Experiment 10 – OS Simulator
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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:

Install CPU-OS simulator
Perform the following steps

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.

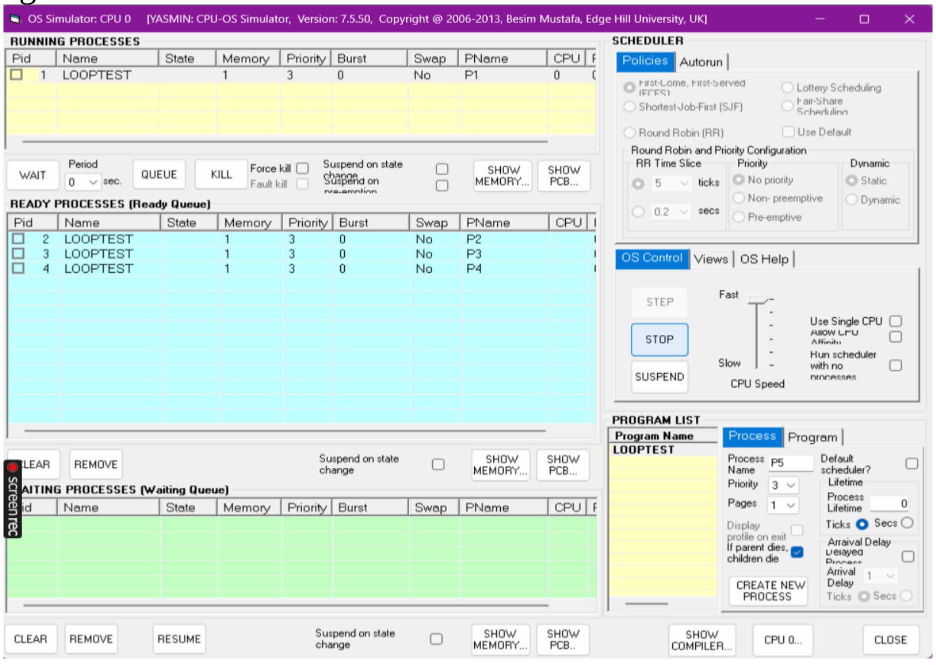
Creating processes from programs in the OS simulator.

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).

Processes are one after the other entering into the running processes box and leaving the ready processes box, in the First-Come-First-Serve manner. After all the processes have been executed, both the boxes are empty and I will have to add new processes 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
1	LOOPTEST		1	3	0	No	P1	0

READY PROCESSES (Ready Queue)

Pid	Name	State	Memory	Priority	Burst	Swap	PName	CPU
2	LOOPTEST		1	3	0	No	P2	
3	LOOPTEST		1	3	0	No	P3	
4	LOOPTEST		1	3	0	No	P4	

WAITING PROCESSES (Waiting Queue)

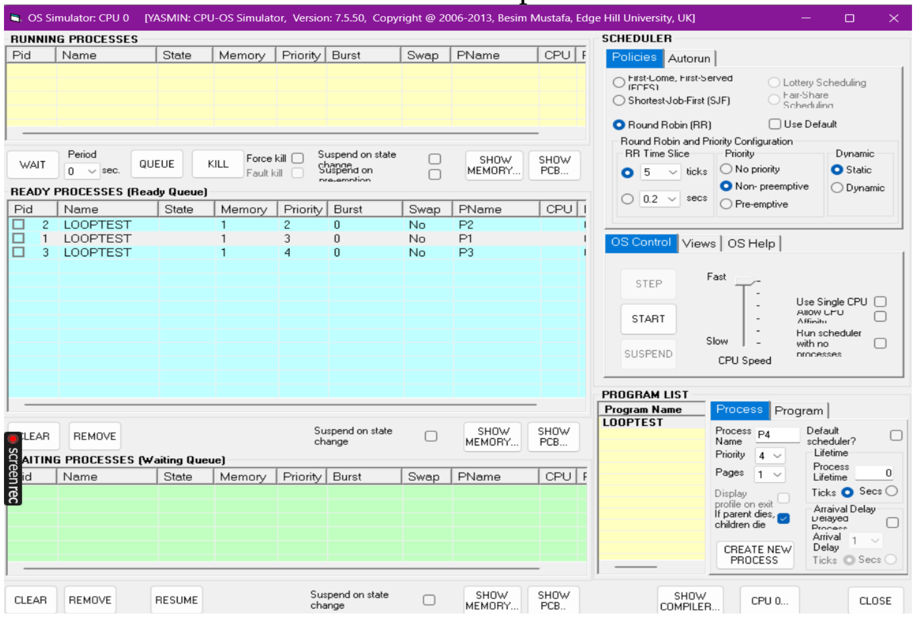
Pid	Name	State	Memory	Priority	Burst	Swap	PName	CPU

SCHEDULER
Policies | Autorun
[✓ First-Come, First-Served (FCFS)] Shortest-Job-First (SJF) Round Robin (RR) Lottery Scheduling Fair-Share Scheduling 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: LOOPTEST
Process | Program
Process Name: P5
Priority: 3
Pages: 1
Default scheduler?
Display profile on exit
If parent dies, children die ✓
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.

