SYSC 3303 Real-Time Concurrent Systems

Assignment #5
Scheduling Exercises
Sample Solutions

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

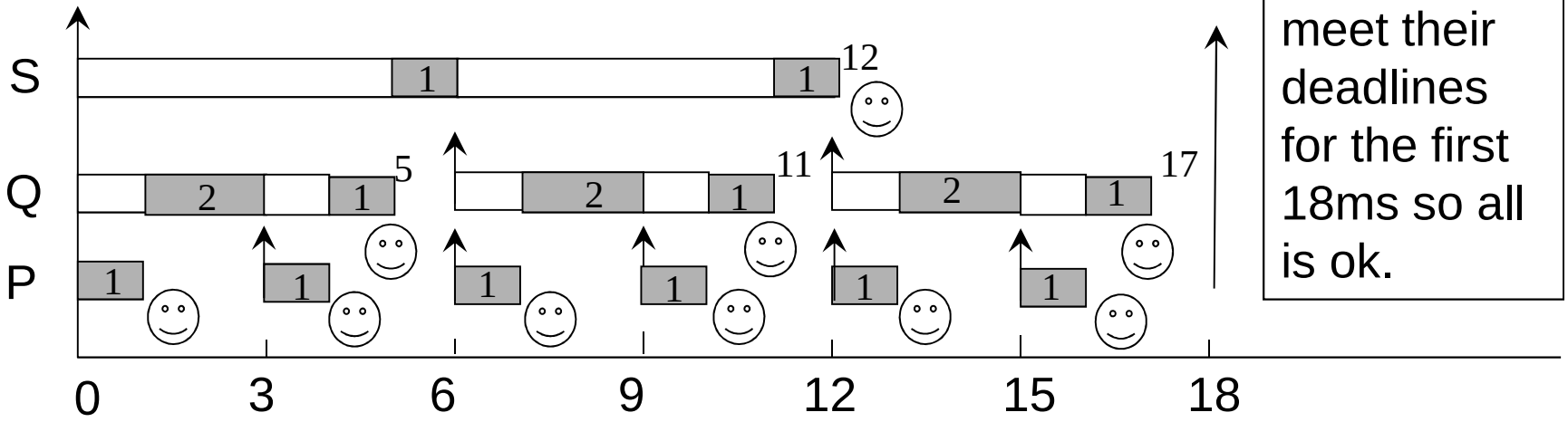
Process	T	C	P	U
P	3	1		
Q	6	3		
S	18	2		

- 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.

