Mechatronics/Software Engineering 4AA4 Midterm Exam

Monday, October 17, 2022 — Duration: 80 Minutes

McMaster University (CAS) — Instructor: Dr. Wenbo He

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This test paper includes 11 pages. You are responsible for ensuring that your copy of the test is complete. Bring any discrepancy to the attention of your invigilator.

Special Instructions:

1. Put all answers on the test paper. Try to keep your answers brief. Use point form if need be.
2. It is an open-note exam.
3. The burden of communication is upon you. Solutions not properly explained will not be considered correct. If we cannot decode "what you wrote, we cannot grade it as a correct answer.
4. For any re-read (re-mark) to occur, answers must be in pen.
5. You may need the following Table of the value of $n\left(2^{1/n}-1\right)$

N	$n\left(2^{1/n}-1\right)$
1	1
2	0.828
3	0.780
4	0.757
5	0.743
6	0.735
7	0.729
8	0.724
9	0.721
10	0.718
∞	0.693

Grading

Section	Grade	
Question #1 – Multiple Choice	20 points	18.5
Question #2 – Short Answer Questions	10 points	10
Total:	30points	28.5

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Question 1: Multiple Choice Questions (20 points)

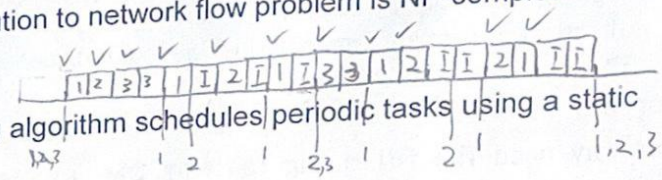
A 1) Given the task set: T1(4, 1); T2(5, 1); T3(10, 2), and you are asked to find a Cyclic Executive (CE) schedule using flow graph. Assume that the frame size is 2. Which of the following is true?

A. There are 11 job nodes and 10 frame nodes in the flow graph.

B. There are 14 job nodes and 11 frame nodes in the flow graph.

C. Using the network flow to model CE scheduling cannot handle the task split in CE.

D. The algorithms finding the solution to network flow problem is NP-complete.



B 2) The _____ scheduling algorithm schedules periodic tasks using a static priority policy with preemption.

A. earliest deadline first EDF dynamic

B. rate monotonic

C. first come first served X

D. priority X

C 3) If a set of processes cannot be successfully scheduled by rate monotonic scheduling algorithm, then:

A. they can be scheduled by EDF algorithm X

B. they cannot be scheduled by EDF algorithm

C. they cannot be scheduled by any other algorithm

D. None of the above

EDF

RM

A 4) Consider the task set T = {(8, 4), (10, 2), (12, 3)}, which of the following is true:

A. T is both RM and EDF schedulable.

B. T is not RM scheduable but EDF schedulable.

C. T is neither RM nor EDF scheduable.

D. T is not EDF scheduable but RM scheduable.

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A 5) A Task set consists of n pre-emptive and periodic tasks. If the task is NOT RM schedulable which of the following can be inferred?
A. The CPU utilization is over 0.693 x
B. The task set is DM scheduable x
C. The task set is EDF scheduable x
D. The CPU utilization is over 1 -0.5.

D 6) What is the output of g value if the following code is given:

```
#include <stdio.h>
#include <pthread.h>

int g = 0;
void *aThread()
{
   g++;
   pthread_exit(NULL);
}

int main (int argc, char *argv[])
{
    int i;
    pthread_t thread[3];
    for (i=0; i<3; i++)
    {
       if( pthread_create( thread+i, NULL, aThread, NULL) )
       {
          printf("ERROR; return code from pthread_create()\n");
          return -1;
       }
    }
    printf("The value of g is %d\n", g);

    return 0;
}
```

A. The value of g is 1
B. The value of g is 2
C. The value of g is 3
D. There is a race condition, so the value of g cannot be determined.

C 7) Which of the following is a drawback of thread programming
A. Context switch time among different threads can be large.
B. Tasks implemented by threads are less efficient than tasks implemented by processes.
C. Without a synchronization, race condition on shared variables can be disastrous.
D. It does not share code among threads in the same process.

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D 8) Which of the following is NOT a reason that a user program rarely makes a raw system call?
A. APIs provided in library achieve better security protection than raw system calls.
B. APIs provided in library is easy to use compared to raw system calls.
C. APIs provided in library has better portability than raw system calls
D. System calls are only available in kernel mode, so a user program cannot access raw system calls.