Processes the processes went into the Running processes box for a fixed amount of time only, one by one. Unlike FCFS, they did come back to the ready queue even after entering the running state because there execution was not completed.


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

READY PROCESSES (Ready Queue)

Pid	Name	State	Memory	Priority	Burst	Swap	PName	CPU
2	LOOPTEST		1	2	0	No	P2	
1	LOOPTEST		1	3	0	No	P1	
3	LOOPTEST		1	4	0	No	P3	

WAITING PROCESSES (Waiting Queue)

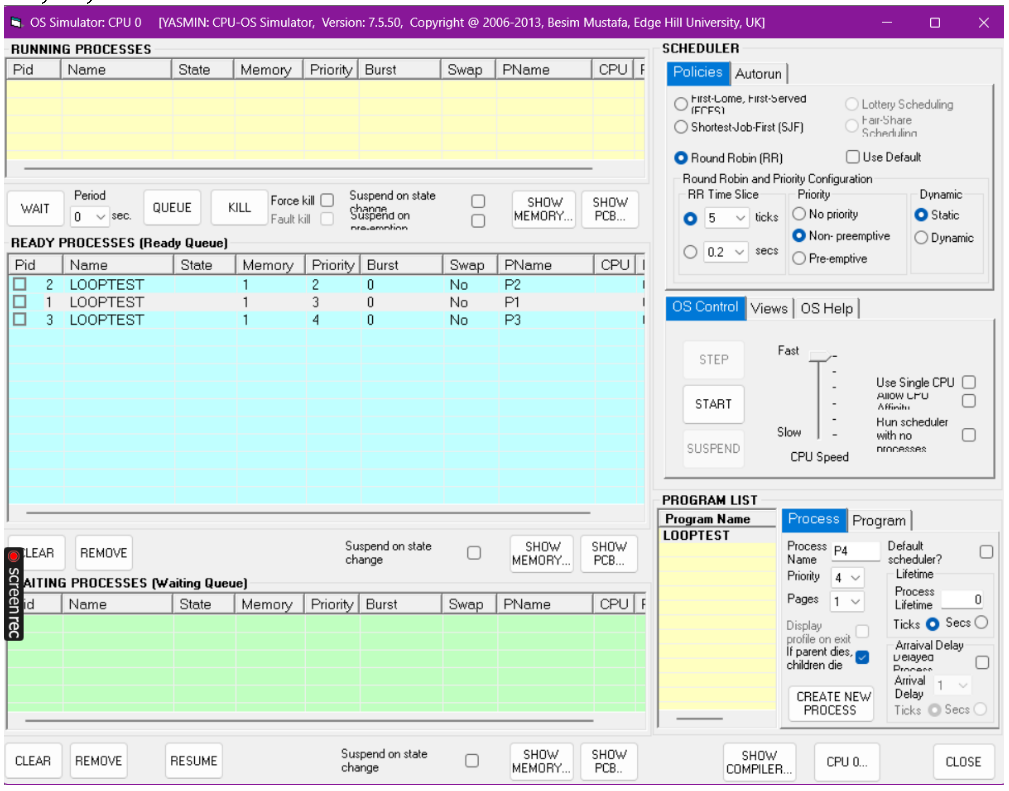
Pid	Name	State	Memory	Priority	Burst	Swap	PName	CPU

SCHEDULER — Policies: [✓ Round Robin (RR)]; Round Robin and Priority Configuration: RR Time Slice [✓ 5 ticks]; Priority [✓ Non- preemptive]; Dynamic [✓ Static]

PROGRAM LIST: LOOPTEST — Process Name P4, Priority 4, Pages 1, Process Lifetime 0

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).

P2,P1,P3.


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

READY PROCESSES (Ready Queue)

Pid	Name	State	Memory	Priority	Burst	Swap	PName	CPU
2	LOOPTEST		1	2	0	No	P2	
1	LOOPTEST		1	3	0	No	P1	
3	LOOPTEST		1	4	0	No	P3	

WAITING PROCESSES (Waiting Queue)

