
SYSC 3303 Real-Time Concurrent Systems

Assignment #5 Scheduling Exercises Sample Solutions

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Question 1

Three logical processes P, Q, and S have the following characteristics: P: period 3, required execution time 1; Q: period 6, required execution time 3, S: period 18, required execution time 2.

- a) Show how these processes can be scheduled using the rate monotonic scheduling algorithm.
- b) Show how a cyclic executive could be constructed to implement the three logical processes.

Question 1 a) - page 1

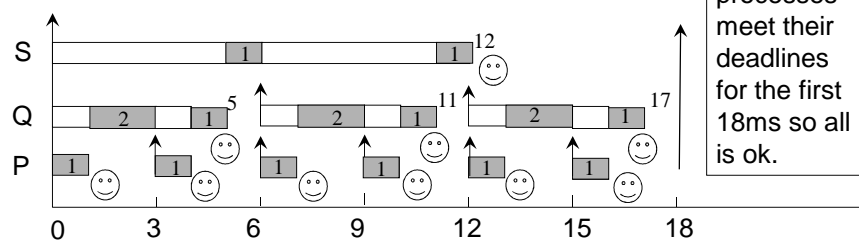
Process	T	C	P	U
P	3	1		
Q	6	3		
S	18	2		

- Assign priorities (RMA) and calculate utilization:

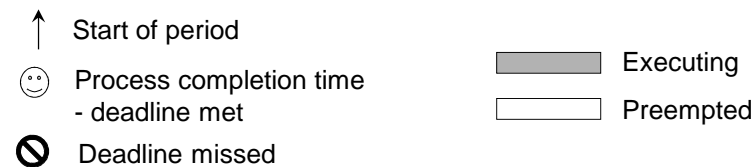
Process	T	C	P	U
P	3	1	3	.33
Q	6	3	2	.50
S	18	2	1	.11

- Combined utilization is 0.94 (94%), which is above the bound for three processes (78%), so it may not be schedulable

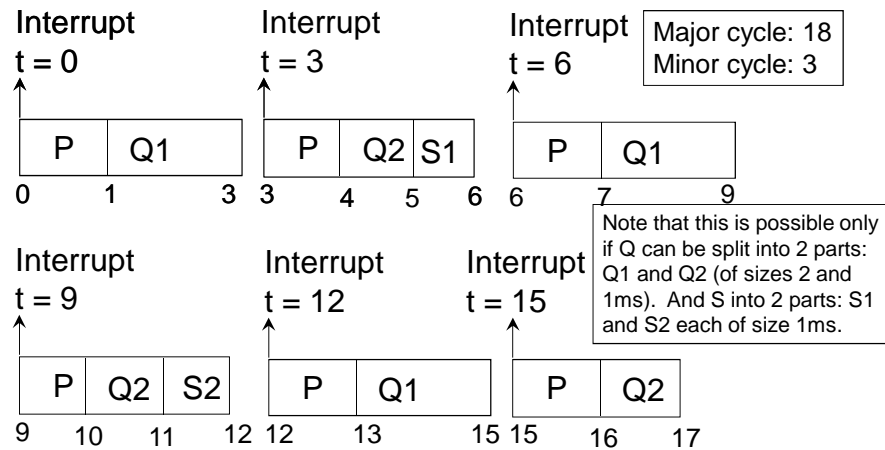
Question 1 a) - page 2



All processes meet their deadlines for the first 18ms so all is ok.



Question 1 b) - page 1



Question 1 b) - page 2

```
for (;;) {
    wait_for_interrupt;
    P;
    Q1;
    wait_for_interrupt;
    P;
    Q2;
    S1;
    wait_for_interrupt;
    P;
    Q1;
}
```

minor cycle

minor cycle

minor cycle

The previous page is sufficient, but you could also show the code.

Question 1 b) - page 3

```
wait_for_interrupt;
P;
Q2;
S2;
wait_for_interrupt;
P;
Q1;
wait_for_interrupt;
P;
Q2;
}
```

} minor cycle

} minor cycle

} minor cycle

Question 2

Consider three processes P, Q, and S. P has a period of 100 ms in which it requires 15 ms of processing. The corresponding values for Q and S are (5, 1) and (25, 10) respectively.

- What is the processor utilization of P, Q, and S?
- If the processes were scheduled by a cyclic executive, would they meet their deadlines? Explain your answer.
- If the processes were scheduled using the rate monotonic scheduling algorithm, would they meet their deadlines? Explain your answer.