Start of period

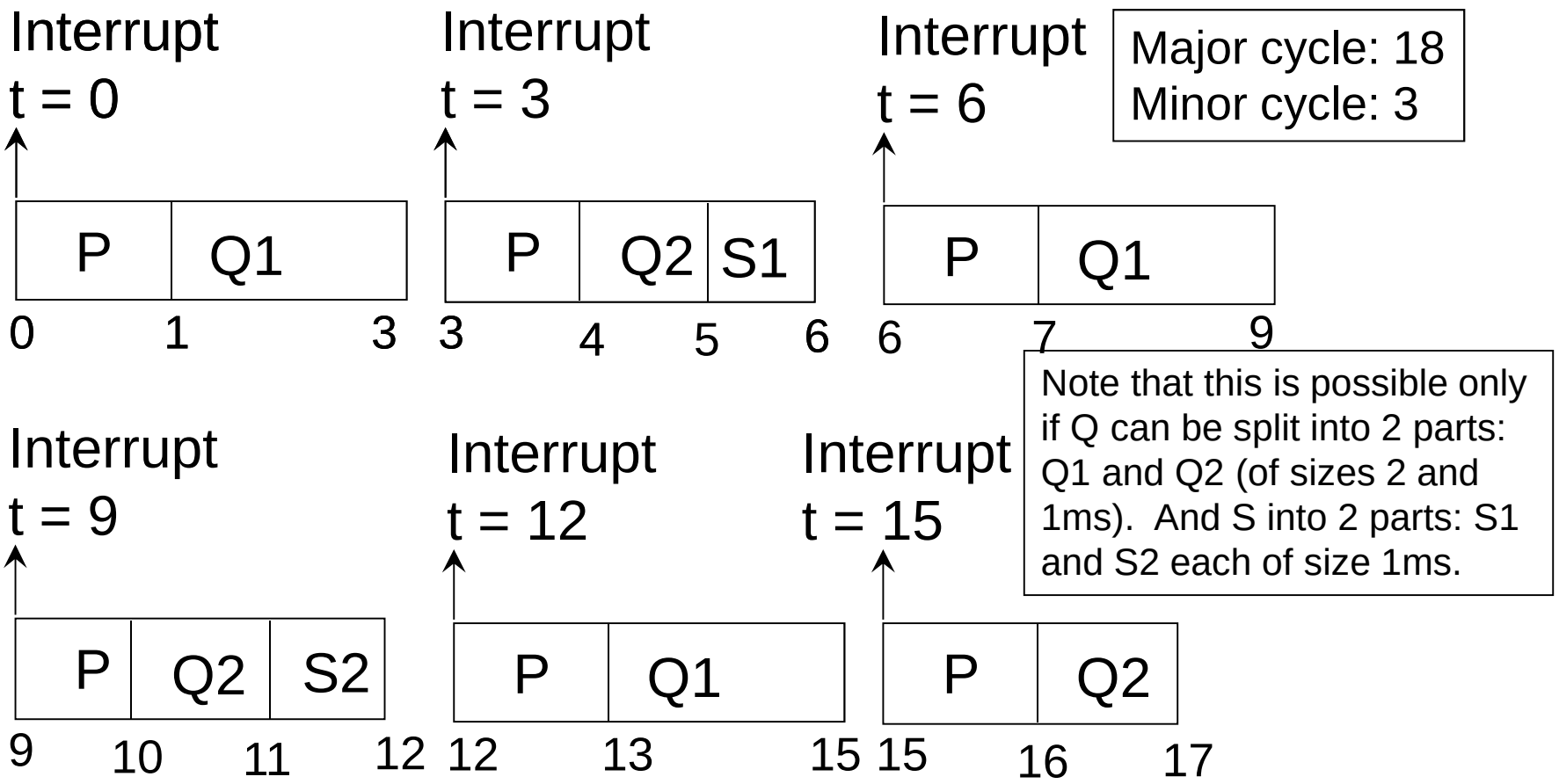
Process completion time - deadline met

Deadline missed

Executing

Preempted

Question 1 b) - page 1



Question 1 b) - page 2

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

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

minor cycle

minor cycle

minor cycle

Question 1 b) - page 3

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

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.

a) What is the processor utilization of P, Q, and S?

b) If the processes were scheduled by a cyclic executive, would they meet their deadlines? Explain your answer.

c) If the processes were scheduled using the rate monotonic scheduling algorithm, would they meet their deadlines? Explain your answer.

