Real-time systems
Assignment 1
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Task 1. Mention shortly at least 4 different characteristics important for real-time systems in general (4p)

- Real time systems are large and complex. The kernel of a real time system varies from a few hundred lines of assembler or C to 20 million lines of Ada estimated for the Space Station Freedom.
- Real time systems offer concurrent control of separate system components, to devices that operate in parallel in the real world.
- Real time systems offer facilities to interact with special purpose hardware
- Real time systems have extreme reliability and safety. This is due to the fact that most real time systems are embedded systems which typically control the environment in which they operate. A failure to control can result in loss of life, damage to environment or economic loss.
- Real time systems have guaranteed response times since we need to be able to predict with confidence the worst case response times for systems; efficiency is important but predictability is essential.
- Tasks must be ensured by real time systems that they meet their respective time constraint.

Task 2.
x = modulo(<student number>, 3) + 4
= modulo(71141, 3) + 4 = 6

a, Calculate processor utilization factor and the Hyperperiod H (1p).

- Processor utilization factor U = sum(ei/pi) = 0.1/2 + ¼ + 2/6 = 0.63
- Hyperperiod H = lcm(2,4,6) = 12

b, Draw the schedule for H using EDF (if tasks have the same deadline then task with lower index has higher priority) (2p).

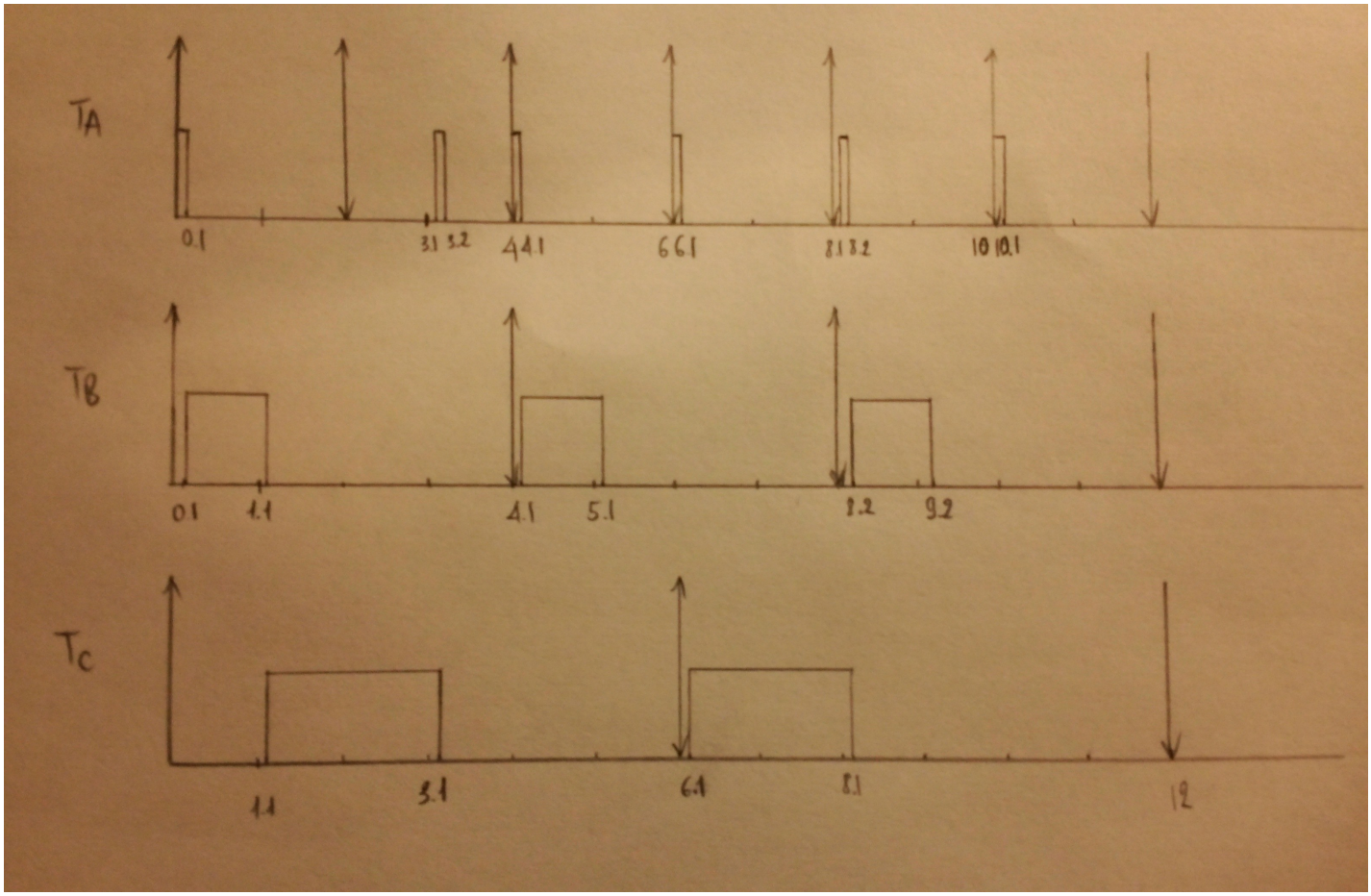

Figure 1. EDF scheduling for the given system

c, Calculate the slack time (1p)
The system is schedulable since the processor utilization factor = 0.63 < 1.
The hyperperiod is H = 12 => Slack time = (4 – 3.2) + (6 – 5.1) + (10 – 9.2) + (12 – 10.1) = 4.4

Task 3.
a, What is the difference between jitter and phase? (1p)
