Question 1

A measured change in output of sensor with a corresponding change in input is:

a) Bias
b) Slew rate
c) Resolution
d) Discrimination
e) c & d ----------------------------------
f) a, c & d
g) None of the above

Question 2

Which of the following can be the cause of a non-zero output with a zero input:

a) **Bias**
b) Non-monotonicity
c) **Offset**
d) Resolution
e) **a & c ---**
f) a, b & c
None of the above

Question 3

What are the 3 sources of possible error in an instrument:

a) Accuracy, discrimination and systematic
b) Accuracy, resolution and Defect
c) Systematic, random and precision
d) Random, systematic & defect
e) None of the above

Question 4

What does NMI stand for?

a) non-machine interrupt
b) non-measurable interrupt
c) non-massive interrupt
d) non-memory interrupt
e) Both a) & b)
f) None of the above ---

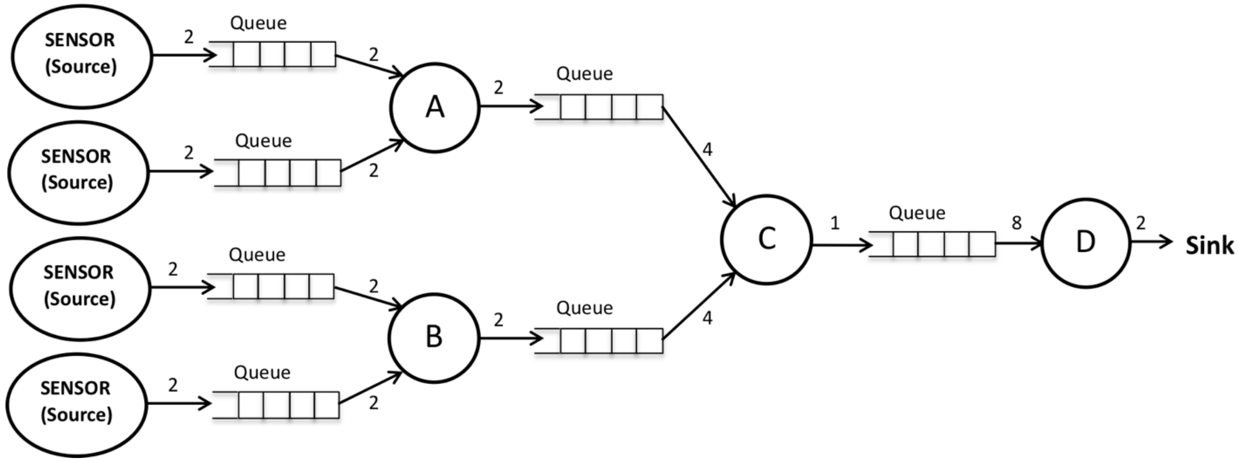
Question 5

Which of the following allows a lower priority task to run despite the higher priority task is active and waiting to preempt?

a) priority message queue
b) priority message passing
c) priority preemption
d) priority inversion --
e) semaphore
f) None of the above

Question 6

Determine the periodic schedule for the following SDF topology:



(8(2AB)C)D
(8(ABABC))D

Question 7

Dataflow definitions – Fill in the underlined sections in the Essay Box below.

Dataflow* Models

- **Definitions**
  - A token is a data value or data structure
  - A signal is a sequence of tokens
  - A node maps input tokens onto output tokens
  - Set of firing rules specify when a node can fire
  - A firing of a node consumes input tokens and produces output tokens
  - A sequence of firings is a dataflow process

Question 8

Given the SDF topology in the previous question determine the energy consumed per periodic schedule.

- A single write operation to a queue consumes: 2.250 nJ/Op
- A single read operation from a queue consumes: 1.340 nJ/Op
- Sensor evaluation: 10.880 nJ/Op
- Node A consumes: 13.440 nJ/Op
- Node B consumes: 15.590 nJ/Op
- Node C consumes: 26.170 nJ/Op
- Node D consumes: 18.910 nJ/Op
- A single write to the output (sink): 1.440 nJ/Op

Determine the energy consumed per periodic schedule.