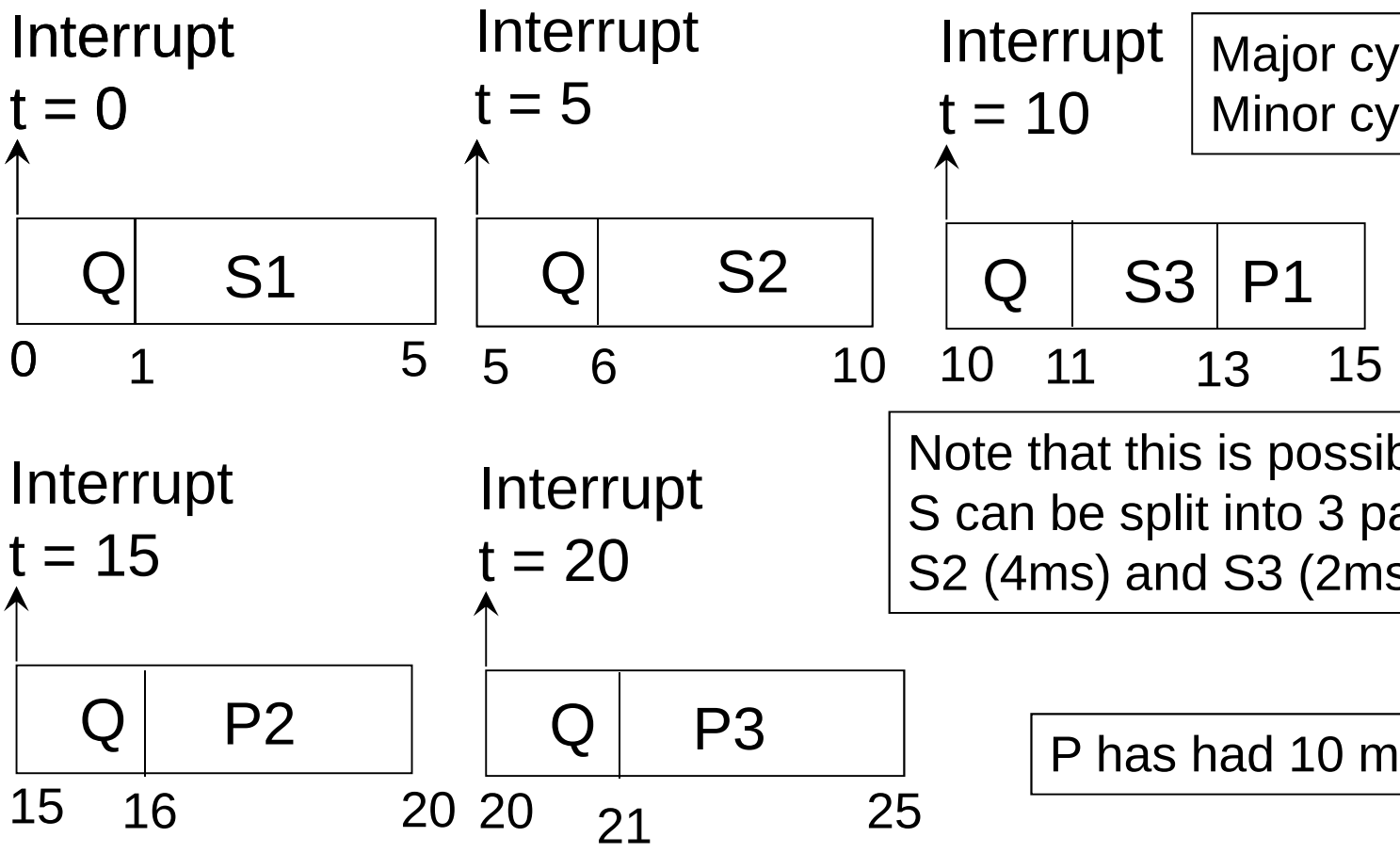
Question 2 a)