Jitter, defined as [r-, r+], is the maximal span of changes in the release time. If the jitter is small or zero, the time r is fixed. Phase is the intended shift in period and release time.

b, What properties are included in priority-driven schedulers but not in clock based schedulers? (1p)
Priority-driven schedulers are online schedulers in which

- the schedule is not pre-computed
- scheduler assigns priority to released jobs and places them in ready job queue in priority order
- at each scheduling decision time, scheduler updates the ready job queue and schedules job with highest priority

c, In what situations is the start time not equal to the release time? (1p)
Start time is the time instant at which the computation starts after the stimulus. Release time is time instant at which a job becomes available for execution. The start time is not equal to release time in cases where there are jobs which have the same release time but priority is given the them. As a result,

the job with lowest priority will have start time later than their actual release time.

Task 4. How long is the hyperperiod when tasks a, b, and c have the periods:
a, 1, 2, and 4? How many jobs of each task fit into one hyperperiod? (1p)
The hyperperiod is H = lcm(1,2,4) = 4
Task a has a period of 1, so 4 jobs can be fitted into one hyperperiod of 4
Task a has a period of 2, so 2 jobs can be fitted into one hyperperiod of 4
Task a has a period of 4, so 1 jobs can be fitted into one hyperperiod of 4

b, 54, 352, 1122? How many jobs of each task fit into one hyperperiod? (1p)
The hyperperiod is H = lcm(54, 352, 1122) = 161568
Task a has a period of 54, so 2992jobs can be fitted into one hyperperiod of 161568
Task a has a period of 352, so 459 jobs can be fitted into one hyperperiod of 161568
Task a has a period of 1122, so 144 jobs can be fitted into one hyperperiod of 161568