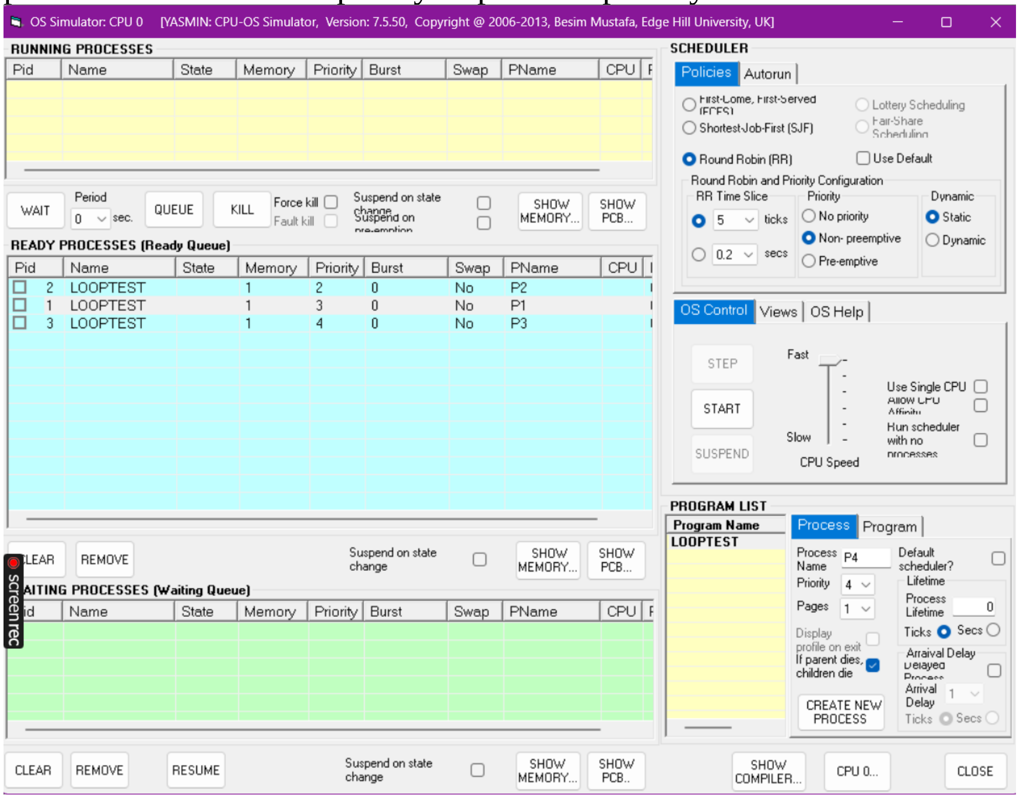
Pid	Name	State	Memory	Priority	Burst	Swap	PName	CPU

SCHEDULER — Policies: [✓ Round Robin (RR)]; Round Robin and Priority Configuration: RR Time Slice [✓ 5 ticks]; Priority [✓ Non- preemptive]; Dynamic [✓ Static]

PROGRAM LIST: LOOPTEST — Process Name P4, Priority 4, Pages 1, Process Lifetime 0

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.

The newly created process P4 with priority 1 had to wait till P2(priority 2 which started executing first) finished execution . Then P4 started execution and then the remaining two processes executed completely as per 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

READY PROCESSES (Ready Queue)

Pid	Name	State	Memory	Priority	Burst	Swap	PName	CPU
2	LOOPTEST		1	2	0	No	P2	
1	LOOPTEST		1	3	0	No	P1	
3	LOOPTEST		1	4	0	No	P3	

WAITING PROCESSES (Waiting Queue)

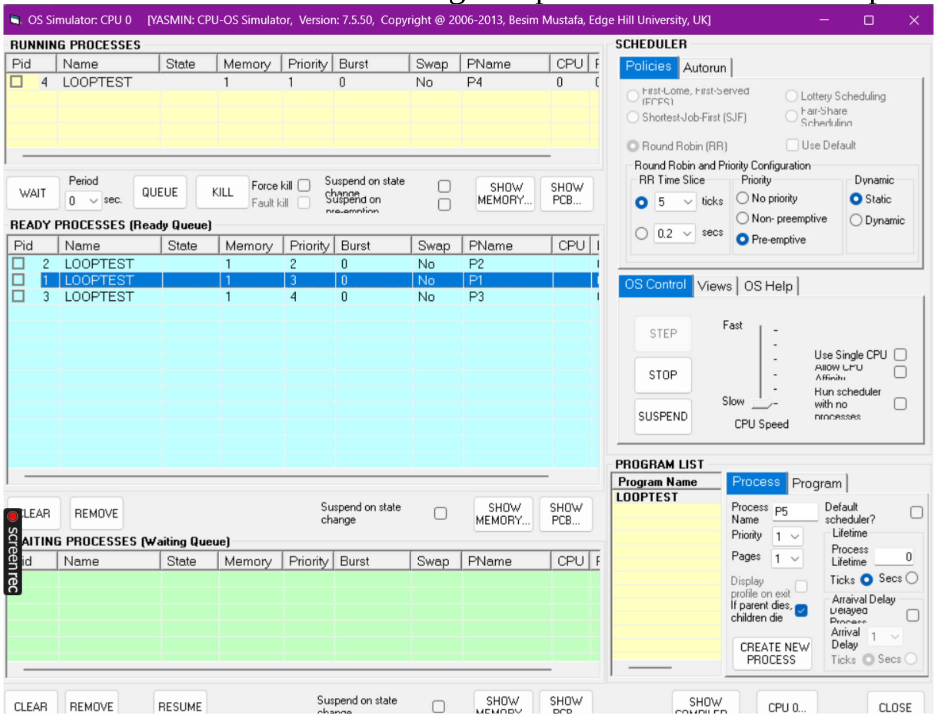
Pid	Name	State	Memory	Priority	Burst	Swap	PName	CPU

SCHEDULER — Policies: [✓ Round Robin (RR)]; Round Robin and Priority Configuration: RR Time Slice [✓ 5 ticks]; Priority: [✓ Non- preemptive]; Dynamic: [✓ Static]

PROGRAM LIST: LOOPTEST — Process Name P4, Priority 4, Pages 1

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?

