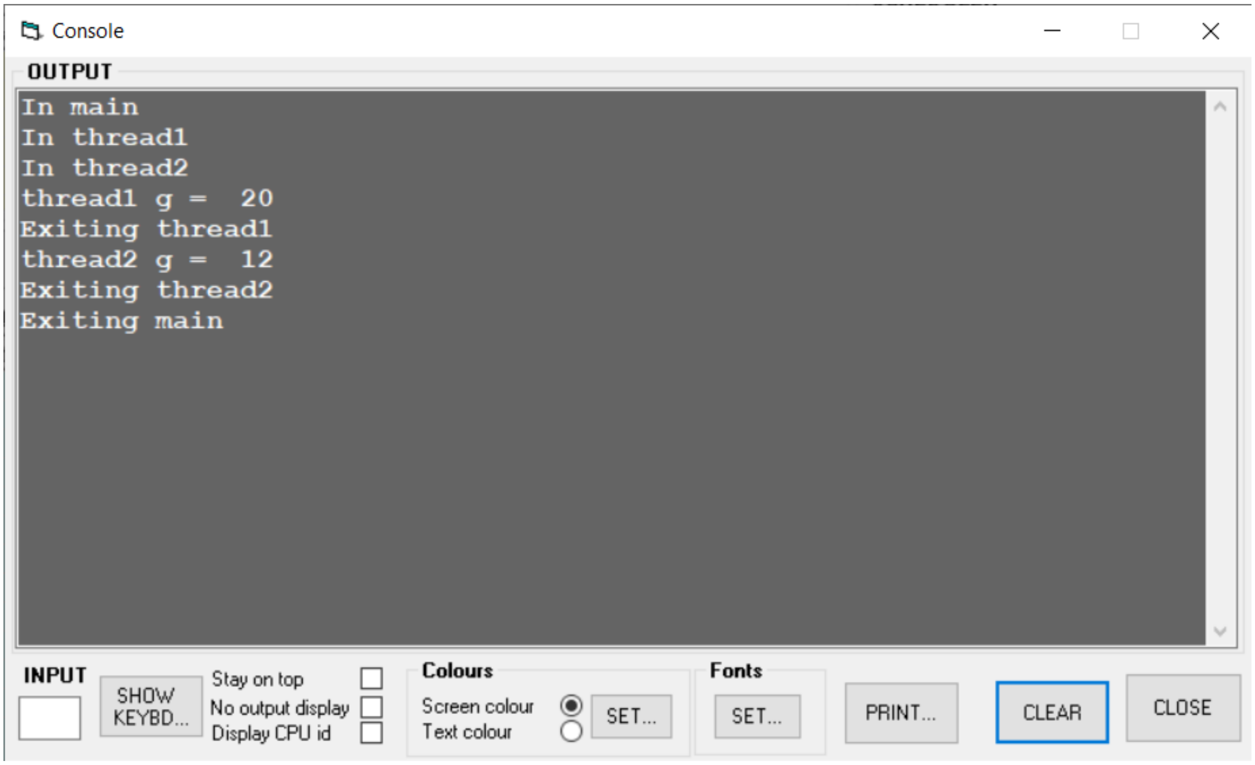
```
program CriticalRegion2
    var g integer
    sub thread1 as thread
        writeln("In thread1")
        enter
        g = 0
        for n = 1 to 20
            g = g + 1
        next
        writeln("thread1 g = ", g)
        leave
        writeln("Exiting thread1")
    end sub
    sub thread2 as thread
        writeln("In thread2")
        enter
        g = 0
        for n = 1 to 12
            g = g + 1
        next
        writeln("thread2 g = ", g)
        leave
        writeln("Exiting thread2")
    end sub

    writeln("In main")

    call thread1
    call thread2

    wait
    writeln("Exiting main")


end
```

NOTE: The **enter** and **leave** keyword pair protect the program code between them. This makes sure the protected code executes exclusively without sharing the CPU with any other thread.

Locate the CPU assembly instructions generated for the **enter** and **leave** keywords in the compiler's **PROGRAM CODE** view. You can do this by clicking in the source editor on any of the above keywords. Corresponding CPU instruction will be highlighted.:

Compile the above program and load in memory as before. Next, run it. Make a note of the two values of variable **g**.

Thread 1 = 20
Thread 2 = 12



```
In main
In thread1
In thread2
thread1 g =  20
Exiting thread1
thread2 g =  12
Exiting thread2
Exiting main
```

Deadlock prevention and avoidance

Four processes are running. They are called **P1** to **P4**.There are also four resources available (only one instance of each). They are named **R0** to **R3**. At some point of their existence each process allocates a different resource for use and holds it for itself forever. Later each of the processes request another one of the four resources.

