



*Centre for Research on Embedded Systems (CERES)  
Embedded Systems Programming  
Model Examination, October 13, 2015*

**Instructions.** No reading material, computer or calculator is allowed into the examination; you may only use a paper-based dictionary. The exam comprises 5 questions in 2 pages and will take 3 hours. Before starting to answer the questions, please make sure that your copy is properly printed. Good luck!

**Question 1 (20/100 points).** Explain how reading from memory differs from reading from memory mapped IO (one difference suffices, **(5 points)**), what kind of challenge arises from the differences (mention two challenges, **(10 points)**) and how these challenges can be overcome (mention at least one programming technique, **(5 points)**).

**Question 2 (20/100 points).** Consider the following implementation of a program reading a temperature and a pressure sensor, calculating new goal temperature and pressure values based on the values read from the sensors and controlling a thermostat to reach the goal values.

```
int main() {
    int temp, goal_temp;
    int pres, goal_pres;
    while (1) {
        if (New_Temp) {
            temp = Temp_Data;
            calculate_goal_temp(temp, &goal_temp);
        }
        if (New_Pres) {
            pres = Temp_Pres;
            calculate_goal_pres(pres, &goal_pres);
        }
        control_thermostat(goal_temp, goal_pres);
    }
    return ERR_CODE;
}
```

Criticize and explain what can go wrong with the above-given program (**10 points**).

Re-write this into a program that does not suffer from the problems you noticed (**10 points**).

**Question 3 (40/100 points).** Consider the following specification of 3 periodic tasks.

Task	Execution Time	Period = Deadline
A	22	50
B	5	20
C	3	10

**3.a.** Is this set of tasks schedulable using Rate Monotonic scheduling? Motivate your answer (for your information:  $2^{(1/2)} = 1.4$  and  $2^{(1/3)} = 1.3$ ). **(10 points)**

**3.b.** Show the scheduling of the first instance of A with the first three instances of B and the first 5 instances of C, using both the Rate Monotonic and the Earliest Deadline First algorithm. Assume that the first instance of all three tasks arrive simultaneously. **(15 points)**

**3.c.** Assume that we modify the task set by adding a new task and also relaxing the assumption of Period = Deadline, as follows.

Task	Execution Time	Period	Deadline
A	22	50	20
B	5	20	15
C	2	10	5
D	3	10	10

Analyze whether this task set is schedulable using deadline monotonic scheduling. **(15 points)**

**Question 4 (10/100 points).** Assume that you have two tasks  $Ta_1$  and  $Ta_2$  with the periods  $T_1$  and  $T_2$ , respectively such that  $T_1 < T_2$ . Moreover assume that  $C_1$  and  $C_2$  are their worst-case execution times and  $D_1 = T_1$  and  $D_2 = T_2$  are their deadlines. Show that the worst response time for  $Ta_2$  happens when  $Ta_1$  and  $Ta_2$  arrive at the same time. How many times an instance of  $Ta_2$  should be preempted in such a case? **(10 points)**

**Question 5 (10/100 points).** Explain how an Android application can spawn a new thread and how the worker thread can interact with the activity.