The new process P4 with priority 1 did not wait and went for execution then P2 started execution and then the remaining two processes executed completely as per 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
4	LOOPTEST		1	1	0	No	P4	0

READY PROCESSES (Ready Queue)

Pid	Name	State	Memory	Priority	Burst	Swap	PName	CPU
2	LOOPTEST		1	2	0	No	P2	
1	LOOPTEST		1	3	0	No	P1	
3	LOOPTEST		1	4	0	No	P3	

WAITING PROCESSES (Waiting Queue)

Pid	Name	State	Memory	Priority	Burst	Swap	PName	CPU

SCHEDULER — Round Robin and Priority Configuration: RR Time Slice [✓ 5 ticks]; Priority: [✓ Pre-emptive]; Dynamic: [✓ Static]

PROGRAM LIST: LOOPTEST — Process Name P5, Priority 1, Pages 1

```
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
```

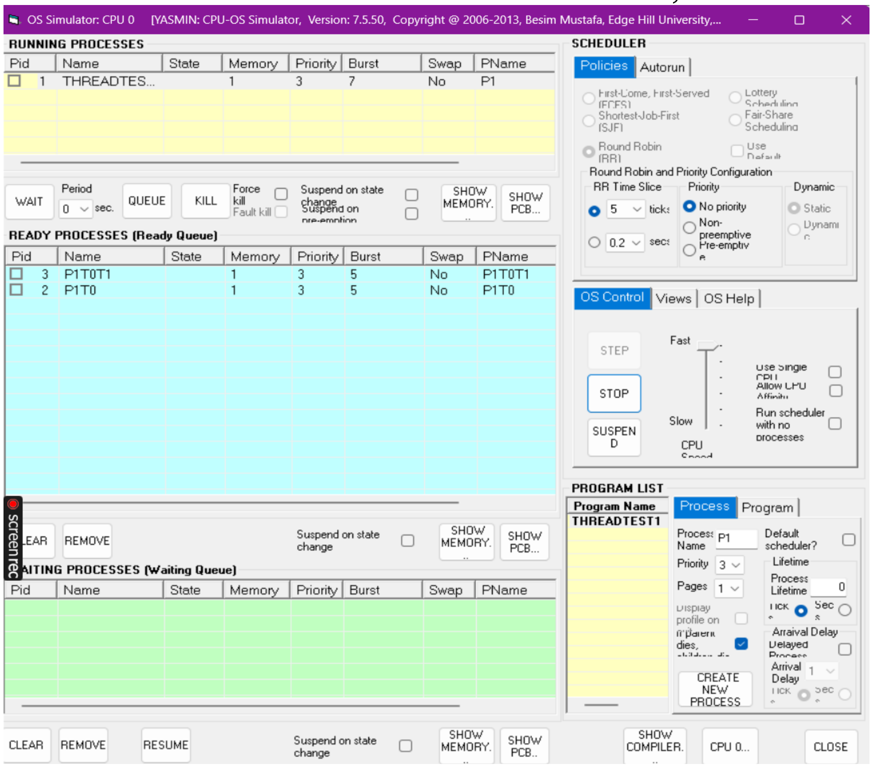
Compile the above source and load the generated code in memory.

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.

Briefly explain your observations and the no. of processes created in the box below.

3Processes have been created: THREADTEST1, P1T0T1 & P1T0



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

RUNNING PROCESSES

Pid	Name	State	Memory	Priority	Burst	Swap	PName
1	THREADTES...		1	3	7	No	P1

READY PROCESSES (Ready Queue)

Pid	Name	State	Memory	Priority	Burst	Swap	PName
3	P1T0T1		1	3	5	No	P1T0T1
2	P1T0		1	3	5	No	P1T0

WAITING PROCESSES (Waiting Queue)

Pid	Name	State	Memory	Priority	Burst	Swap	PName

SCHEDULER — Policies: [✓ Round Robin (RR)]; Round Robin and Priority Configuration: RR Time Slice [✓ 5 ticks]; Priority: [✓ No priority]

PROGRAM LIST — Program Name: THREADTEST1; Process Name: P1; Priority: 3; Pages: 1; Process Lifetime: 0; If parent dies, children die [✓]

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:

->two threads are created along with the main process. All are put in the running state in a round robin manner.
->If the parent process is THREADTEST1, then the child processes are given as P1T0T1 and P1T0.
->Parent is THREADTEST1 and P1T0T1 and P1T0 are the children.