Task 5.
a, Draw the precedence graph

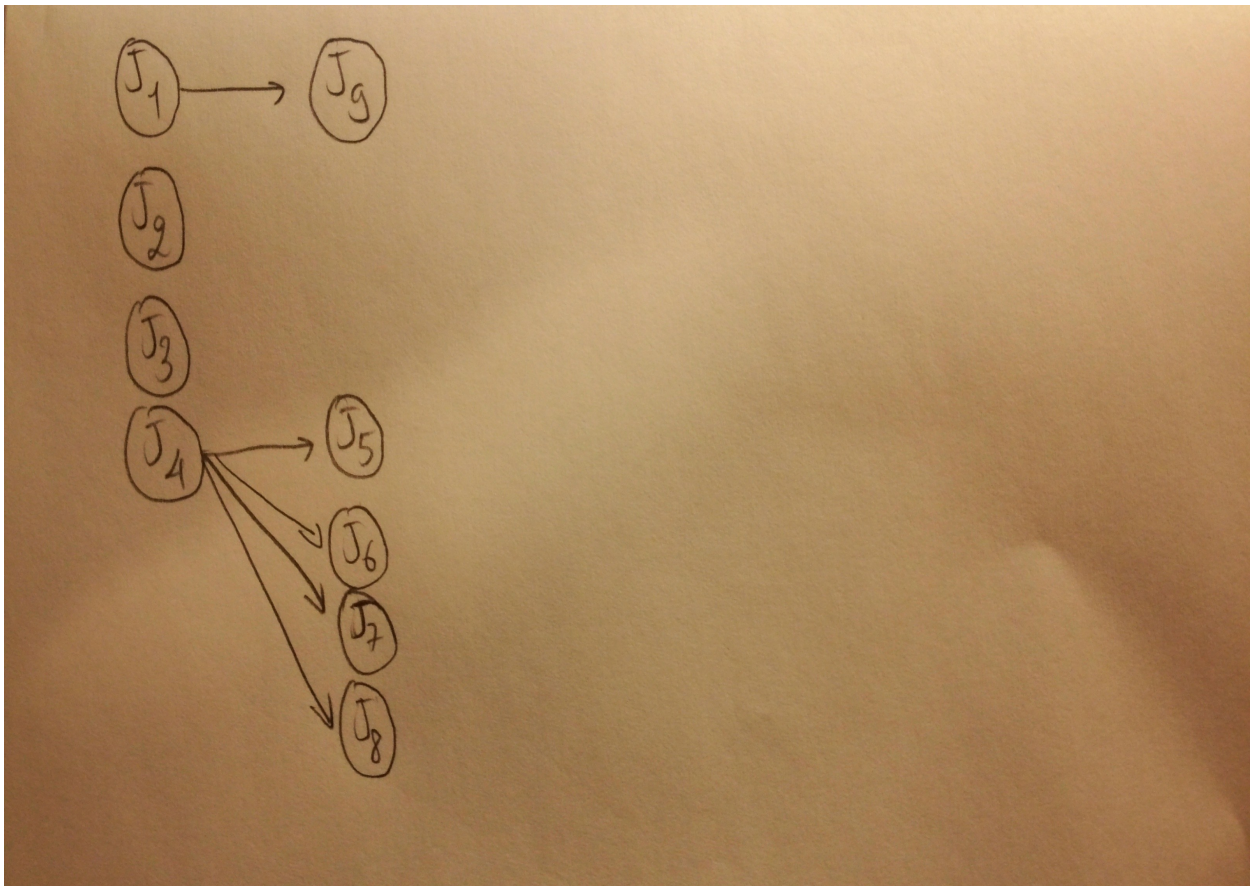

Figure 2. Precedence graph

b, Can the jobs be scheduled on 3 processors so that all jobs meet their deadlines assuming the jobs are non-preemptive? (1p)