D 9) With the following code, how many "hello" messages are printed?

```
#include <stdio.h>
#include <sys/types.h>
int main()
{
   fork();
   fork();
   fork();
   printf("hello\n");
   return 0;
}
```

A. 2 B. 4 C. 6 D. 8 E. 10

D 10) Given the following three real-time tasks: T1(1, 6, 2, 8), T2(2, 10, 2, 10), and T3(12, 2, 10) in a system. What is the CPU utilization of the system if no other tasks exist?

A. 65%
B. 69.3%
C. 61.7%
D. 70%

D 11) Which of the following output is not possible?

```
#include <pthread.h>
#include <stdio.h>
#include <stdlib.h>

int MAX = 10;
int count = 0;

void *even(void *arg)
{
   printf("This is even thread()\n");
```

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```
    while(count < MAX)
        if(count % 2 == 0)
            printf("%d ", count++);
    pthread_exit(0);
}

void *odd(void *arg)
{
    printf("This is odd thread()\n");
    while(count < MAX)
        if(count % 2 == 1)
            printf("%d ", count++);
    pthread_exit(0);
}

int main()
{
    pthread_t t1;
    pthread_t t2;

    pthread_create(&t1;, 0, &even;, NULL);
    pthread_create(&t2;, 0, &odd;, NULL);

    pthread_join(t1, 0);
    pthread_join(t2, 0);

    return 0;
}
```

A. 1 0 2 3 4 5 6 7 9 8
B. 1 0 2 4 3 5 6 7 8 9
C. 0 1 2 3 4 6 5 7 8 9
D. 1 0 2 4 5 3 6 7 9 8

0 1 2 3 4 5 6 7 8 9

C (12) In cyclic executive scheduling, which of the following statement is correct.
A. CE scheduling algorithm is based on static priority of tasks. A task's priority is inverse proportional to its period. X
B. A drawback of CE scheduling algorithm is that you have to compute an offline schedule which can be arbitrarily long.
C. The frame size of the CE algorithm cannot be to small since we want an instance of a task is completed within a single frame. ✓
D. The frame size of the CE algorithm cannot be to large, otherwise the computational complexity is too high. X

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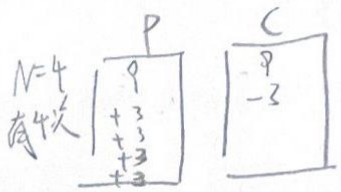
D 13) What is the Output of the following program? Note that the SIGCHLD signal is sent to the parent of a child process when it exits, is interrupted, or resumes after being interrupted.

```
#include<stdio.h>
#include<signal.h>
#include<sys/wait.h>

#define N 4
int val = 9;
void handler(sig) {
  val += 3;
  return;
}

int main() {
  pid_t pid;
  int i;
  signal(SIGCHLD,handler);
  for (i=0;i<N;i++) {
    if ((pid =fork()) == 0) {
       val -= 3;
       exit(0);
    }
  }
  for (i=0;i<N;i++) {
    waitpid(-1,NULL,0); //suspends execution of the calling process until any child has changed state.
  }
  printf("val = %d\n",val);
}
```



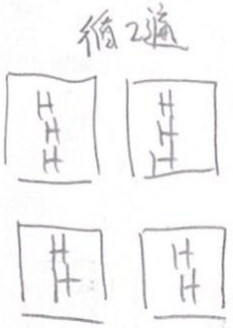
A. 9
B. 12
C. 18
D. 21
E. None of the above

D 14) How many times would "Hello World" be printed?

```
int main()
{
  int i;
  for (i = 0; i < 2; i ++){
    fork();
```

```
  printf("Hello World!\n");
 }
 printf("Hello World!\n");
 return 0;
}
```

A. 4
B. 6
C. 8
D. 10
E. None of the above



B 15) Given the task set: T1(4, 1); T2(6, 1); T3(12, 2). What is the largest suitable frame size f?

A. f=3
B. f=4
C. f=6
D. f=12

A 16) Real-time systems must have _____.

A. preemptive kernels
B. non preemptive kernels
C. memory protection between processes
D. zero interrupt latency

B 17) Given 3 periodic tasks T1, T2, and T3. They have the same execution time, but different periods. If the periods of the tasks are 4, 8, and 16. What is the maximum execution time so that the 3 tasks are RM schedulable?

A. 2 B. 2.28 C. 2.75 D. 3

D 18) Consider n periodic tasks Ti:(p_i, e_i) for $1 \leq i \leq n$, where p_i=2^i, and e_i=1. What is the value of largest n, so that the task set is (Rate Monotonic) RM schedulable?

A. 2 B. 4 C. 8 D. infinity

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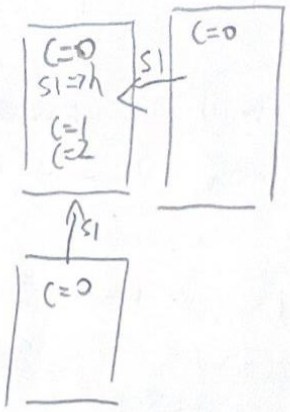
C 19) Which of the following is most likely to be the output of the following code.