- 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

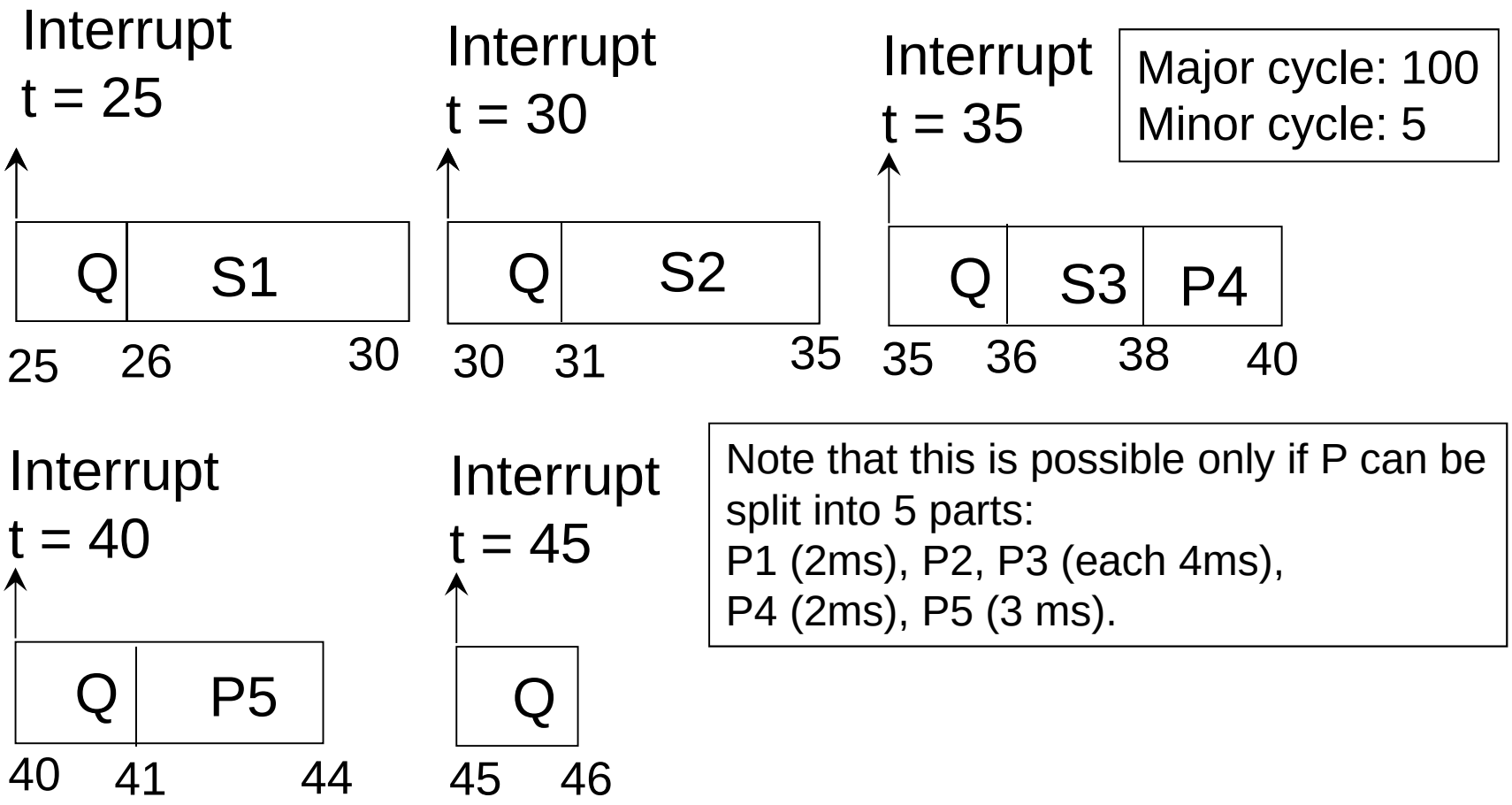


Major cycle: 100
Minor cycle: 5