Use the Scenario P1 holding R0 and waiting for R1. P2 Holding R1 and waiting for R2. P3 holding R2 and waiting for R3. P4 holding R3 and waiting for R0.
Draw the resource allocation graph for a four process deadlock condition.

In the compiler window, enter the following source code in the compiler source editor area (under **PROGRAM SOURCE** frame title).

```
program DeadlockPN
     resource(X, allocate)
     wait(3)
     resource(Y, allocate)
     for n = 1 to 20
     next
end
```

2)

a. Copy the above code and paste it in three more edit windows so that you have a total of four pieces of source code. (Click on New under compiler to create new edit windows)

b. In each case change **N** in the program name to 1 to 4, e.g. DeadlockP**1,** DeadlockP**2,** etc.

c. Look at your graph you constructed in (1) above and using that information fill in the values for each of the **X**s and **Y**s in the four pieces of source code. (X is resource the process is holding and Y is the resource process is waiting for. Eg. For P1, X=0 and Y=1)

d. Compile each one of the four source code.

e. Load in memory the four pieces of code generated.

f. Now switch to the OS simulator.

g. Create a single instance of each of the programs. You can do this by double-clicking on each of the program names in the **PROGRAM LIST** frame under the **Program Name** column.

h. In the **SCHEDULER** frame select **Round Robin (RR)** scheduling policy in the **Policies** tab.

i. In OS Control tab, push the speed slider up to the fastest speed.

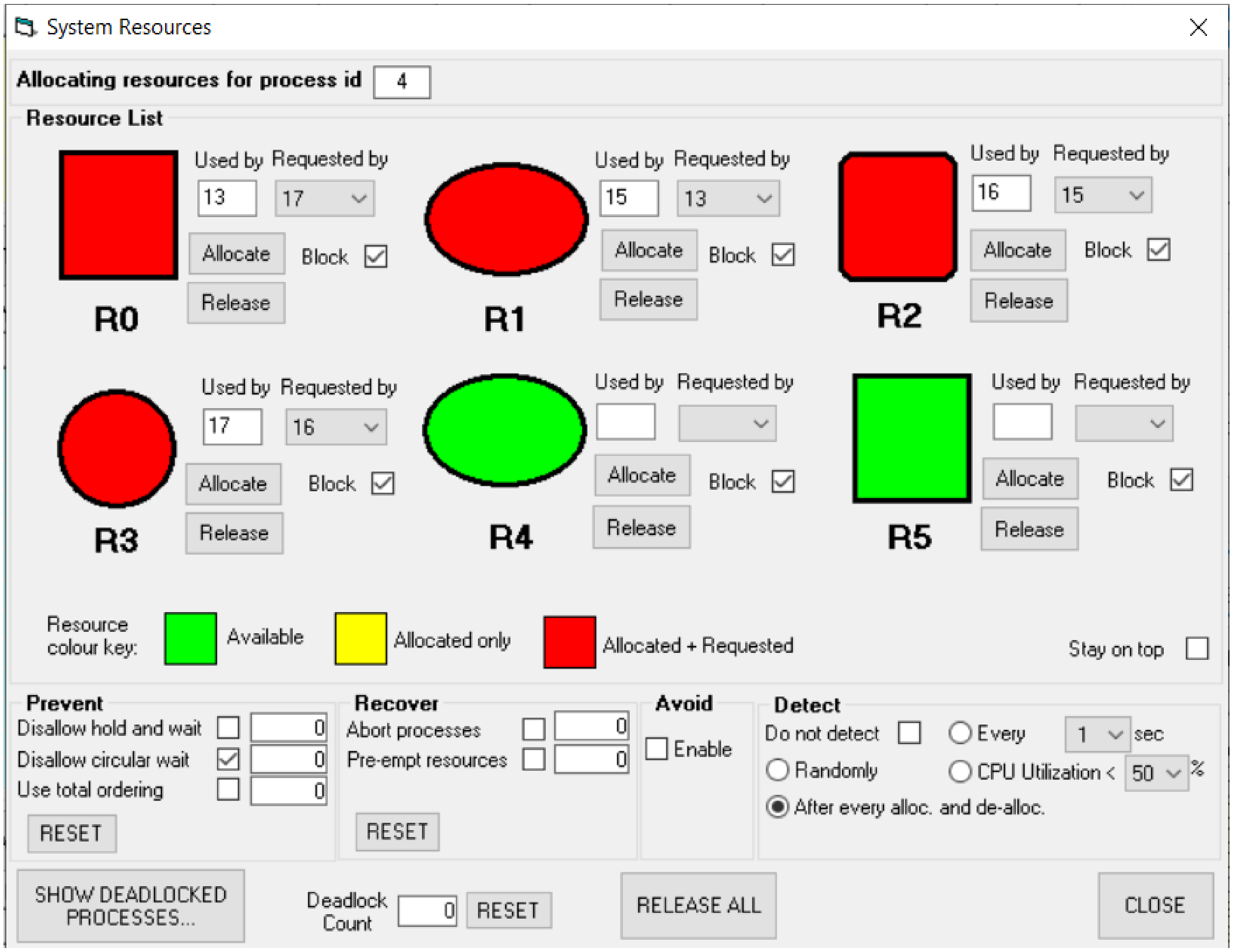
j. Select the **Views** tab and click on the **VIEW RESOURCES…** button.

