
Final Exam

Please Read:

This exam consists of 20 (mostly) multiple choice questions. Please send your solutions by email. The email should have the exact subject line: "CS424 FINAL" (in uppercase letters). The first line of the body of the email should be your name and NetID, separated by a comma (e.g., "Tarek Abdelzaher, zaher"). The next 20 lines should contain the question numbers, each followed by a colon, and then the answer (e.g., "1: a", "2: c", "3: 0.113" etc).

Exam is Due by Wednesday, December 18th, 11:59pm central time

Please work on this final independently. The final is open book. Use of books, notes, calculators, laptops, and Internet resources is allowed. Collaboration is **not allowed** (which includes use of electronic communication such as chat, Skype, etc). Please read each question carefully and answer as described above. Do not assume that the answer necessarily needs you to use all the data in the question. One of the hallmarks of knowing your field is to know which pieces of information are pertinent to the problem.

Good Luck!

Final

For each of the following task sets, please indicate the exact worst-case response time of the *lowest priority task* under *rate monotonic* scheduling. In the task sets below, P_i refers to the period of task i , and C_i refers to the execution time of task i . All times are in seconds. If the response time is larger than the period of the task, you can simply say “unschedulable”.

1. Task set #1: $P_1=10, C_1=2. P_2=100, C_2=16. P_3=12, C_3=3. P_4=20, C_4=8$

2. Task set #2: $P_1=5, C_1=3. P_2=41, C_2=15$

3. Task set #3: $P_1=15, C_1=11. P_2=50, C_2=10, D_2=44$

4. Task set #4:

$P_1=50, C_1=3$ (includes a 2 sec critical section protected by semaphore S1)

$P_2=5, C_2=0.5$ (includes two separate 0.5 sec critical sections, one protected by semaphore S1 and one protected by semaphore S2).

The priority ceiling protocol is used.

5. Task set #5: $P_1=50, C_1=19. P_2=20, C_2=10. P_3=15, C_3=2.$

Consider the table below, where rows indicate tasks (smaller task numbers imply higher priority) and columns indicate resources. A cell at row X and column Y is set to 1 if task X uses resource Y . Each resource is protected by its own semaphore. When a task needs resource Y , it executes a Lock(Y) operation. When it is done, it executes Unlock(Y). The priority *ceiling* algorithm is used together with *rate monotonic* scheduling. Indicate which of the lock/unlock sequences below are possible and which are impossible. Assume that each sequence represents all lock/unlock operations that (presumably) occurred. Assume that no other blocking occurs except on the semaphores below.

	Resource R1	Resource R2	Resource R3	Resource R4	Resource R5
Task T1			1	1	
Task T2	1				1
Task T3		1		1	
Task T4	1		1		

6. T4 locks R1, T2 locks R5, T1 locks R3.

a) Possible

b) Not possible

7. T4 locks R1, T1 locks R4, T1 unlocks R4, T4 unlocks R1.

- a) Possible
- b) Not possible

8. T2 locks R5, T1 locks R4, T2 unlocks R5, T1 unlocks R4.

- a) Possible
- b) Not possible

9. A system has an average mean time to failure of 2 years. What are the chances that the system will remain operational for at least six months? (Pick the nearest number to the correct answer)

- a) 17%
- b) 43%
- c) 60%
- d) 78%
- e) 100%

10. Which of the following aperiodic servers has the lowest schedulable utilization bound for periodic tasks?

- a) Polling server
- b) Sporadic server
- c) Slack stealing server
- d) Priority exchange server
- e) Deferrable server

11. In the ACPI standard, P-states refer to:

- a) Processor sleep states
- b) Process scheduler states
- c) Pending states
- d) Power supply states
- e) Performance states

12. A processor uses 50mW of power when running at full speed and 40mW of power when running at half speed. Roughly, what percentage of *energy* is saved on task execution at half

speed compared to full speed, when executing a *memory-intensive* task? (Use negative numbers if it is a net energy loss.)