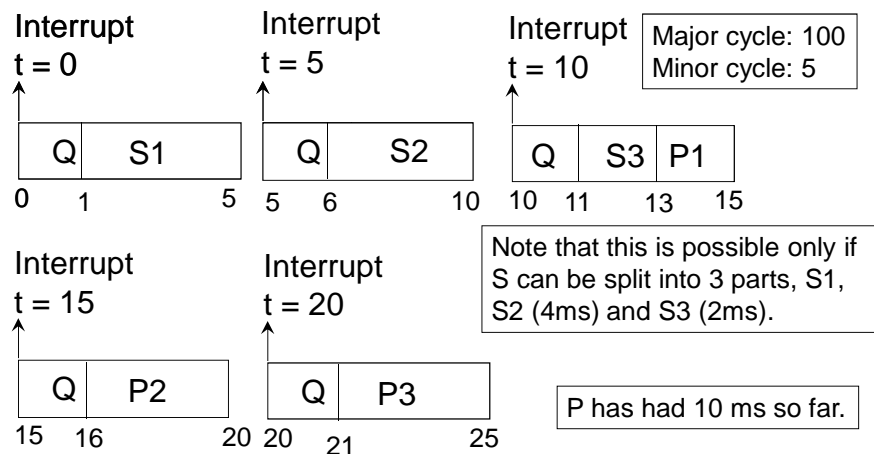
Question 2 a)

- Assign priorities (RMA) and calculate utilization:

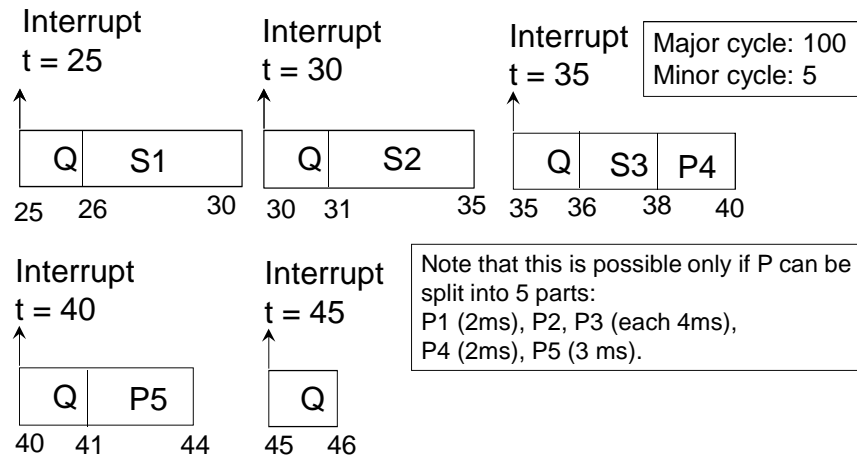
Process	T	C	P	U
P	100	15	1	.15
Q	5	1	3	.20
S	25	10	2	.40

- Combined utilization is 0.75 (75%), which is below the bound for three processes (78%)