k. Select **Stay on top** check box in the displayed window.

l. Back in the **OS Control** tab use the **START** button to start the OS scheduler and observe the changing process states for few seconds.

m. Have you got a deadlock condition same as you constructed in (1) above? If you haven't then check and if necessary re-do above. Do not proceed to (n) or (3) below until you get a deadlock condition.

n. If you have a deadlock condition then click on the **SHOW DEADLOCKED PROCESSES…** button in the **System Resources** window. Does the highlighted resource allocation graph look like yours?



System Resources

Allocating resources for process id 4

Resource List

Resource	Used by	Requested by	Block
R0	13	17	☑
R1	15	13	☑
R2	16	15	☑
R3	17	16	☑
R4			☑
R5			☑

Resource colour key: 🟩 Available 🟨 Allocated only 🟥 Allocated + Requested

Stay on top □

Prevent
Disallow hold and wait □ 0
Disallow circular wait ☑ 0
Use total ordering □ 0

Recover
Abort processes □ 0
Pre-empt resources □ 0

Avoid
□ Enable

Detect
Do not detect □
○ Every 1 sec
○ Randomly
○ CPU Utilization < 50 %
● After every alloc. and de-alloc.

Deadlock Count 0

Now that you created a deadlock condition let us try two methods of getting out of this condition:

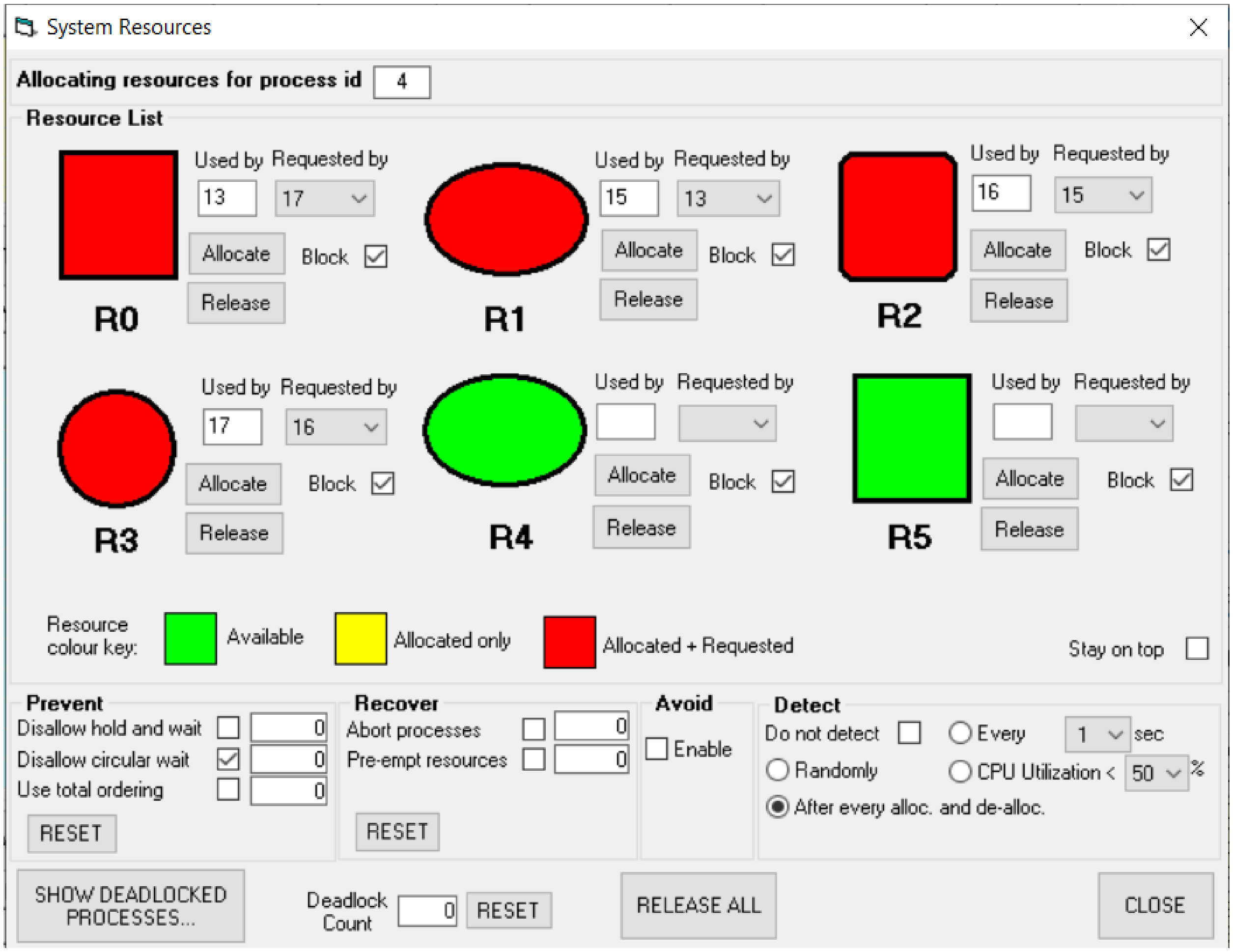
a. In the **System Resources** window, there should be four resource shapes that are in red colour indicating they are both allocated to one process and requested by another.