- a) – 60%
- b) – 30%
- c) 0%
- d) 20%
- e) 40%

13. A processor has a fixed voltage and three alternative clock speeds: 0.8 GHz, 1 GHz, and 1.2 GHz. The processor sleeps when not executing a task. The sleep power consumption and wake-up costs are negligible. Which frequency minimizes the processor's *power* consumption while executing a task?

- a) 0.8 GHz
- b) 1 GHz
- c) 1.2 GHz
- d) It depends on whether it is a CPU-intensive or memory-intensive task

14. The energy consumed in executing a task on a given processor is $E = 250f^2 + 4/f$, where f is the normalized frequency (such that $f=1$ when the processor is running at maximum frequency). Assume that sleep energy and wakeup costs are negligible. At what value of normalized frequency should the processor operate in order to be energy-optimal?

- a) 1
- b) 0.8
- c) 0.6
- d) 0.4
- e) 0.2

15. A processor consumes power at a rate of 2.1 W when active, and at a rate of 0.1 W when asleep. The wake-up cost is 0.2 Joules. If this processor goes to sleep, what is the shortest sleep interval (in ms) such that dropping below it will actually waste more energy compared to not sleeping?

- a) 25 ms
- b) 50 ms
- c) 100 ms
- d) 200 ms
- e) 250 ms

16. You are trying to schedule a single 500ms task on the processor above. The task should execute once within each period of 1 second. It does not matter where the task executes within its period (e.g., it can be scheduled at the beginning, middle, or end, as needed). Taking wakeup cost into account, when an energy-optimal schedule is used, what is the average *power consumption* of the processor (in Watts)?

Answer: _____

17. An avionics system consists of a navigation module with triple-modular-redundancy, followed by a voter. Each instance of the navigation module has *a different implementation* of the same navigation function. The voter compares the answers delivered by the three instances of the navigation module and chooses the majority answer. The system remains operational as long as the voter and at least two of the three navigation module instances are functional. Otherwise a failure is said to occur. Each individual instance of the navigation module has reliability $r_1=0.97$. The voter has reliability $r_2=0.98$. Which of the following answers best approximates the reliability of the entire system? Please choose the closest number to the actual reliability value.

- a) 0.99
- b) 0.98
- c) 0.97
- d) 0.96
- e) 0.95

18. Which of the following scheduling policies has the highest multiprocessor utilization bound for periodic tasks, assuming that, for each task, task execution time is no larger than its period?

- a) FIFO
- b) Partitioned EDF
- c) Global EDF
- d) Shortest job first

19. A border control system uses an array of motion sensors and an array of magnetic sensors, scattered in the desert between two countries, to detect moving vehicles that cross the border. Given the existence of a moving vehicle crossing the border, the motion sensor array detects it with a 90% probability, and the magnetic sensor array detects it with a 70% probability. On average, 1000 moving objects cross the border every year, of which 20 are actual vehicles and the rest are wild animals and random objects carried by the wind. The motion sensor array is

triggered, on average, 100 times a year. The magnetic sensor array is triggered on average 25 times a year. What is the probability that there is a vehicle crossing the border when both arrays fire? (Indicate at least three digits after the decimal point)

Please copy *only the final answer* into the body of the email. It should have the format 0.###, where ### are the three digits after the decimal point.

20. The probability that sensor A detects a target, when a target is present, is approximately 80%. The probability that sensor B detects a target, when it is present, is approximately 60%. The probability that both sensors detect the target, when it is present, is approximately 50%. Which of the following is the *least likely* example of sensors A and B, if both sensors were located at the same place? Hint: Consider whether or not the sensors are independent.

- a) One acoustic and one magnetic sensor
- b) Two acoustic sensors
- c) One magnetic sensor and one camera
- d) One motion sensor and one acoustic sensor
- e) One motion sensor and one magnetic sensor

Thank you!