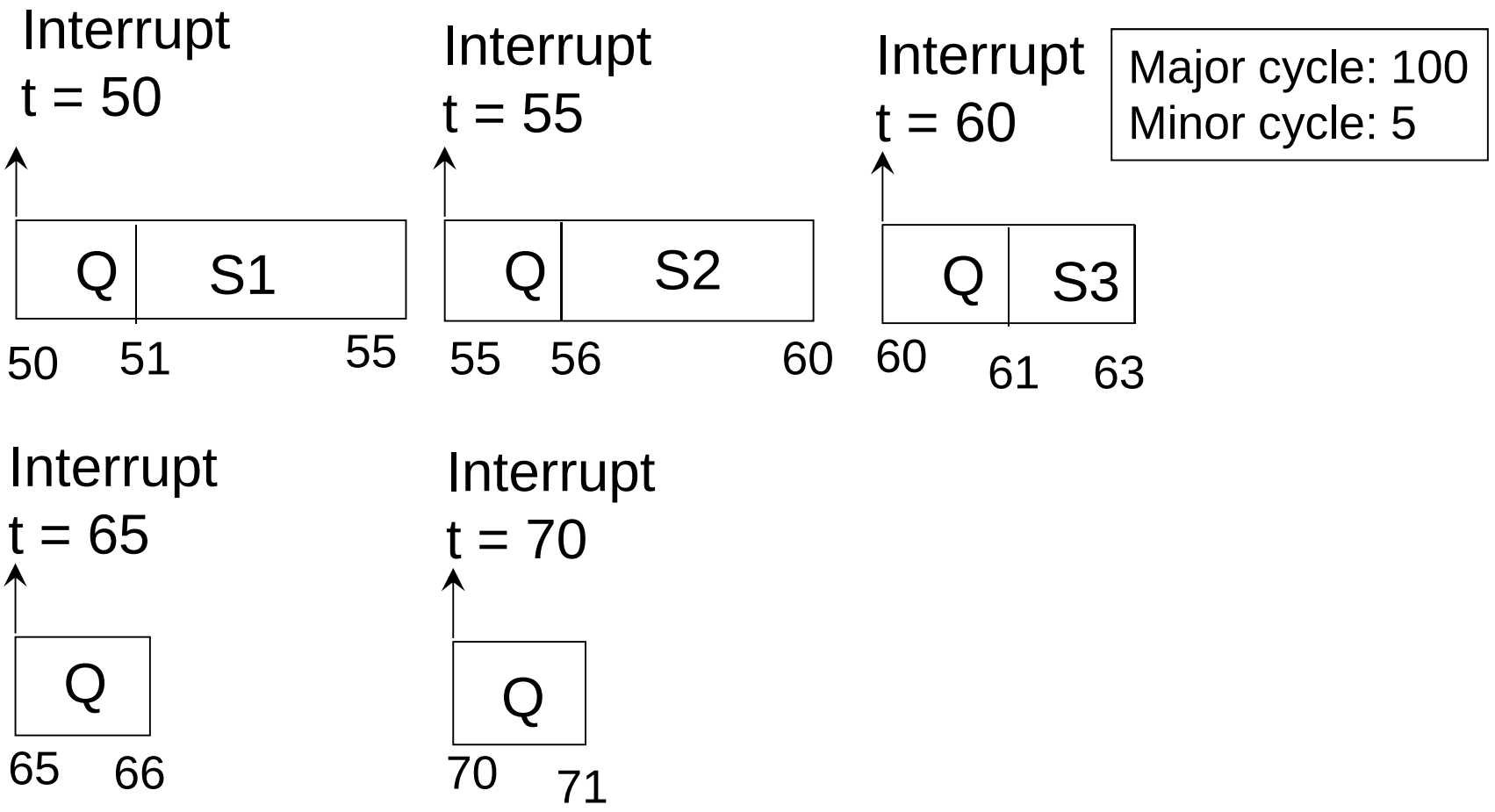
Note that this is possible only if S can be split into 3 parts, S1, S2 (4ms) and S3 (2ms).

P has had 10 ms so far.