b. Select one of these resources and click on the **Release** button next to it.

c. Observe what is happening to the processes in the OS Simulator window.

d. Is the deadlock situation resolved? Explain briefly why this helped resolve the deadlock.

Yes, the deadlock got resolved. This is because that process released whatever resources it was holding which in turn was required by another. This process continued and all the process came out of the deadlock



System Resources

Allocating resources for process id 4

Resource List

R0 — Used by 13 — Requested by 17 — Block ☑

R1 — Used by 15 — Requested by 13 — Block ☑

R2 — Used by 16 — Requested by 15 — Block ☑

R3 — Used by 17 — Requested by 16 — Block ☑

R4 — Used by — Requested by — Block ☑

R5 — Used by — Requested by — Block ☑

Resource colour key: 🟩 Available 🟨 Allocated only 🟥 Allocated + Requested

Stay on top □

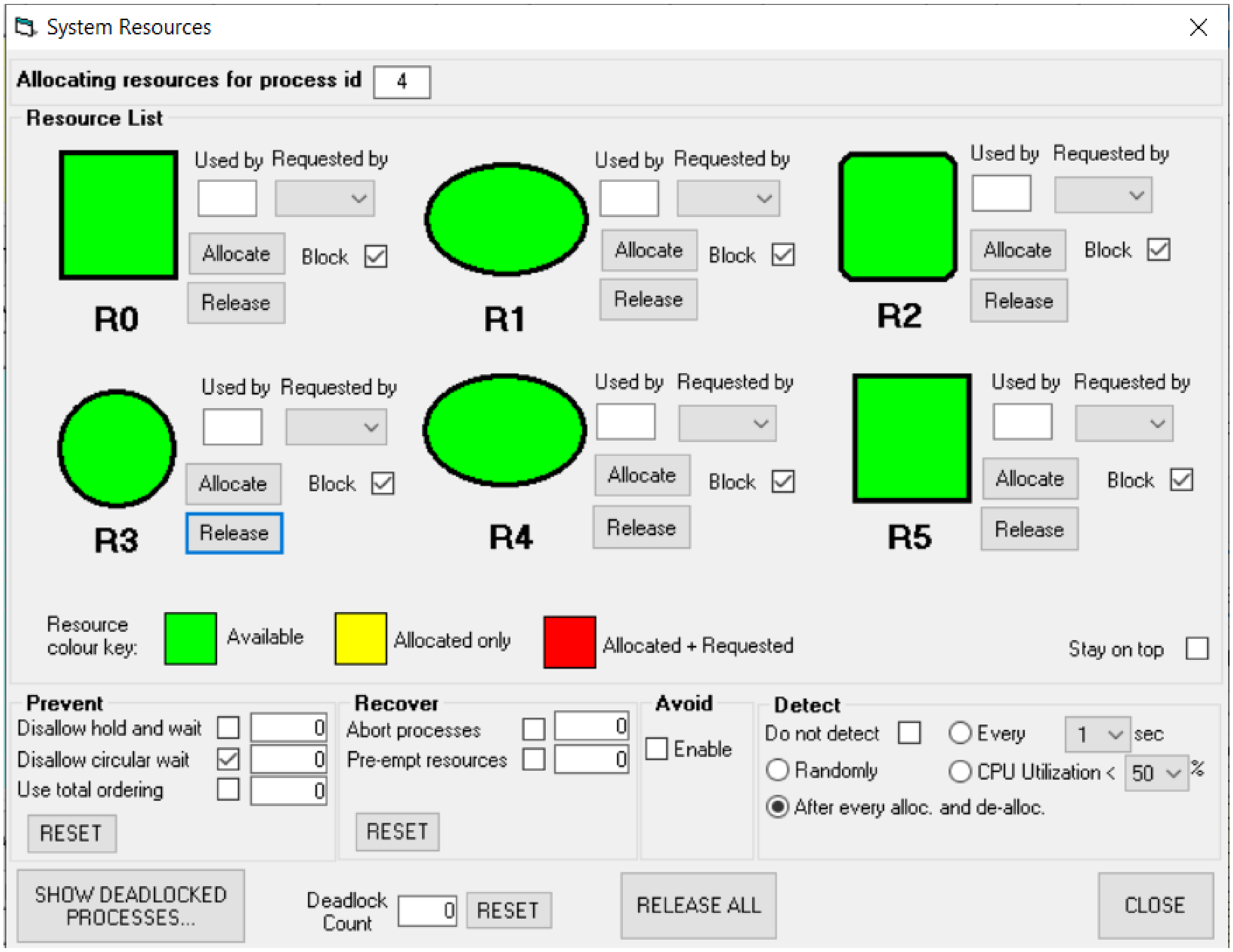
Prevent
Disallow hold and wait □ 0
Disallow circular wait ☑ 0
Use total ordering □ 0

