Please work independently on the questions below. Exam is open book/notes. Internet use is allowed, but collaboration is not (including collaboration via online/electronic means). Time: 75 minutes.

Circle the best answer for each of the following questions:

Q1. *Global EDF* is used to schedule independent periodic tasks (with periods equal to relative deadlines) on a multicore system of 32 cores. Assume that the computation time of each task is no larger than its relative deadline. Let us define *global utilization* as the percentage of utilized capacity of the entire multicore system (hence, for example, if one core is fully utilized and the others are idle, then global utilization is 1/32). Of the values of global utilization shown below, choose the *smallest* one at which deadlines *can be missed*.

(a) 0 % **(b)** 3 % **(c)** 10 % **(d)** 55% **(c)** 75%

Q2. Repeat the above question if *partitioned EDF* is used.

(a) 0 % **(b)** 3 % **(c)** 10 % **(d)** 55% **(c)** 75%

Q3. Consider the system in (Q1) again, where global EDF is used. Additionally, assume that the heaviest task has a computation time that is 40% of its period. Of the values of *global utilization* shown below, what is the *maximum* one at which ***no*** *deadline misses* can occur?

(a) 3.125 % **(b)** 50 % **(c)** 61.25 % **(d)** 67.7% **(c)** 100%

Q4. Which of the following aperiodic task servers results in the *lowest schedulability* for periodic tasks?

(a) Polling **(b)** Deferrable **(c)** Priority exchange **(d)** Sporadic **(e)** Slack stealing

Q5. The *power* consumed by a single core is given by: $Power = 8 f^3 + 2$, where f is the frequency of core (normalized to the maximum frequency). If tasks are I/O bound (dominated by writing data to a slow storage device), which of the settings below will result in *minimum energy consumption* for these tasks when executed on this core?

(a) $f = 0.15$ **(b)** $f = 0.25$ **(c)** $f = 0.33$ **(d)** $f = 0.5$ **(e)** $f = 1$

Q6. Repeat (Q5) in the case where the tasks are *CPU-bound*.

(a) $f = 0.15$ **(b)** $f = 0.25$ **(c)** $f = 0.33$ **(d)** $f = 0.5$ **(e)** $f = 1$

Q7. Assume that the core in (Q5) was used to schedule a large number of small independent periodic tasks with periods equal to their relative deadlines using *EDF scheduling*. The tasks were *CPU-bound*. The total utilization of the task set was 40% when f=1. At what frequency should you run the core if your goal is to *minimize energy consumption while meeting all deadlines*?

(a) $f = 0.25$ **(b)** $f = 0.33$ **(c)** $f = 0.4$ **(d)** $f = 0.5$ **(e)** $f = 1$

Q8. Repeat (Q7), but assume now that tasks are *memory-bound*.

(a) $f = 0.25$ **(b)** $f = 0.33$ **(c)** $f = 0.4$ **(d)** $f = 0.5$ **(e)** $f = 1$

Q9. A core consumes 2.2 Watt when running and 0.2 Watt when in sleep mode. The wake-up cost is 0.2 Joules. What is the minimum sleep interval that must elapse before you overcome wake up cost start saving energy?

(a) 10 ms **(b)** 100 ms **(c)** 200 ms **(d)** 1 s **(e)** 10 s

Q10. A periodic task with a period of 300 ms is scheduled on the core in Q9. The schedule is optimally constructed with energy saving in mind. Of the values of computation time mentioned below, choose the largest value for which non-zero energy savings are possible.

(a) None! Savings are impossible. **(b)** 50 ms **(c)** 110 ms **(d)** 240 ms **(e)** 260 ms

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Good luck!