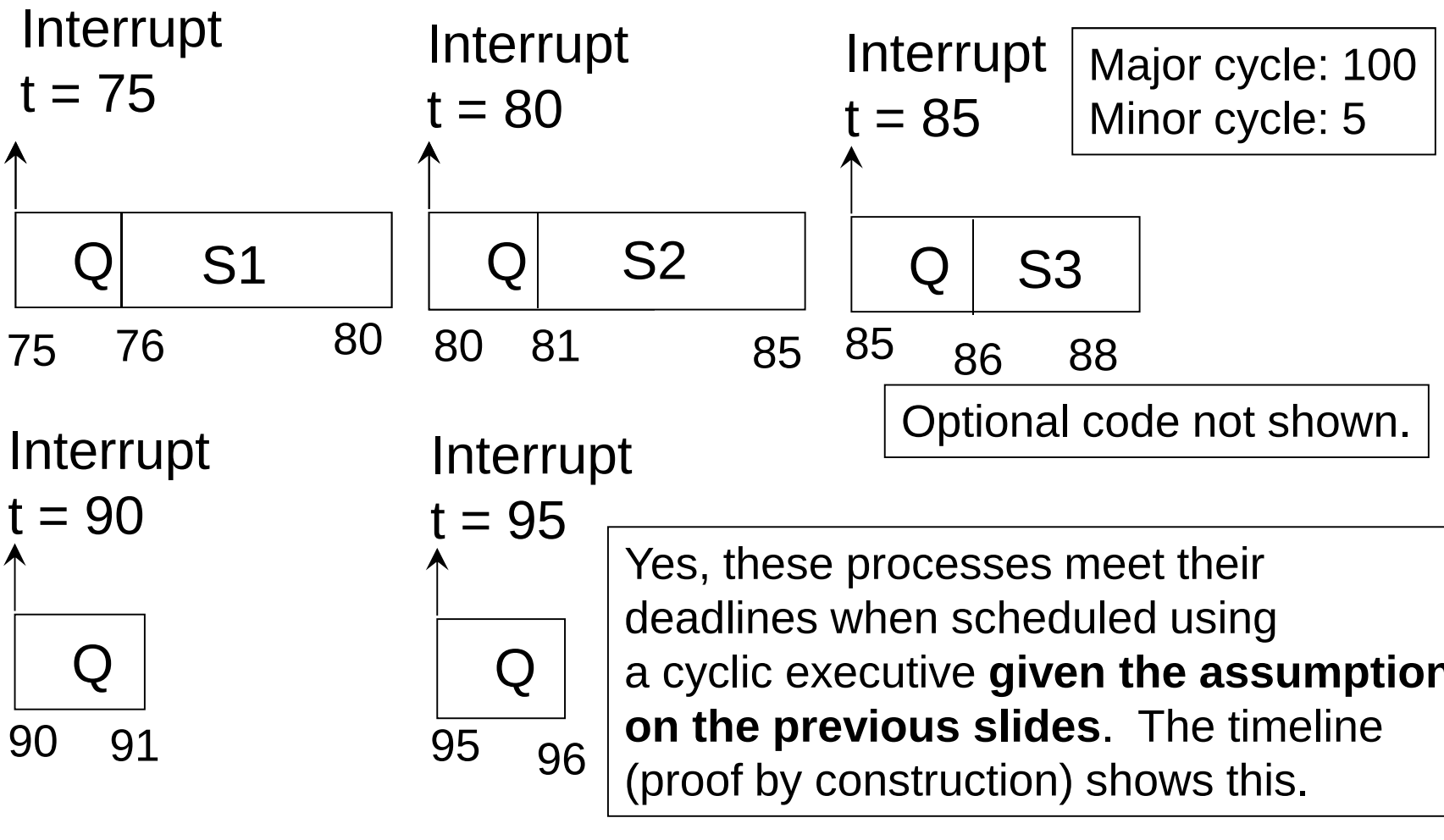
Question 2 b) - page 2



Question 2 b) - page 3



Question 2 b) - page 4

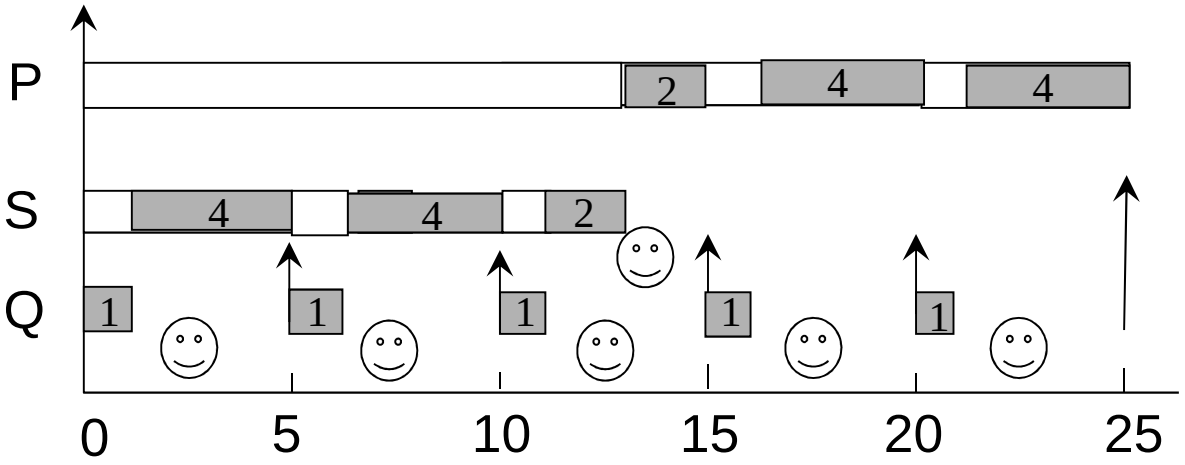


Question 2 c) - page 1

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



P has had 10ms so far

continued...