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

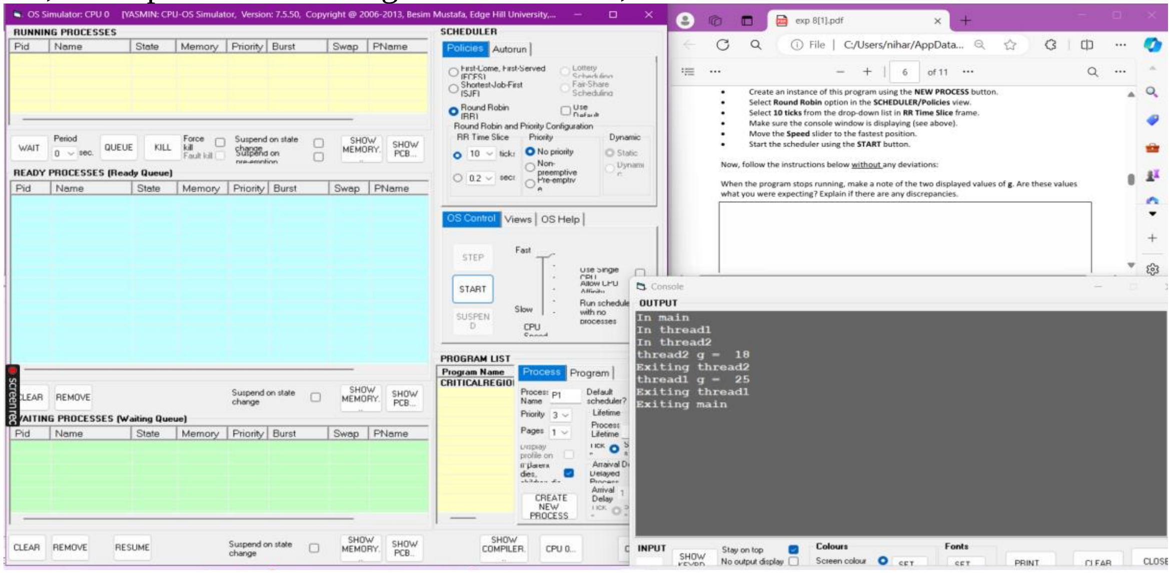
Synchronization
Loading and Compiling a Program
In the compiler window, enter the following source code in the compiler source editor area (under

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.

No, the expected values of g were 20 and 12, which are not here.



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

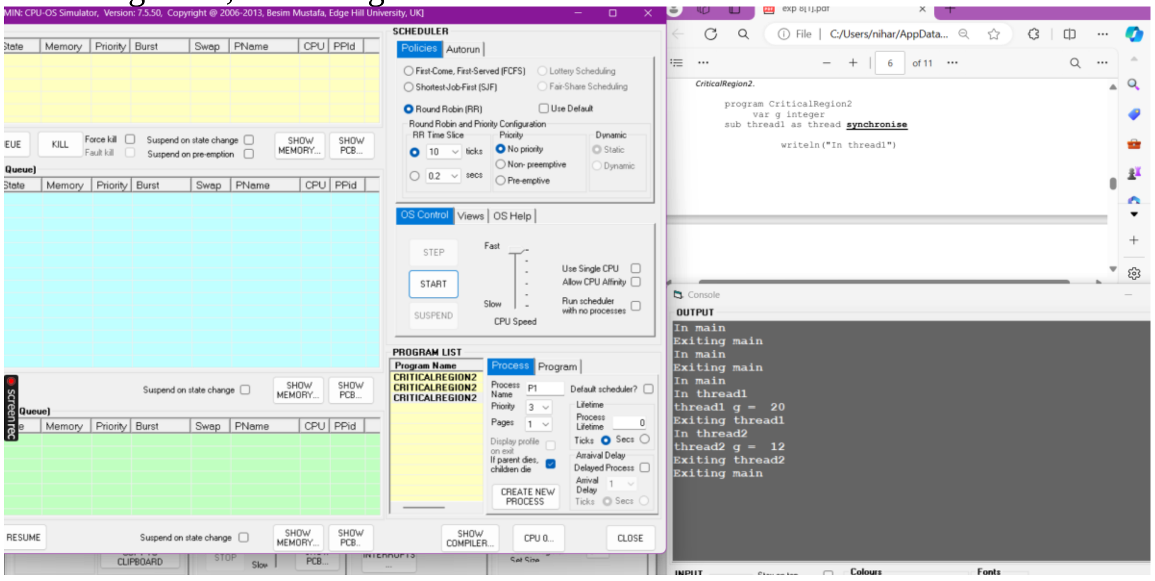
Modify this program as shown below. The changes are in bold and underlined. Rename the program *CriticalRegion2*.

```
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**.

Thread1 g = 20 , Thread2 g = 12



```
CriticalRegion2.

    program CriticalRegion2
        var g integer
    sub thread1 as thread synchronise

            writeln("In thread1")
```

```
In main
Exiting main
In main
Exiting main
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*.