Recover
Abort processes □ 0
Pre-empt resources □ 0

Avoid
□ Enable

Detect
Do not detect □
○ Every 1 sec
○ Randomly
○ CPU Utilization < 50 %
● After every alloc. and de-alloc.

Deadlock Count 0



Allocating resources for process id 4

Prevent
Disallow hold and wait □ 0
Disallow circular wait ☑ 0
Use total ordering □ 0
RESET

Recover
Abort processes □ 0
Pre-empt resources □ 0
RESET

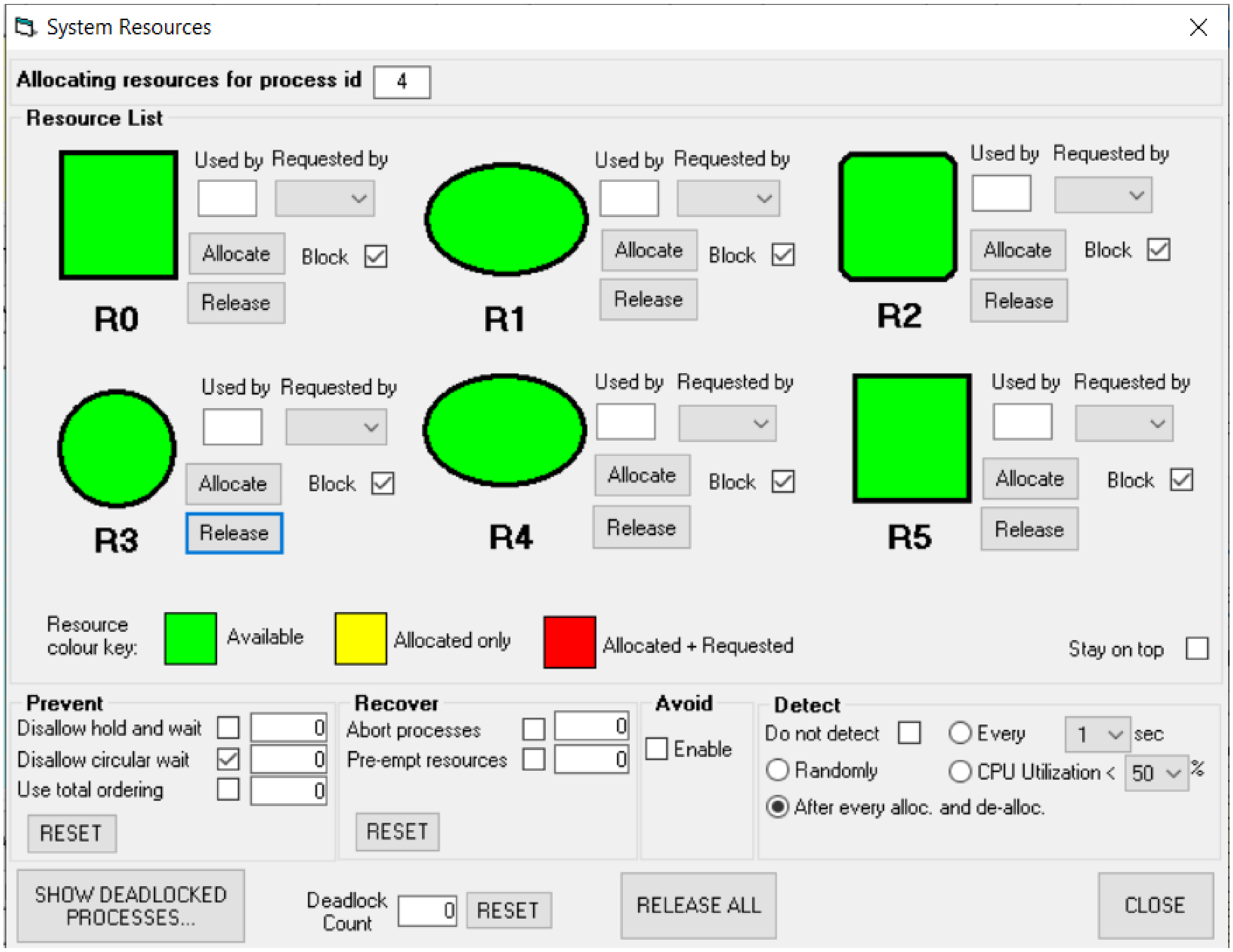
Avoid
□ Enable

Detect
Do not detect □ ○ Every 1 sec
○ Randomly ○ CPU Utilization < 50 %
● After every alloc. and de-alloc.

Deadlock Count 0 RESET

e. Re-create the same deadlock condition (steps in 2 above should help).
f. Once the deadlock condition is obtained again do the following: In the OS Simulator window, select a process in the waiting queue in the **WAITING PROCESSES** frame.
g. Click on the REMOVE button and observe the processes.
h. Has this managed to resolve the deadlock? Explain briefly why this helped resolve the deadlock.

Yes, this again deleted the process and released the resources it was holding which was required by another process and so on thus the deadlock got resolved


System Resources

Allocating resources for process id 4

Resource List

R0: Used by □ Requested by; Block ☑

R1: Used by □ Requested by; Block ☑

R2: Used by □ Requested by; Block ☑

R3: Used by □ Requested by; Block ☑

R4: Used by □ Requested by; Block ☑

R5: Used by □ Requested by; Block ☑

Resource colour key: 🟩 Available 🟨 Allocated only 🟥 Allocated + Requested

Stay on top □

Prevent

Disallow hold and wait □ 0

Disallow circular wait ☑ 0

Use total ordering □ 0

Recover

Abort processes □ 0

Pre-empt resources □ 0

Avoid

□ Enable

Detect

Do not detect □

○ Every 1 sec

○ Randomly

○ CPU Utilization < 50 %

● After every alloc. and de-alloc.