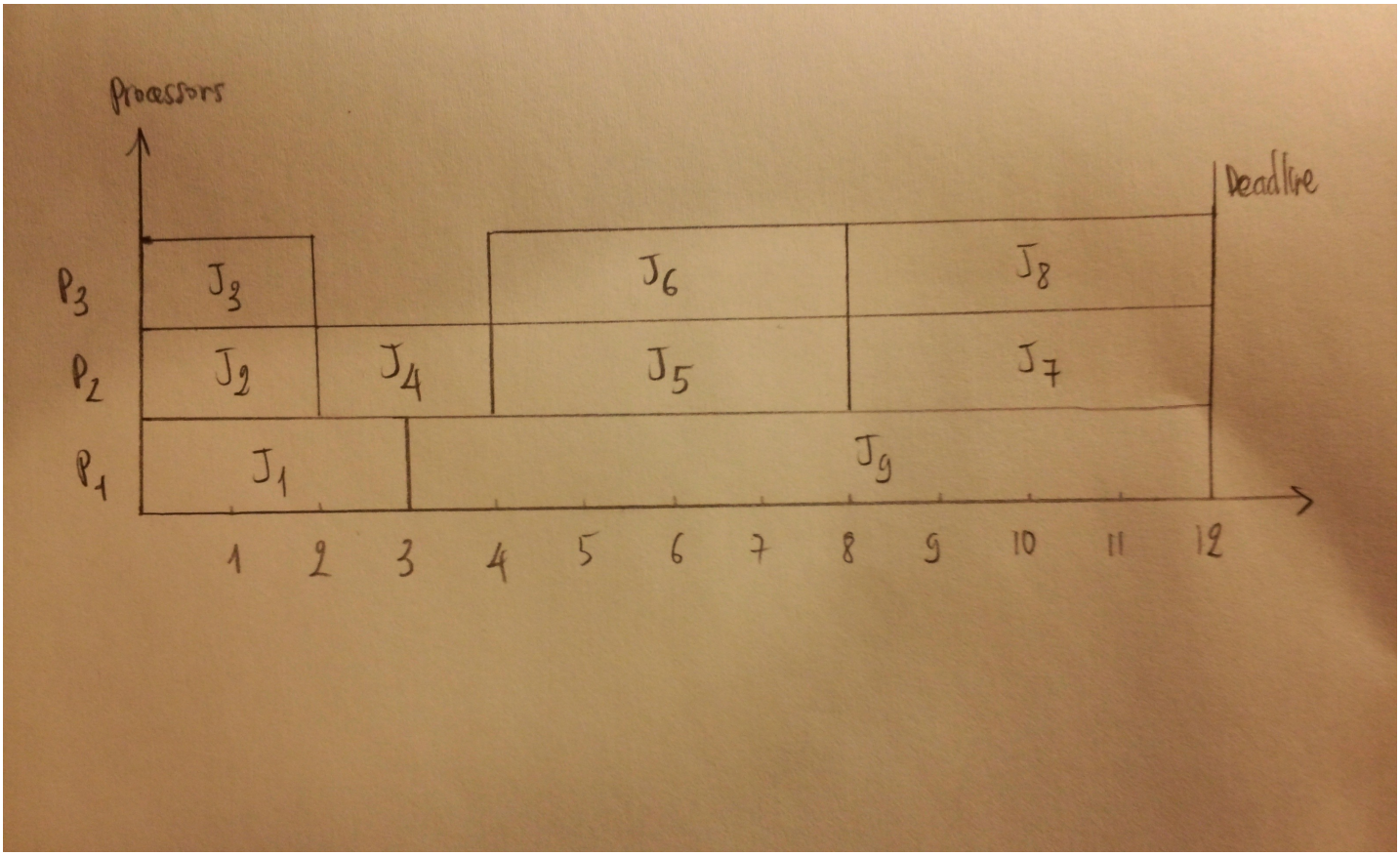

Figure 3. Non-preemptive jobs scheduled on 3 processors

The jobs can be scheduled on 3 processors so that all jobs meet their deadlines assuming the jobs are non-preemptive.

c, Can the jobs be scheduled on 3 processors so that all jobs meet their deadlines assuming the jobs are preemptive? (1p)