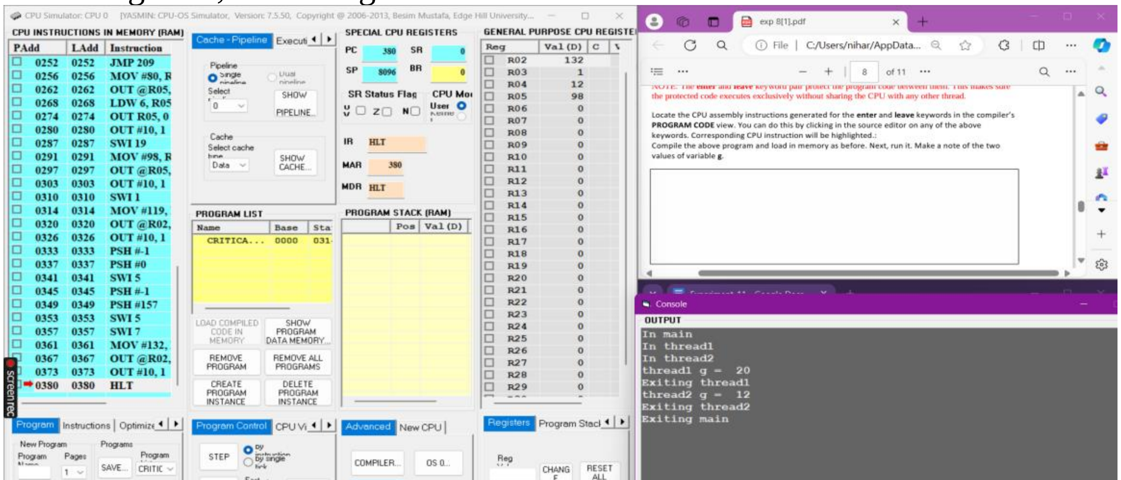
```
    program CriticalRegion2
        var g integer
        sub thread1 as thread
            writeln("In thread1")
            enter
            g = 0
            for n = 1 to 20
                g = g + 1
            next
            writeln("thread1 g = ", g)
            leave
            writeln("Exiting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

Thread1 g = 20, Thread2 g = 12



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

CPU INSTRUCTIONS IN MEMORY (RAM)

PAdd	LAdd	Instruction
0252	0252	JMP 209
0256	0256	MOV #80, R
0262	0262	OUT @R05,
0268	0268	LDW 6, R05
0274	0274	OUT R05, 0
0280	0280	OUT #10, 1
0287	0287	SWI 19
0291	0291	MOV #98, R
0297	0297	OUT @R05,
0303	0303	OUT #10, 1
0310	0310	SWI 1
0314	0314	MOV #119,
0320	0320	OUT @R02,
0326	0326	OUT #10, 1
0333	0333	PSH #-1
0337	0337	PSH #0
0341	0341	SWI 5
0345	0345	PSH #-1
0349	0349	PSH #157
0353	0353	SWI 5
0357	0357	SWI 7
0361	0361	MOV #132,
0367	0367	OUT @R02,
0373	0373	OUT #10, 1
0380	0380	HLT

SPECIAL CPU REGISTERS

PC 380 SR 0 SP 8096 BR 0

IR HLT MAR 380 MDR HLT

PROGRAM LIST

Name	Base	Sta
CRITICA...	0000	031

GENERAL PURPOSE CPU REGISTERS

Reg	Val (D)
R02	132
R03	1
R04	12
R05	98
R06	0
R07	0
R08	0
R09	0
R10	0
R11	0
R12	0
R13	0
R14	0
R15	0
R16	0
R17	0
R18	0
R19	0
R20	0
R21	0
R22	0
R23	0
R24	0
R25	0
R26	0
R27	0
R28	0
R29	0

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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**.

Console

OUTPUT

```
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.