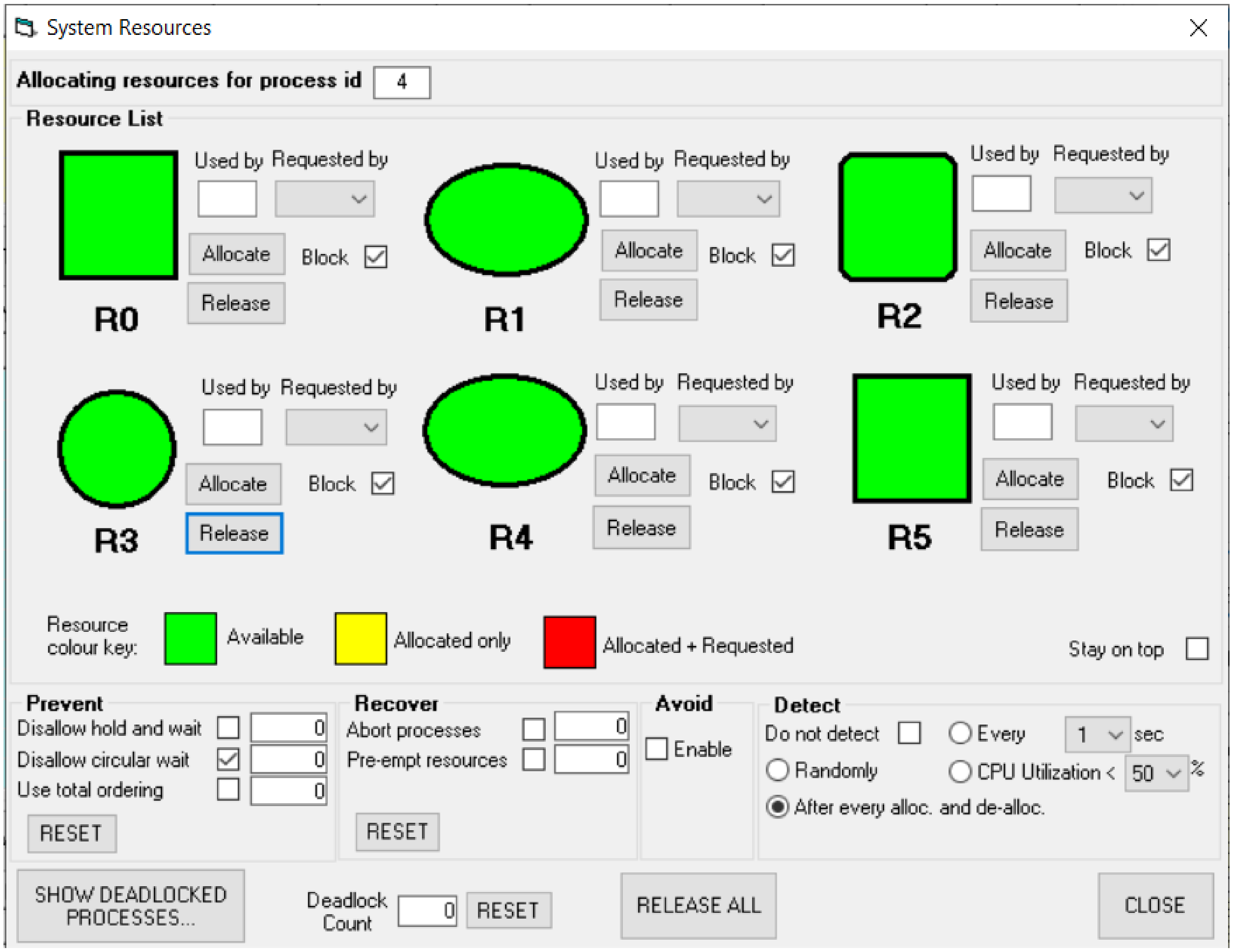
Deadlock Count 0

This part of the exercises was about two methods of **recovering** from a deadlock condition **after** it happens.

We now look at two methods of **preventing** a deadlock condition **before** it happens.
a. In the **System Resources** window select the **Disallow hold and wait** check box in the **Prevent** frame.
b. Try to re-create the same deadlock condition as before. Have you been successful? What happened? Click on the **SHOW DEADLOCKED PROCESSES...** button and observe the displayed information in the text window for potential clues.
c. Next, uncheck the **Disallow hold and wait** check box and check the **Disallow circular wait** check box.
d. Try to re-create the same deadlock condition as before. Have you been successful? What happened? Click on the **SHOW DEADLOCKED PROCESSES...** button and observe the displayed information in the text window for potential clues.

We are now going to try a third method of preventing deadlocking before it happens. It is called "total ordering" method. Here the resources are allocated in increasing resource id numbers only. So, for example, resource R3 must be allocated after resources R0 to R2 and resource R1 cannot be allocated after resource R2 is allocated. Looking at your resource allocation graph can you see how this ordering can prevent a deadlock? Comment.