Start of period

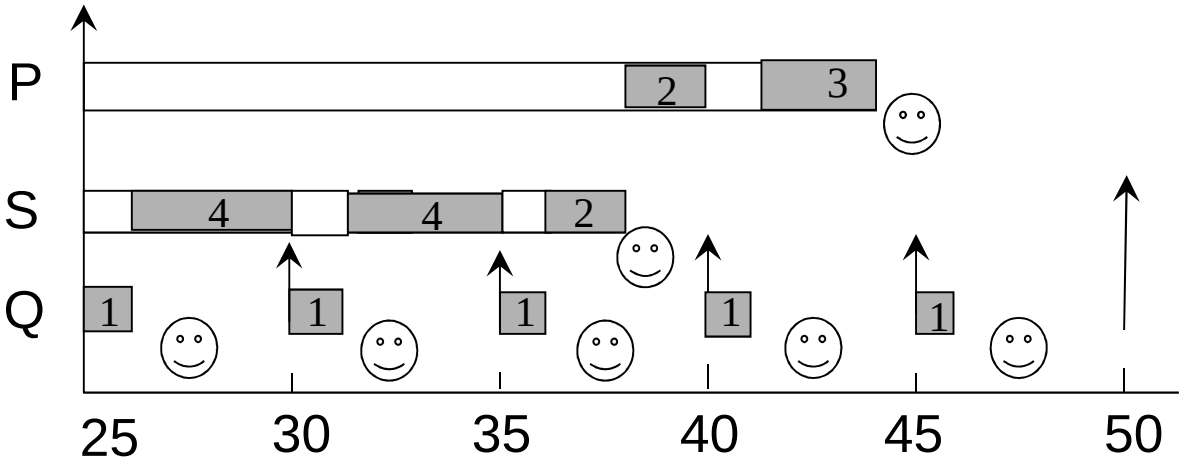
Process completion time - deadline met

Deadline missed

Executing

Preempted

Question 2 c) - page 3



P has had 15ms, as required

continued...

Start of period

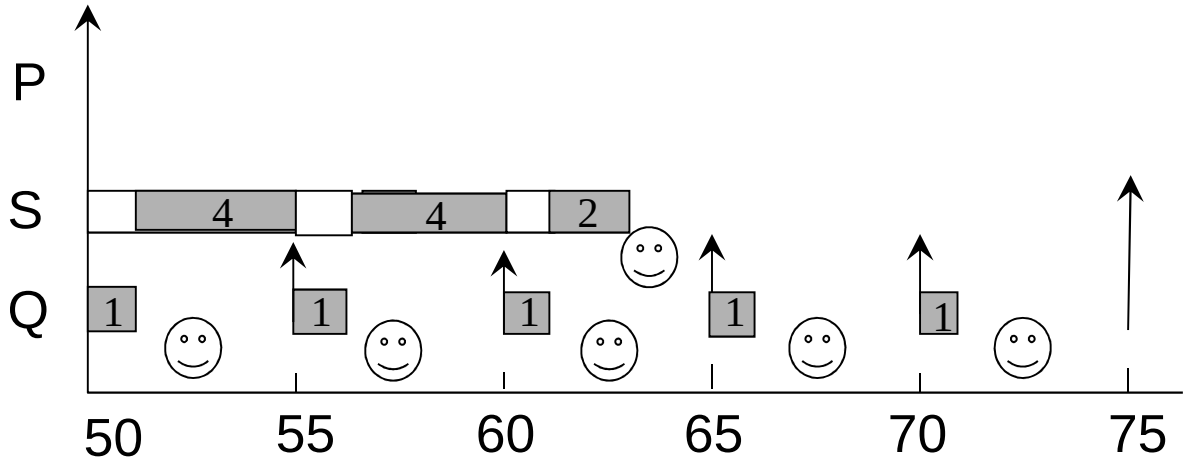
Process completion time - deadline met

Deadline missed

Executing

Preempted

Question 2 c) - page 4



continued...