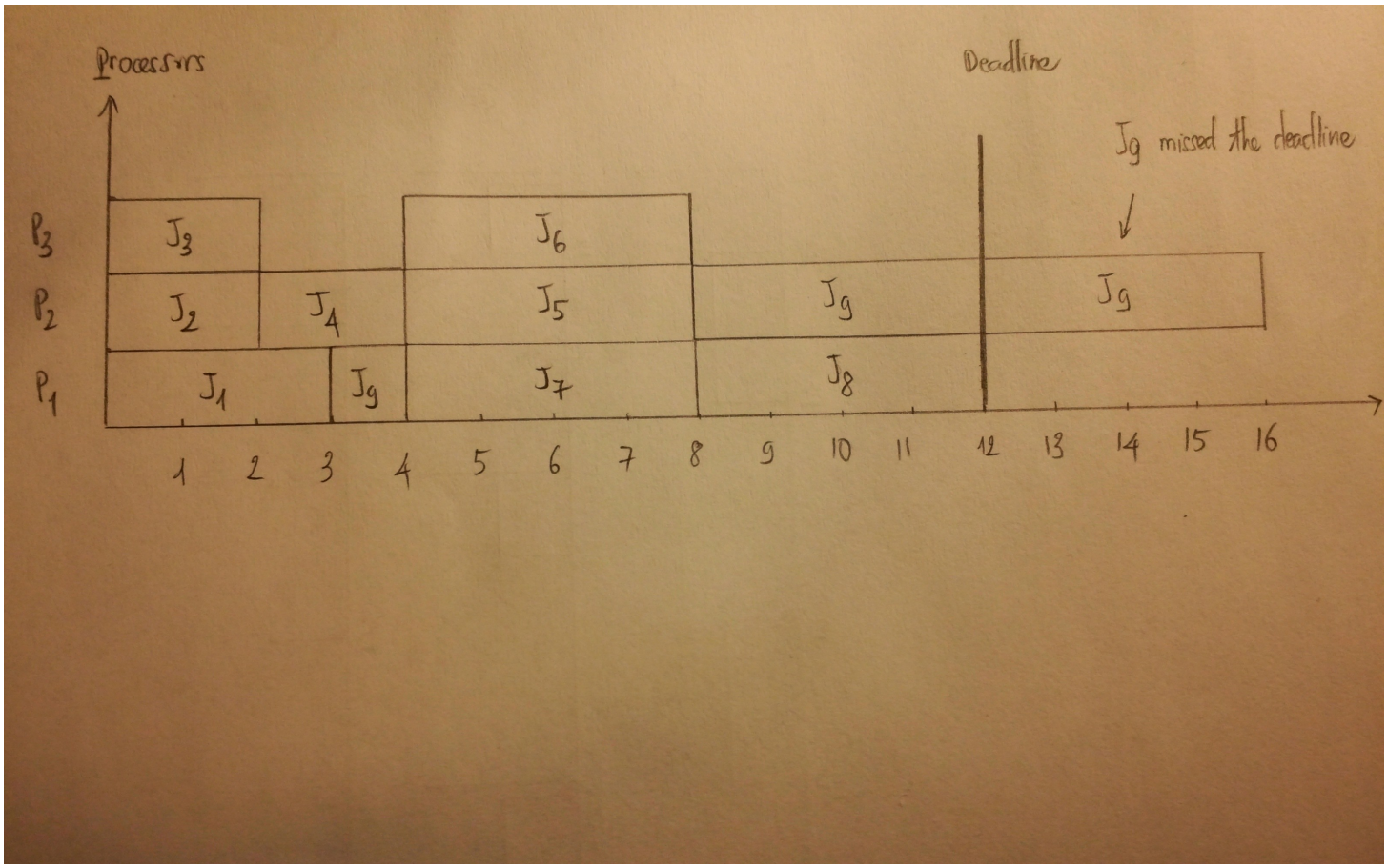

Figure 4. Preemptive jobs scheduled on 3 processors

Jobs cannot be scheduled on 3 processors so that all jobs meet their deadlines assuming the jobs are preemptive. This is because job J9 misses the deadline.

d, Can the jobs be scheduled on 4 processors so that all jobs meet their deadlines assuming the jobs are non-preemptive? (1p)