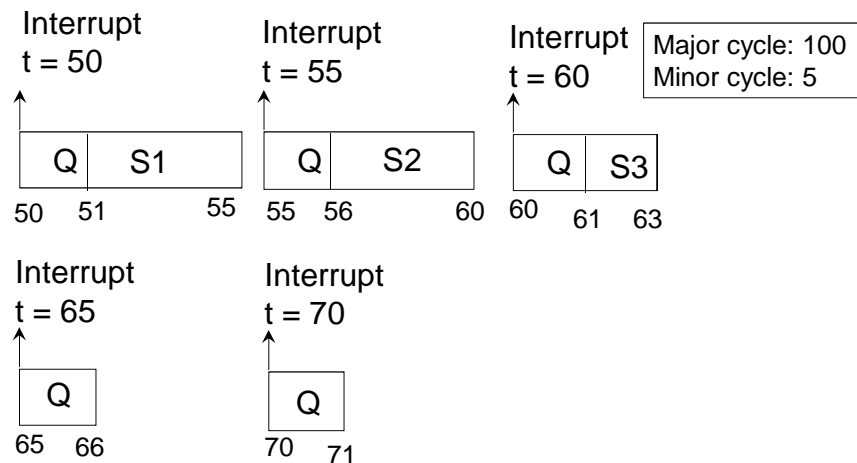
Question 2 b) - page 1



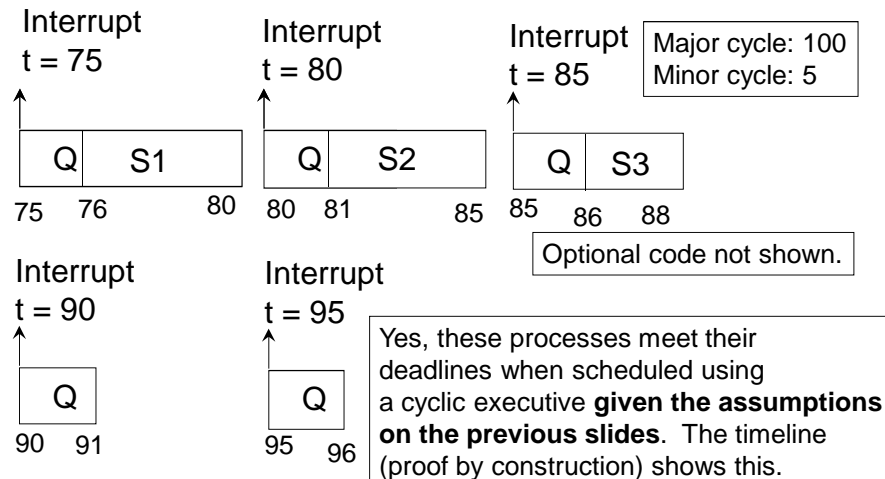
Question 2 b) - page 2



Question 2 b) - page 3



Question 2 b) - page 4

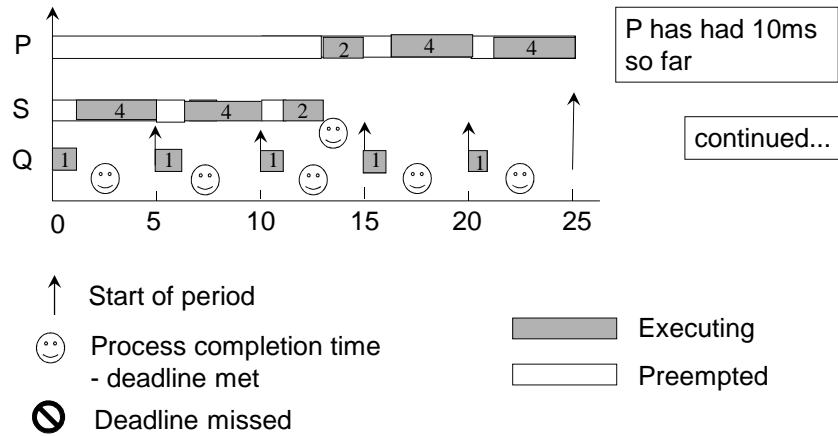


Question 2 c) - page 1

As the process set is schedulable using the Liu/Layland utilization test, they will meet their deadlines if they are scheduled using the rate monotonic scheduling algorithm.

(For more practice, you may draw the timeline [optional]: see next 4 pages.)

