National Institute of Technology, Rourkela
Mid-semester Examination, Spring 2022
Real-Time Systems Design (CS 6414)
6th semester B.Tech and 2nd semester M.Tech in Computer Science & Engineering

Duration: 2 Hours **Full Marks: 30**
Number of pages: 2

- **There are six questions.**
- **All questions are compulsory.**
- **If you answer a question with multiple parts, all parts should be answered together.**

Q 1. State whether you consider the following statements to be TRUE or FALSE. Justify your answer in each case in one or two sentences. [5 × 1]

(a) Soft real-time tasks are those which do not have any time bounds associated with them.

(b) All hard real-time systems are safety-critical in nature.

(c) Minimization of average task response times is the objective of any good hard real-time task scheduling algorithm.

(d) If a set of periodic real-time tasks fails Lehoczky's test, then it can safely be concluded that this task set cannot be feasibly scheduled under RMA.

(e) Suppose a task needs three non-preemptable shared resources CR1, CR2, and CR3 during its computation. Under highest locker protocol (HLP), once the task acquires one of these resources, it is guaranteed not to block for acquiring the other required resources.

Q 2. Consider the following (partial) specification of a real-time system:

The velocity of a space craft must be sampled by a computer on-board the space craft at least once every second (the sampling event is denoted by second). After sampling the velocity, the current position is computed (denoted by event C) within 100 msec, parallely the expected position of the space craft is retrieved from the database within 200 msec (denoted by event R). Using these data, the deviation from the normal course of the space craft must be determined within 100 msec (denoted by event D) and corrective velocity adjustments must be carried out before a new velocity value is sampled in (the velocity adjustment event is denoted by A). Calculated positions must be transmitted to the earth station at least once every minute (position transmission event is denoted by the event T).

Identify the different timing constraints in the system. Classify these into either performance or behavioural constraints. Construct an extended finite state machine (EFSM) to model the system. [5]

Q 3. Consider a real-time system which consists of three tasks T_1, T_2, and T_3, which have been characterized in the following table.

Task	Phase (msec)	Execution Time (msec)	Relative Deadline (msec)	Period (msec)
T_1	20	10	20	20
T_2	40	10	50	50
T_3	70	20	80	80

If the tasks are to be scheduled using a table-driven scheduler, what is the length of time for which the schedules have to be stored in the precomputed schedule table of the scheduler. [5]

Q 4. A cyclic real-time scheduler is to be used schedule of three periodic tasks T_1, T_2, and T_3 with the following characteristics.

Task	Phase (msec)	Execution Time (msec)	Relative Deadline (msec)	Period (msec)
T_1	0	20	100	100
T_2	0	20	80	80
T_3	0	30	150	150

Suggest a suitable frame size that can be used. Show all intermediate steps in your calculations. [5]

Q 5. A set of hard real-time periodic tasks need to be scheduled on a uniprocessor using RMA. The following table contains the details of these periodic tasks and their use of three non-preemptable shared resources. Can the tasks T_2 and T_3 meet their respective deadlines when priority ceiling protocol (PCP) is used for resource scheduling?

Task	p_i	e_i	R_1	R_2	R_3
T_1	400	30	15	20	–
T_2	200	25	–	20	10
T_3	300	40	–	–	–
T_4	250	35	10	10	10
T_5	450	50	–	–	5

p_i indicates the period of task T_i and e_i indicates its computation time. The period of each task is the same as its deadline. The entries in the R_1, R_2 and R_3 columns indicate the time duration for which a task needs the named resource in non-preemptive mode. Assume that after a task releases a resource, it does not acquire the same or any other resource. [5]

Q 6. Consider a real-time system whose task characteristics and dependencies are described in the following table. Assume that the tasks have zero phasing and repeat with a period of 90 msec. Determine a feasible schedule which could be used by a table-driven scheduler. [5]

Task	Computation Time (e_i) msec	Deadline (d_i) msec	Dependency
T_1	30	90	–
T_2	15	40	T_1, T_3
T_3	20	40	T_1
T_4	10	70	T_2

All the best