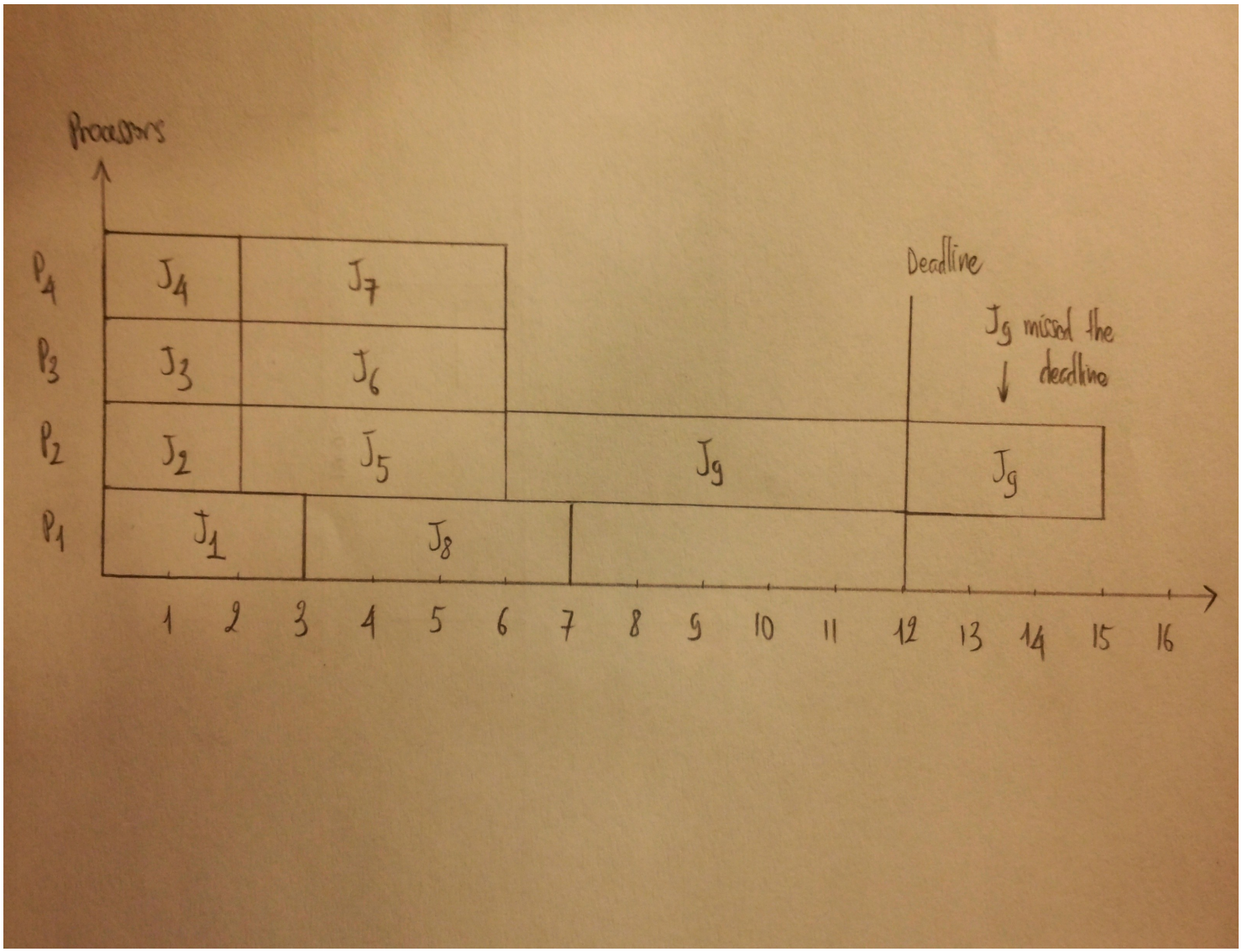

Figure 5. Non-preemptive jobs scheduled on 4 processors

The jobs cannot be scheduled on 4 processors assuming the jobs are non-preemptive. This is because job J9 misses the deadline.

e, Assume that we can speed up all jobs by one time unit (new execution time = old execution time-1). Can the jobs be scheduled on 3 processors so that all jobs meet their deadlines? (assuming the jobs are non-preemptive) (1p)