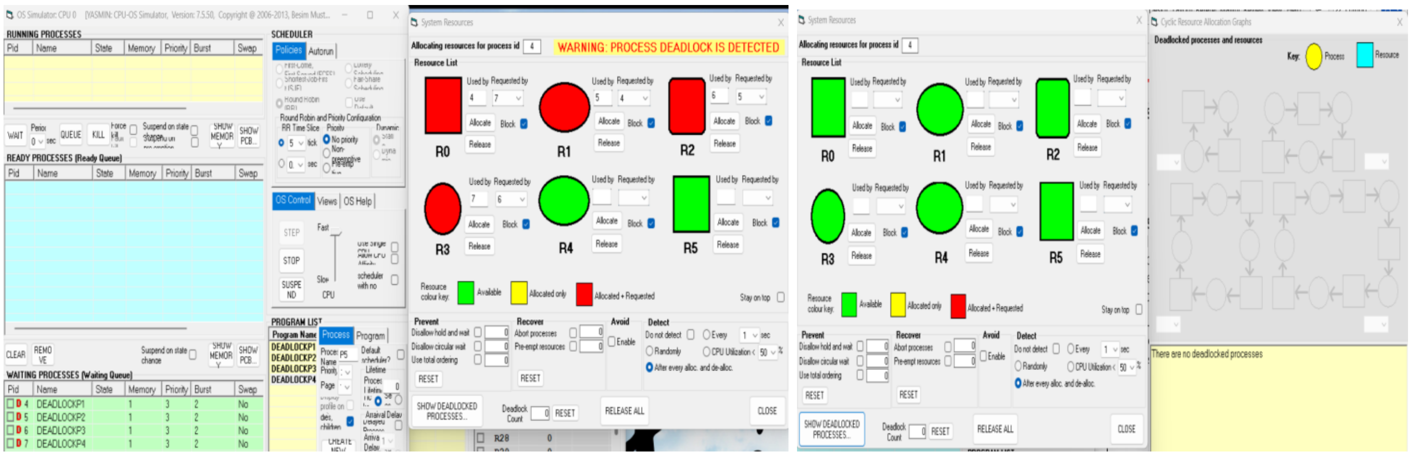
In the compiler window, enter the following source code in the compiler source editor area (under **PROGRAM SOURCE** frame title).

```
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?
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.

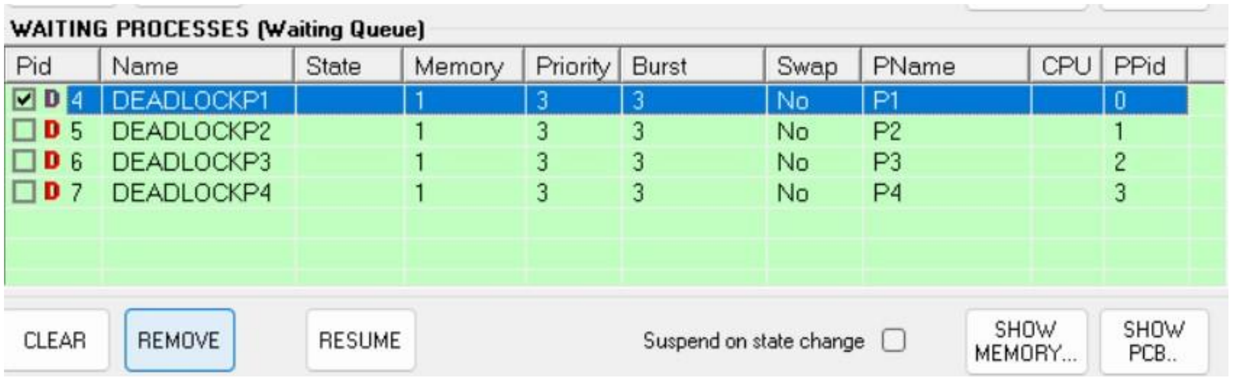
Yes deadlock resolved since one process released resources requested by another so the other process used them and finished execution and so on.


WARNING: PROCESS DEADLOCK IS DETECTED

There are no deadlocked processes

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 deadlock removed. Since the process which was waiting was removed other processes were executed which were holding the resource that the removed process needed.


WAITING PROCESSES (Waiting Queue)

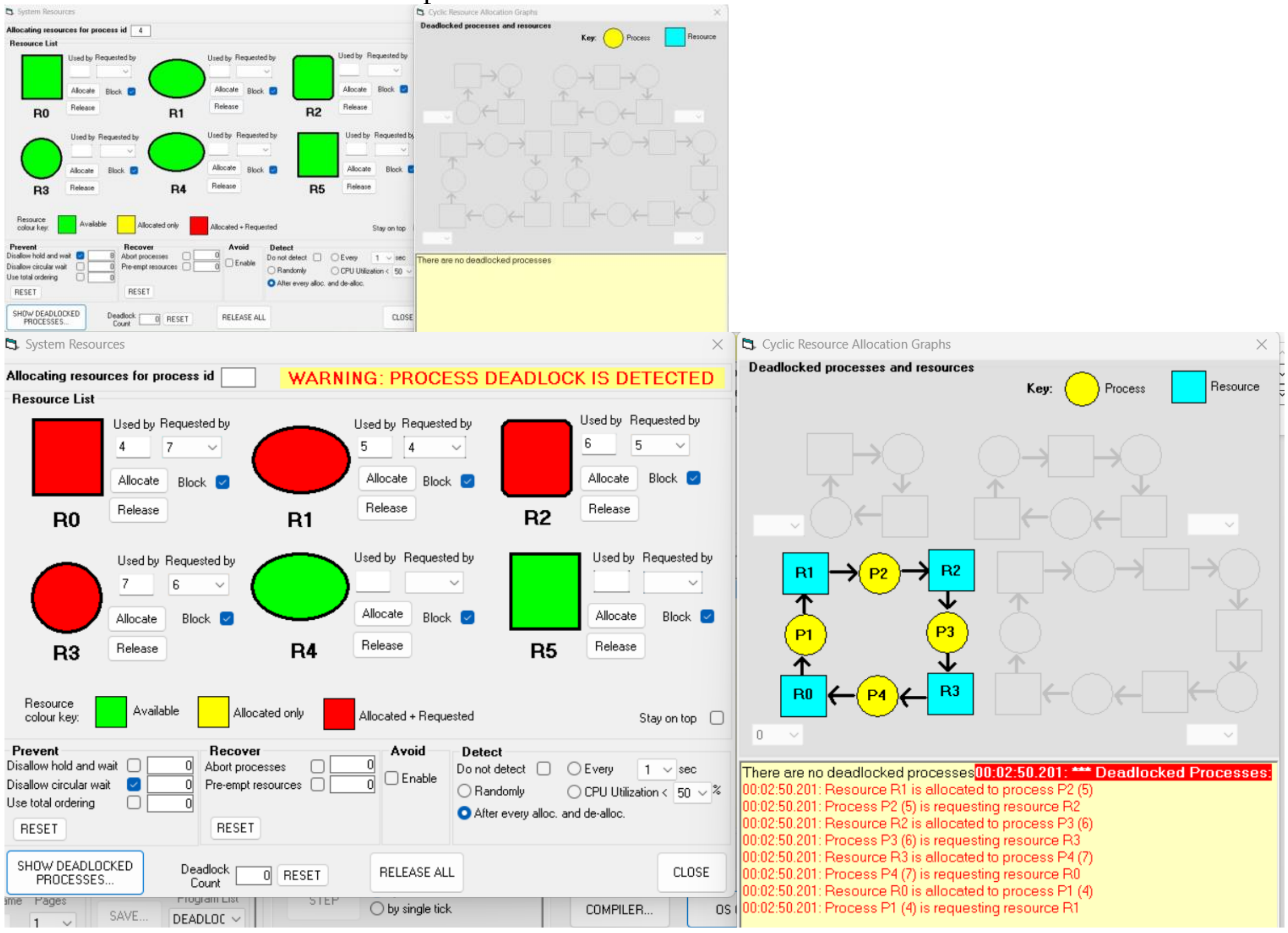
Pid	Name	State	Memory	Priority	Burst	Swap	PName	CPU	PPid
☑ D 4	DEADLOCKP1		1	3	3	No	P1		0
☐ D 5	DEADLOCKP2		1	3	3	No	P2		1
☐ D 6	DEADLOCKP3		1	3	3	No	P3		2
☐ D 7	DEADLOCKP4		1	3	3	No	P4		3

This part of the exercises was about two methods of **recovering** from a deadlock condition **<u>after</u>** it happens.
