National Exams December 2015

04-Soft-A4 Real-time Systems

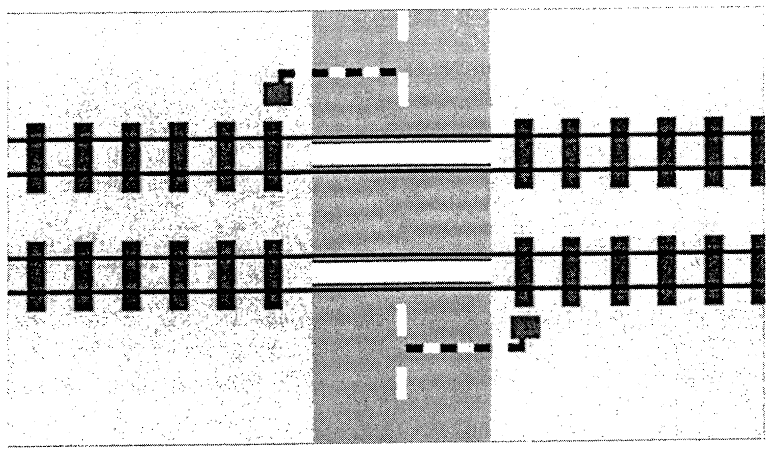
3 hours

Note

- If doubt exists as to the interpretation of any question, the candidate is urged to submit with the detailed answer paper, a clear statement of any assumptions made.
- Candidates may use one of two calculators, the Casio or Sharp approved models. This is a Closed Book exam.
- Any five questions constitute a complete paper. Only the first five questions as they appear in your answer book will be marked.
- All questions are of equal value (20% each).

Question 1 (20%)

Consider that a double-track rail crossing as shown below. Triggering of the movements (down/up) of the gates is an aperiodic task real-time system. Furthermore, it takes 10 secs for the gate to come down and goes up. Suppose that the highest speed of the train is 200 km/h, and the highest speed of the automobiles on the road is 100 km/h, and the drive can safely see the red light at the gate 50 meters ahead to slow down.



Also assume that the sensor to measure out-going train (train already passing the crossing) is located 20 m from the centre line of the road to trigger the lift of the gate. One wants the gate to be lifted as soon as the train has passed, consider the situations where two trains can come towards each other and pass through this railway crossing from both directions at same time.

(1) Identify all possible states for this railway crossing system;
(2) Develop a state diagram;
(3) Select the minimal distance to locate the sensor to measure on-coming train with 100% safety margin; and
(4) Perform analysis on the real-time requirements for this rail crossing gate system to ensure safety of motorists and efficient operation of the crossing.

Question 2 (20%)

A simple concept of a real-time system is that the correctness of the computations not only depends on correctness of the logic operation, but also on the time at which the result is produced. That is, a late answer is a wrong answer (even though the number is correct). Please give examples of real-time systems in your daily activities with following characteristics. You need to explain your choice against these criteria:

1. Periodic real-time systems
2. Deadline-oriented real-time systems
3. Hard-deadline based real-time systems
4. Soft-deadline based real-time systems
5. Aperiodic task based real-time systems

Question 3 (20%)

Please answer the following questions with detailed explanations

1. What are the desired features of a RTOS (Real-Time Operating System)?
2. Why or why not the Microsoft Windows and Mac OS be used in real-time applications? and
3. Can you list four commercially available real-time operating systems for real-time applications?
4. Interrupt
5. Interrupt latency
6. Rate Montonic scheduling
7. Earliest Deadline First scheduling
8. Embedded system

Question 4 (20%)

Four single-instance tasks are listed in Table below:

Task	Arrival Time	Computational time (ms)	Absolute deadline (ms)
T1	0	4	15
T2	0	3	12
T3	2	5	9
T4	5	2	8

(1) Schedule the tasks using First-Come-First-Serve (FCFS) scheduler, and draw a timing diagram to illustrate the scheme
(2) Analyze the result from Step (1). Does FCFS scheduler work in this case?
(3) Re-schedule these tasks using EDF algorithm to meet the real-time requirements. Illustrate this by a timing diagram.

Question 5 (20%)

In a pre-emptive priority system, for each task, the time required to complete and the priority (1 being the highest) are given in Table 2 below:

Tasks	Time required (ms)	Priority
Task 1	10	2
Task 2	20	1
Task 3	30	3
Task 4	40	4

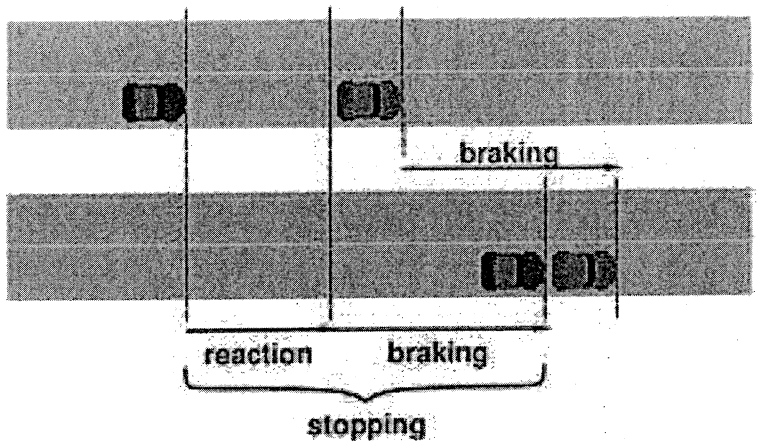
If the tasks arrive in the order (1, 2, 3, 4) and if we assume that the interrupt latency is 1.0 ms,

(a) how much time does it take to complete task 3? and

(b) How much time would it take if the system uses cooperative scheduling?

Question 6 (20%)

Automatic object detection and collision avoidance system is a safety critical real-time system on any self-driving cars.



The stopping distance depends on the reaction time of the combined object detection system and the onboard automatic breaking system, the speed of travel, and the road condition, see the figure below.

Suppose that the automatic object detection system onboard can detect any unusual obstacle on the road 50 meter ahead. When the brake is fully engaged when the automobile is traveling at 60 km/h, it will take the automobile 30 meters to come to a full stop.

(1) Suppose that the automobile is traveling at 60 km/h, an objective appears ahead, what would be the <u>longest</u> reaction time for the detection and braking system to avoid hitting the object?

(2) Now, in a foggy day, the visibility of the object detection system has reduced to 30 meters, how fast can the automobile travel safely, if the reaction time remains to be the same as that in (1)?

(3) If the road condition becomes slippery due to snow fall or water layer, it will take the automobile 50 meters to stop fully when travelling at a speed of 60 km/h. How fast the automobile can travel safely without hitting a spotted object ahead of the road (assume that the automatic object detection system onboard works normally)?