Yes, we are managing the resources such that any resource that will be requested by a process is not held up by another deadlocked process and thus avoids the deadlock at all.



System Resources

Allocating resources for process id: 4

Resource List

Resource	Used by	Requested by	Block
R0			☑
R1			☑
R2			☑
R3			☑
R4			☑
R5			☑

Resource colour key: 🟩 Available 🟨 Allocated only 🟥 Allocated + Requested

Stay on top □

Prevent

- Disallow hold and wait □ 0
- Disallow circular wait ☑ 0
- Use total ordering □ 0

Recover

- Abort processes □ 0
- Pre-empt resources □ 0

Avoid

- □ Enable

Detect

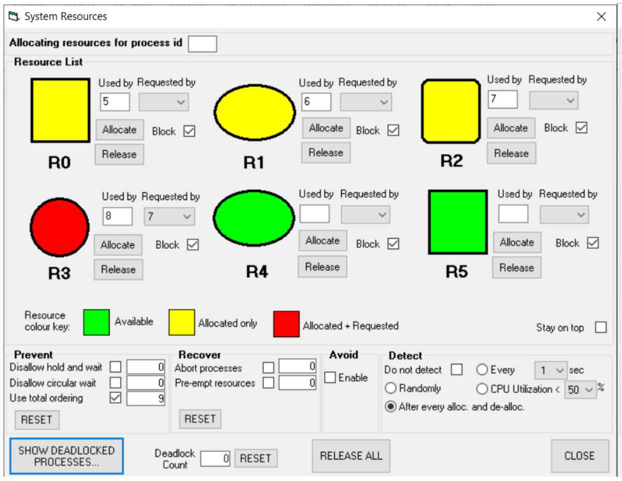
- Do not detect □
- ○ Every 1 sec
- ○ Randomly
- ○ CPU Utilization < 50 %
- ● After every alloc. and de-alloc.

Deadlock Count: 0

a. In the **System Resources** window select the **Use total ordering** check box in the **Prevent** frame. The other options should be unchecked.

b. Try to re-create the same deadlock condition as before. Have you been successful? What happened? Click on the **SHOW DEADLOCKED PROCESSES…** button and observe the displayed information in the text window for potential clues. What happened? Comment.