Start of period

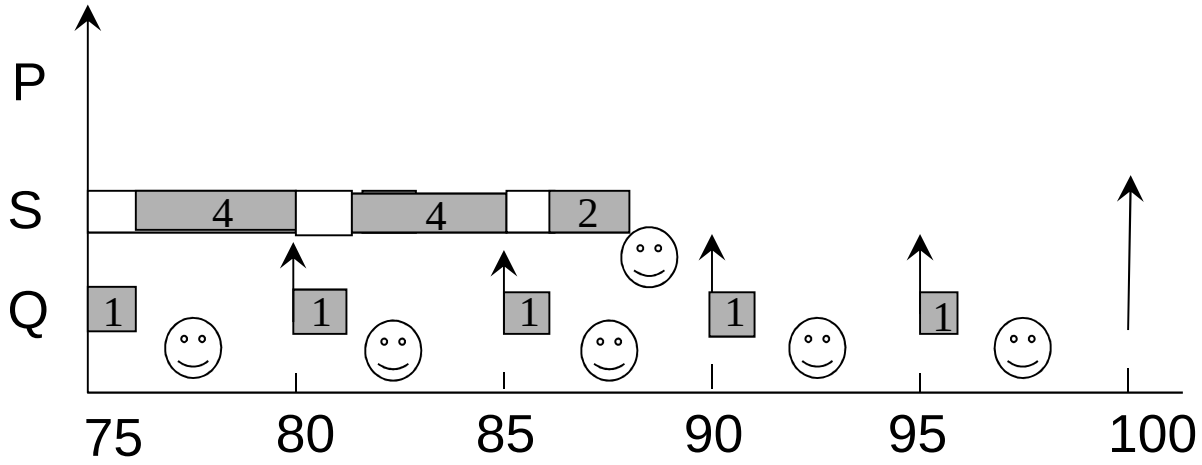
Process completion time
- deadline met

Deadline missed

Executing

Preempted

Question 2 c) - page 5



All processes meet their deadlines for the first 100ms so all is ok.

Start of period

Process completion time - deadline met

Deadline missed

Executing

Preempted

Question 3

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

Process	Period	Execution Time
P1	70	30
P2	40	10
P3	20	5

Question 3 - page 1

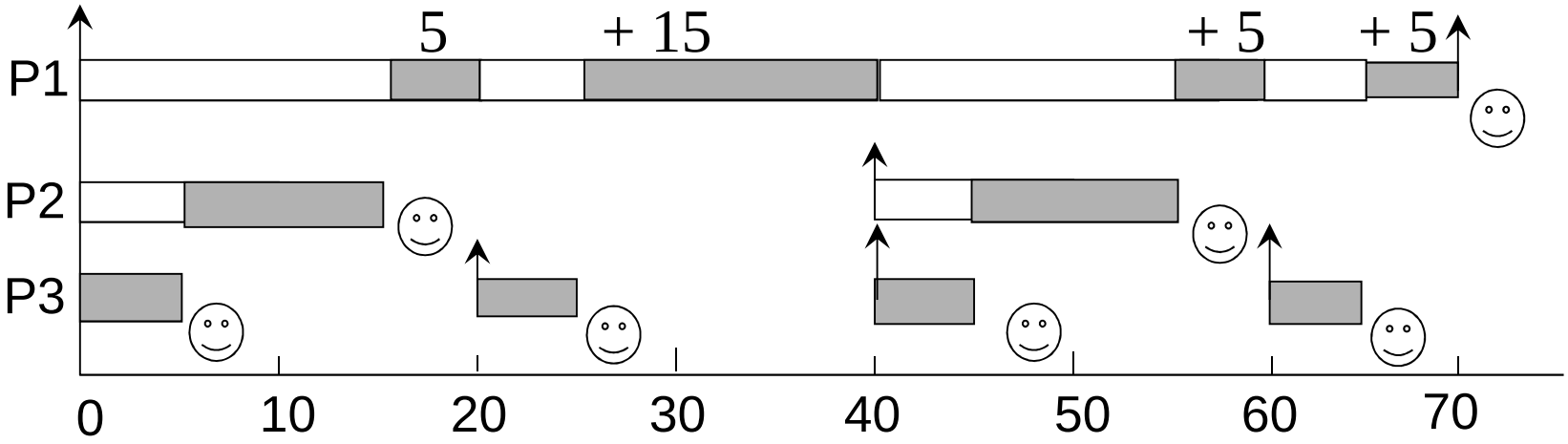
- Assign priorities (RMA) and calculate utilization:

Process	T	C	P	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.



Start of period

Process completion time - deadline met

Deadline missed

Executing

Preempted

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 <= 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.