CS 424 Final

Instructions: Please work on the final independently. It is due by *11:59pm on Sunday, December 17th.* Please email the answers to zaher@illinois.edu. Make sure that your email subject line is "CS424 FINAL" (please type it exactly, since matching will be done by an automatic filter). The first line of the body of the email should be your full name, followed by a comma and your netID: "<your full name>, <your netID>". In subsequent lines, please answer one question per line in the format: "<#question>) <answer>". Hence, for example:

Tarek Abdelzaher, zaher
1) a
2) c
3) 14
4) d
etc.

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1. The reliability of a component after one month of execution is 60%. What is the (approximate) mean time to failure?

a) 15 days
b) 1 month
c) 2 months
d) 6 months

2. The correctness of a system made of three components (whose individual reliability is less than 100% each) requires that all three components be functional at the same time for the system to work. Which of the following statements best expresses the relation between system reliability and the reliability of its individual components?

a) System reliability is lower than the reliability of each of the individual components
b) System reliability is higher than the reliability of each of the individual components
c) System reliability is equal to the reliability of the weakest link (least reliable component)
d) System reliability will depend on how the components are connected within this system

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In questions 3-7: For each of the following task sets, please indicate whether the task set is schedulable or not using *rate monotonic* scheduling. In the task sets below, Pi refers to the period of task i, Ci refers to the execution time of task i, and Di refers to the relative deadline of task i. All times are in seconds. If Di is not mentioned, assume that it is equal to Pi.

3. Task set #1: P1=10, C1=4. P2=100, C2=7. P3=120, C3=24. P4=230, C4=2

a) Schedulable
b) Not schedulable

4. Task set #2: P1=5, C1=3. P2=110, C2=31, D2=83

a) Schedulable
b) Not schedulable

5. Task set #3: P1=15, C1=11. P2=40, C2=5, D2=34. P3=60, C3=10, D3=44.

a) Schedulable
b) Not schedulable

6. Task set #4:

P1=70, C1=4 (includes a 2.5 sec critical section protected by semaphore S1)
P2=6.3, C2=1.1 (includes two separate 0.5 sec critical sections, one protected by semaphore S1 and one protected by semaphore S2)
P3=25, C3=5 (includes a 3 sec critical section protected by semaphore S2)
Priority inheritance is used.

a) Schedulable
b) Not schedulable

7. Task set #5: Repeat the question for task set #4 in the case where Priority ceiling is used.

a) Schedulable
b) Not schedulable

In questions 8-10: 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 locking/blocking/unlocking occurs except using the semaphore operations listed.

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

8. T1 locks R1, T2 locks R2, T3 locks R4.

a) Possible
b) Not possible

9. T3 locks R5, T1 locks R1, T1 unlocks R1, T3 unlocks R5.

a) Possible
b) Not possible

10. T4 locks R3, T3 locks R4, T2 locks R2, T1 locks R1.

a) Possible
b) Not possible

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11. In the ACPI standard, P-states describe which type of states?

a) States that represent different sleep modes
b) States that represent different scheduling policy selections
c) States that represent different processor frequency/voltage settings
d) Power supply states

12. A processor uses 40W of power when running at full speed and 30W of power when running at half speed. Compared to full-speed execution, roughly what percentage of *energy* is saved when executing a CPU-intensive task at half speed? (Use negative numbers if it is a net energy loss.)

a) 75%
b) 25%
c) 10%
d) –25%
e) –50%

13. Repeat question #12 for the case when the executed task is memory intensive.

a) 75%
b) 25%
c) 10%
d) –25%
e) –50%

In questions 14-16: A system is composed of components A, B, C, D, and E of reliability 0.9, 0.99, 0.999, 0.7, and 0.2, respectively. In each of the questions below, a set of dependencies between these components is indicated. The notation A → B indicates a dependency (B depends on A), such that if component A fails, B also fails. Indicate for each system below whether dependencies are well-formed.

14. Dependencies are:

C → B

B → A

C → D

a) Well formed

b) Not well formed

15. Dependencies are:

B → A

B → C

A → D

a) Well formed

b) Not well formed

16. Dependencies are:

B → D

B → E

D → E

a) Well formed

b) Not well formed

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17. A processor has a fixed voltage and three alternative clock speeds: 0.9 GHz, 1 GHz, and 1.5 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) 1.5 GHz
b) 1 GHz
c) 0.9 GHz
d) 0.9 GHz for memory-intensive tasks and 1.5 GHz for CPU-intensive tasks
e) 1.5 GHz for memory-intensive tasks and 0.9 GHz for CPU-intensive tasks

18. Which of the following aperiodic task servers has the worst utilization bound for schedulability of periodic tasks under rate monotonic scheduling?

a) Polling server
b) Priority exchange server
c) Deferrable server
d) The above three servers have the same bound.

19. The energy consumed in executing a task on a given processor is $E = 4 f^2 + 1/f$, 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) 1/6
b) 1/5
c) 1/3
d) 1/2

20. A component of a control loop is best approximate by the following relation between input, x, and output, y:

$y = 3 x^2$

During normal operation, the value of input to this component ranges between 1 and 1.5. In stability analysis of the overall control loop, which of the following values would be best represent the gain of this component?

a) 1
b) 3
c) 6
d) 9

Good luck