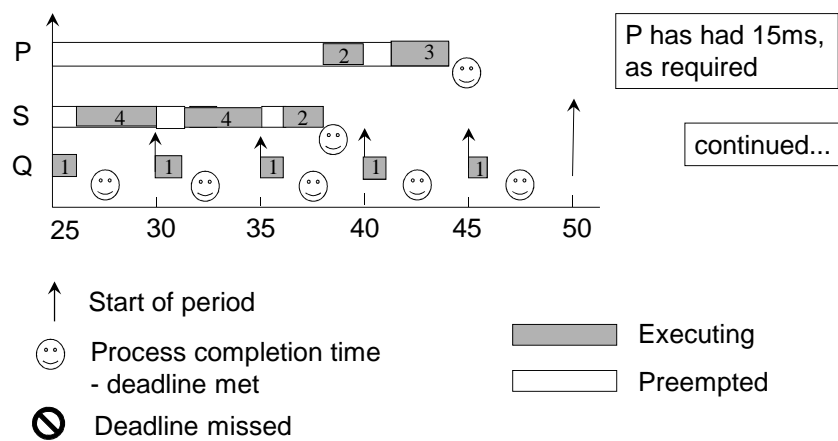
Question 2 c) - page 2



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15

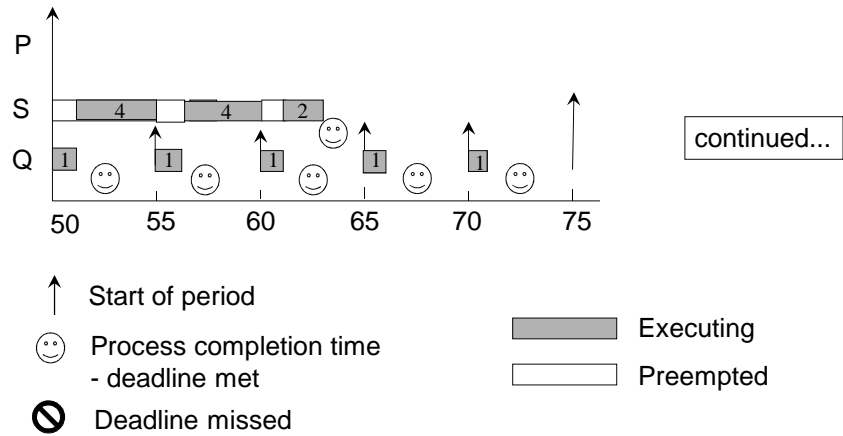
Question 2 c) - page 3



SYSC 3303 - Assignment #5

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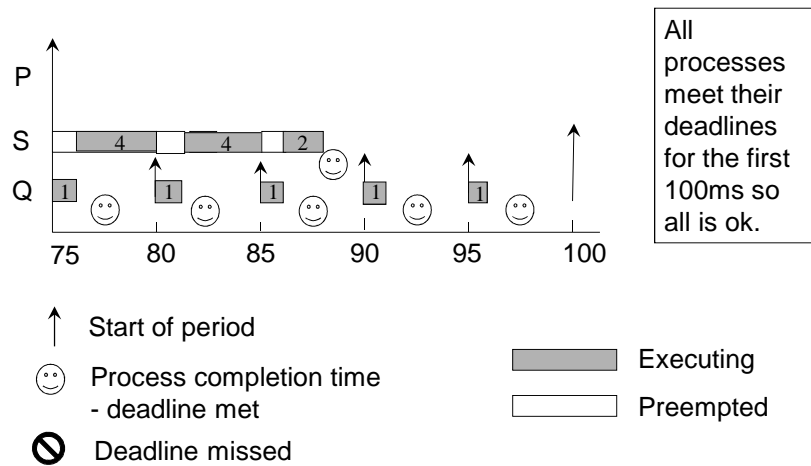
Question 2 c) - page 4



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Question 2 c) - page 5



SYSC 3303 - Assignment #5

18

Question 3

The process set shown here is not schedulable using the Liu/Layland utilization test but does meet all its deadlines. Explain why.

<u>Process</u>	<u>Period</u>	<u>Execution Time</u>
P1	70	30
P2	40	10
P3	20	5

Question 3 - page 1

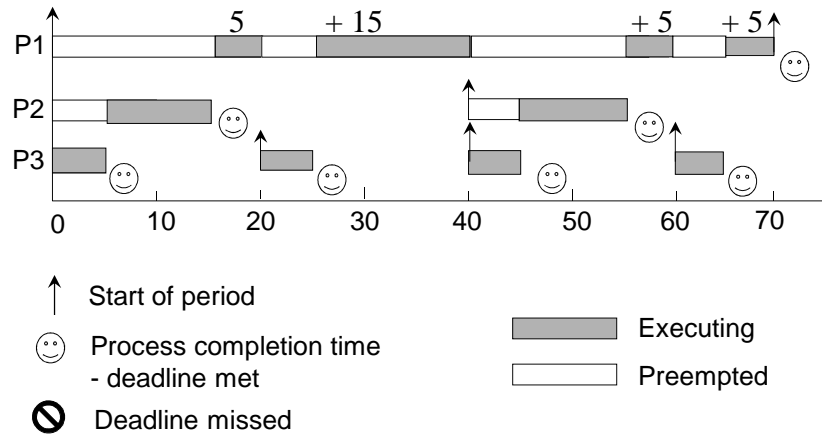
- Assign priorities (RMA) and calculate utilization:

<u>Process</u>	<u>T</u>	<u>C</u>	<u>P</u>	<u>U</u>
P1	70	30	1	.43
P2	40	10	2	.25
P3	20	5	3	.25

- Combined utilization is 0.93 (93%), which is above the bound for three processes (78%), so may not be schedulable
- This is a sufficient but not necessary condition, so we shall construct a timeline to show that the deadlines are met (need to show first 70ms)

Question 3 - page 2

All processes meet their deadlines for the first 70ms so all is ok.



Question 3 - page 3

- The Liu/Layland utilization test is a sufficient but not necessary condition for schedulability using the rate monotonic priority assignment
- If the process set fails the test but the utilization is $\leq 100\%$, then we draw a timeline (up to longest period)
- In this case the timeline shows that all the processes meet their deadlines, so the process set is schedulable using RMPA.