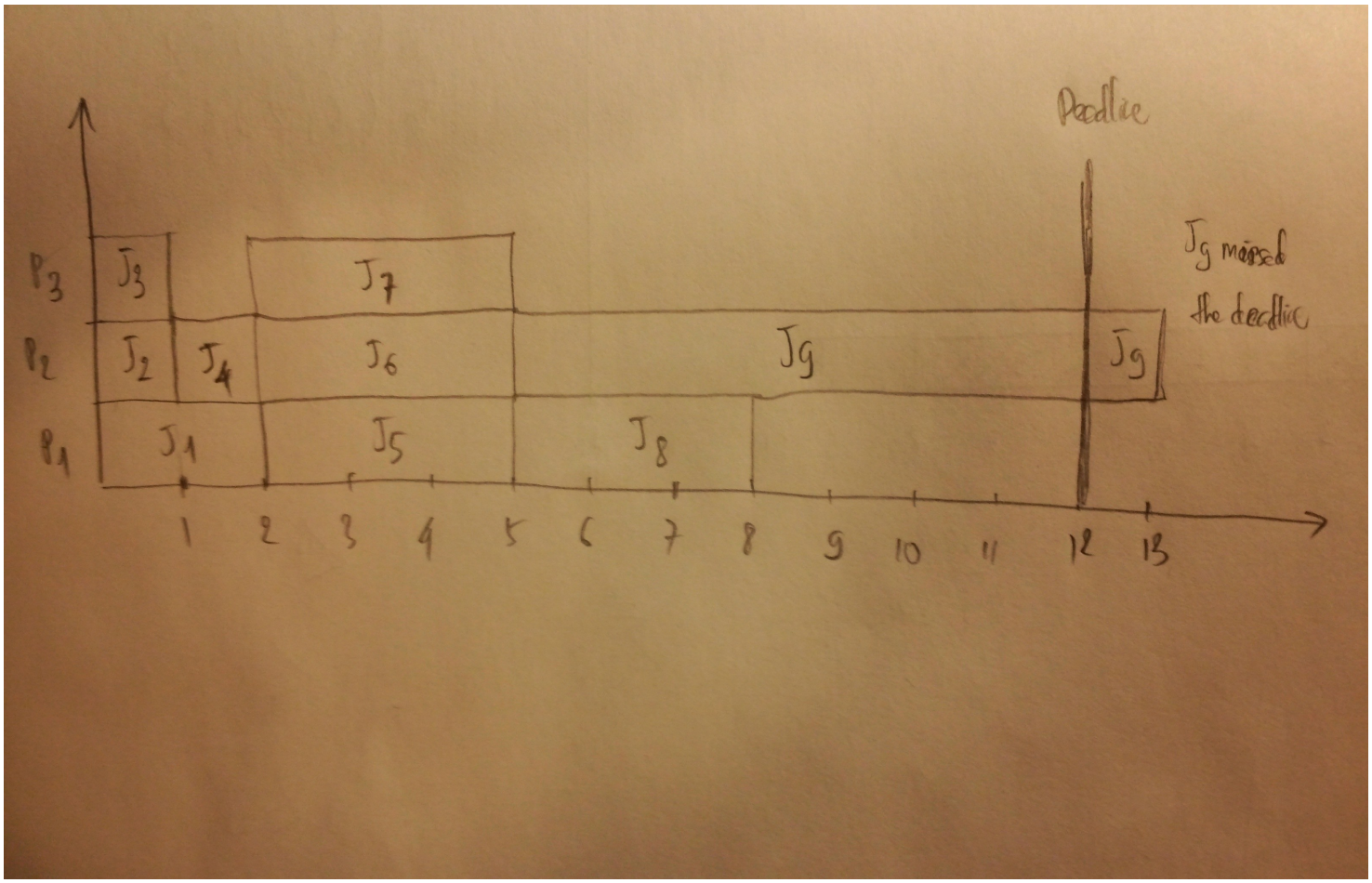

Figure 6. Non-preemptive jobs scheduled on 3 processors with new execution speed

The jobs cannot be scheduled on 3 processors with new execution speed. This is because job J9 misses the deadline.