As seen in the resource allocation Graph, the OS does not allocate a resource if it would lead to breaking of total ordering



System Resources

Allocating resources for process id

Resource List

Resource	Used by	Requested by	Block
R0	5		☑
R1	6		☑
R2	7		☑
R3	8	7	☑
R4			☑
R5			☑

Resource colour key: 🟩 Available 🟨 Allocated only 🟥 Allocated + Requested

Stay on top □

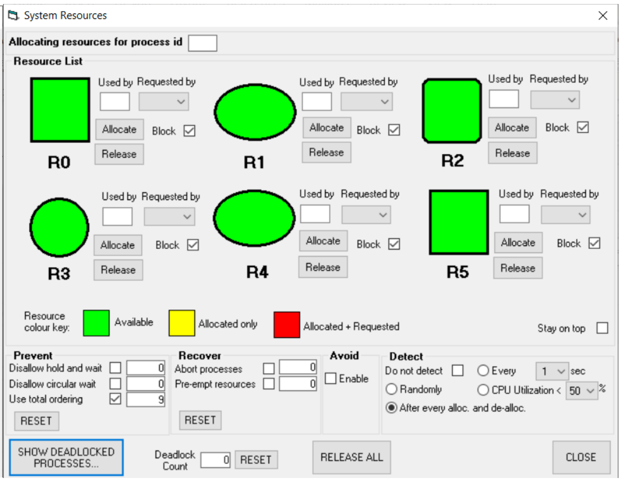
Prevent
Disallow hold and wait □ 0
Disallow circular wait □ 0
Use total ordering ☑ 9

Recover
Abort processes □ 0
Pre-empt resources □ 0

Avoid
□ Enable

Detect
Do not detect □
○ Every 1 sec
○ Randomly
○ CPU Utilization < 50 %
● After every alloc. and de-alloc.

Deadlock Count 0



System Resources

Allocating resources for process id

Resource List

Resource	Used by	Requested by	Block
R0			☑
R1			☑
R2			☑
R3			☑
R4			☑
R5			☑

Resource colour key: 🟩 Available 🟨 Allocated only 🟥 Allocated + Requested

Stay on top □

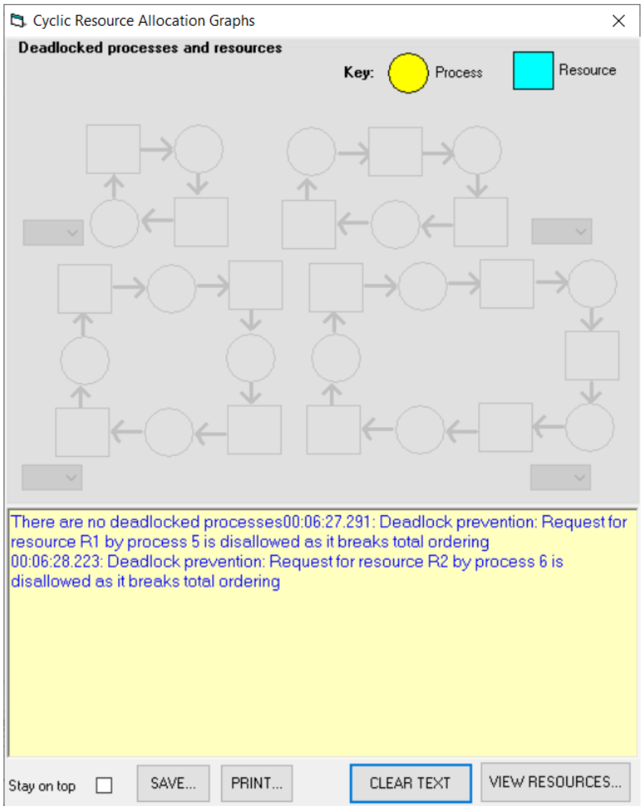
Prevent
Disallow hold and wait □ 0
Disallow circular wait □ 0
Use total ordering ☑ 9

Recover
Abort processes □ 0
Pre-empt resources □ 0

Avoid
□ Enable

Detect
Do not detect □
○ Every 1 sec
○ Randomly
○ CPU Utilization < 50 %
● After every alloc. and de-alloc.

Deadlock Count 0



Cyclic Resource Allocation Graphs

Deadlocked processes and resources

```
There are no deadlocked processes00:06:27.291: Deadlock prevention: Request for
resource R1 by process 5 is disallowed as it breaks total ordering
00:06:28.223: Deadlock prevention: Request for resource R2 by process 6 is
disallowed as it breaks total ordering
```

Stay on top □