We now look at two methods of **preventing** a deadlock condition **<u>before</u>** 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 I see how the deadlock is prevented.



WARNING: PROCESS DEADLOCK IS DETECTED

Prevent: Disallow circular wait [✓]

Detect: [✓ After every alloc. and de-alloc.]

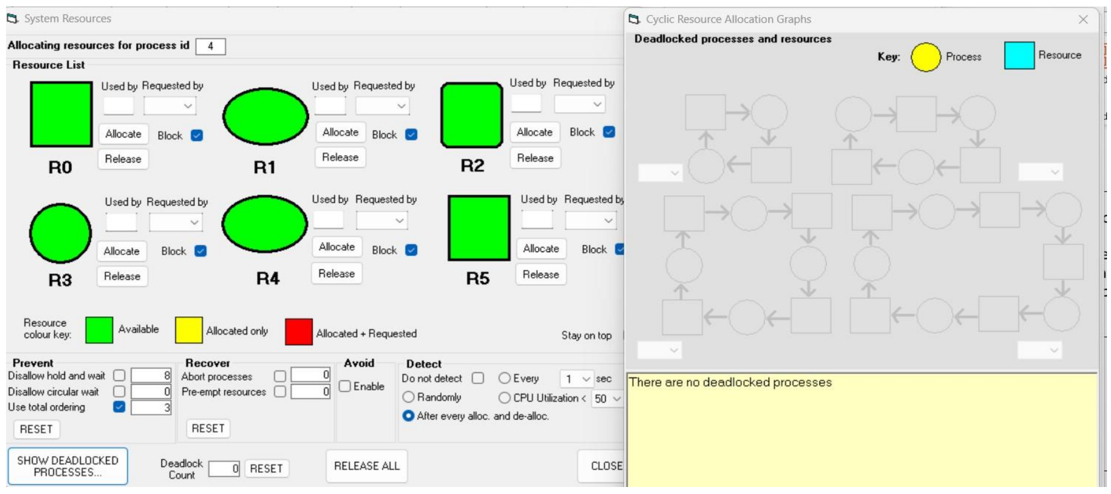
```
There are no deadlocked processes
```

```
There are no deadlocked processes00:02:50.201: *** Deadlocked Processes:
00:02:50.201: Resource R1 is allocated to process P2 (5)
00:02:50.201: Process P2 (5) is requesting resource R2
00:02:50.201: Resource R2 is allocated to process P3 (6)
00:02:50.201: Process P3 (6) is requesting resource R3
00:02:50.201: Resource R3 is allocated to process P4 (7)
00:02:50.201: Process P4 (7) is requesting resource R0
00:02:50.201: Resource R0 is allocated to process P1 (4)
00:02:50.201: Process P1 (4) is requesting resource R1
```

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.

There are no deadlocked processes.



Prevent: Use total ordering [✓]

Detect: [✓ After every alloc. and de-alloc.]

```
There are no deadlocked processes
```