```
#include<stdio.h>
#include<wait.h>
#include<signal.h>
pid_t pid;
int counter = 0;
void handler(int sig)
{
   counter++;
}

int main()
{
   pid_t p;
   int status=0;
   signal(SIGUSR1, handler);
   if ((pid = fork()) == 0)
   {
      kill(getppid(), SIGUSR1);
      exit(0);
   }
   if ((pid = fork()) == 0)
   {
      kill(getppid(), SIGUSR1);
        exit(0);
   }
   //Waits for all the child processes
   while ((p = wait(&status)) > 0);
```



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```
    sleep(1);
    printf("Value of counter is %d", counter);
}
```

A. Value of counter is 0

B. Value of counter is 1

C. Value of counter is 2

D. Value of counter is 3

C

20) Which of the following is not a benefit of using kernel module instead of installing all anticipated functionalities into a base kernel?

A. Save memory space ✓

B. No need to rebuilt and reboot the kernel every time ✓

C. Allow preemption

D. None of the above

Question 2: Short Answer Questions:

1. EDF is an optimal uniprocessor scheduling algorithm, why we still prefer RM instead of EDF in many situations? [1 point]

Because the time behavior of a system scheduled by RM is more predictable. As an engineer, we want more predictable results.

2. Design considerations/objectives for a real time operating system are different from those of a general purpose operating system. Please name two of them. [1 point]

The first consideration is for an OS, the design is for time sharing; but for RTOS, it is for event driven
What's more, OS requires maximum throughput but RTOS is for good scheduling
OS wants fast average response time but RTOS wants to meet the deadline of each task

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3. You are required to schedule the following set of independent, preemptable periodic tasks using Rate Monotonic(RM) scheduling algorithm: T1(50; 12); T2(40; 10); T3(30; 10). Use a suitable necessary and sufficient schedulability test to determine if all or part of the tasks can be scheduled. Show your work. [3 points]

By the period T_3 T_2 T_1

Test 1: $\frac{12}{50}+\frac{10}{40}+\frac{10}{30}=0.823<1$ ok

Test 3: when $i=1$, $j=1$, $k=1$ $t=30$.

$W_1(30)=1\times10=10<30$ ok

when $i=2$ $j=1,2$ $k_1=1$ $k_2=1$ $t=30,40$

$W_2(30)=1\times10+1\times10=20<30$ ok

$W_2(40)=2\times10+1\times10=30<40$ ok

when $i=3$ $j=1,2,3$ $k_1=1$ $k_2=1$ $k_3=1$ $t=30,40,50$

$W_3(30)=1\times10+1\times10+1\times12=32>30$

$W_3(40)=2\times10+1\times10+1\times12=42>40$

$W_3(50)=2\times10+2\times10+1\times12=52>50$

∴ it is not RM schedulable

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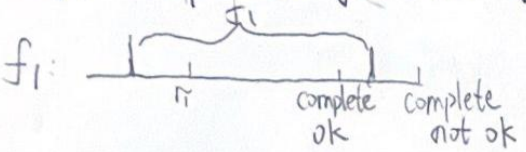
4. In cyclic executive scheduling, why the frame size cannot be too small? and why the frame size cannot be too large? (You can use figure for illustration) [2 points]

If the frame size is too small, a simple instance of a task cannot complete in just one frame

$f \geq \max_{1 \leq i \leq n} e_i$



If the frame size is too large, the release time, deadline may be in the same frame, which is impossible for a task to be released and meet deadline in the same frame.

$2f - \gcd(P_i, f_i) \leq D_i$

5. You are required to schedule the following set of independent, preemptable periodic tasks using Earliest Deadline First (EDF) scheduling algorithm: T1(50; 15); T2(40; 10); T3(30; 10).

(1) Determine if all or part of the tasks can be scheduled. Show your work. [2 points]

(2) Show a feasible schedule using EDF for a period from 0 to 100 seconds if possible. If not, mark when deadline is missed. [1 point]

$\because D_i > P_i \quad \therefore U = \frac{15}{50} + \frac{10}{40} + \frac{10}{30} = 0.88 < 1$

$\therefore$ all parts are schedulable