Sensor (one OP per 2 tokens)			
OP	1	10.88	10.88
Writes	2	2.25	4.50
	SUM		15.38

One NODE A Firing			
OP	1	13.44	13.44
Reads	4	1.34	5.36
Write	2	2.25	4.50
			23.30

One NODE B Firing			
OP	1	15.59	15.59
Reads	4	1.34	5.36
Write	2	2.25	4.50
			25.45

One NODE C Firing			
OP	1	26.17	26.17
Reads	8	1.34	10.72
Write	1	2.25	2.25
			39.14

One NODE D Firing			
OP	1	18.91	18.91
Reads	8	1.34	10.72
Write (sink)	2	1.44	2.88
			32.51

	Number of Firings	Power per firing	Total Power
Sensor	64	15.38	984.32
Node A	16	23.30	372.80
Node B	16	25.45	407.20
Node C	8	39.14	313.12
Node D	1	32.51	32.51
			2109.95

Queue Reads/Writes	Write	Read
A Queue	32	64
B Queue	32	64
C Queue	8	64
D Queue	2	8
Sensor	128	0
SUM	202	200

FIRING SEQ

(8(ABAB)C)D
(8(2AB)C)D
(16(AB))(8C)D

Sensor (one OP per tokens)			
OP	1	10.88	10.88
Writes	1	2.25	2.25
	SUM		13.13

One NODE A Firing			
OP	1	13.44	13.44
Reads	4	1.34	5.36
Write	2	2.25	4.50
			23.30

One NODE B Firing			
OP	1	15.59	15.59
Reads	4	1.34	5.36
Write	2	2.25	4.50
			25.45

One NODE C Firing			
OP	1	26.17	26.17
Reads	8	1.34	10.72
Write	1	2.25	2.25
			39.14

One NODE D Firing			
OP	1	18.91	18.91
Reads	8	1.34	10.72
Write (sink)	2	1.44	2.88
			32.51

	Number of Firir	ower per firir	Total Power
Sensor	128	13.13	1680.64
Node A	16	23.30	372.80
Node B	16	25.45	407.20
Node C	8	39.14	313.12
Node D	1	32.51	32.51
			2806.27

Queue Read:	Write	Read
A Queue	32	64
B Queue	32	64
C Queue	8	64
D Queue	2	8
Sensor	128	0
SUM	202	200

	FIRING SEQ
	(8(ABAB)C)D
or	(8(2AB)C)D
	16(AB))(8C)D

Question 9

The SDF implementation above is powered by a Zinc-Air hearing aid battery that has a capacity of 600 ma-Hour. Nominal cell voltage is 1.65V. Show your work.

a) What is the theoretical peak current the battery can provide during its lifetime?

The lifetime of a battery at peak current levels is defined as 20 hours

600 mA-hour / 20 hours = 30 mA of current

NOTE: Hearing aid cells have a limited current drain; for example an IEC PR44 cell has a capacity of 600 milli-Amp-Hours (mA-H) but a maximum current of only 22 milliamps (mA).

b) How many SDF operations (i.e., periodic schedules) can the battery support during its lifetime?

Recall that 3600 Joule = 1 Watt-Hour (W-H)

The battery can provide:
600 mA-Hour * 1.65 V = .99 Watt-Hour * 3600 Joules/W-H = 3564 Joules

Total number of operations= 3564J/2109.95nj/Op = 1.689*e9 Ops
or
Total number of operations= 3564J/2806.27nj/Op = 1.27*e9 Ops

c) How long will the battery last if the sensors **generate 2 tokens** every milli-second?

Each periodic schedule requires 64 sensor acquisitions. There are 4 sensors in parallel. There are 16 (serial) sensor operations which require 16ms to complete if all of the sensor data is queued in the input queue to node A & B. Therefore there are 62.5 periodic schedules per second.

62.5 Op/sec * 2109nj/Op = 2.109mJ/second

1.689e9 Op * 16e-3 sec/Op = 27.0e6 seconds = 7506 hours
= 312 days 18 hours

Question 10

Which of the following scheduling algorithms are based on the assumption that tasks are executed until they are done?

a) Preemptive scheduling
b) Periodic task
c) **Non-preemptive scheduling** ---------------------------------------
d) Aperiodic task
e) Dynamic scheduler
f) Static scheduler
g) a, b and c
h) a, c and f

Question 11

What is the output of the following code?

```
void main() {
   fork();
   printf("hello poor world\n");
   fork();
   fork();
   printf("hello world\n");
}
```

```
root@ultra96_McD:/root/code/ULTRA/EXAM_1_Q2# more Question_2.c
#include<stdio.h>
#include<wait.h>
#include<unistd.h>
#include<sys/types.h>
#include<sys/wait.h>


void main() {

    fork();

   printf("hello poor world\n");

    fork();

    fork();

    printf("hello world\n");
}


root@ultra96_McD:/root/code/ULTRA/EXAM_1_Q2# ./Question_2
hello poor world
hello poor world
hello world
hello world
hello world
hello world
hello world
hello world
hello world
hello world
```

Question 12

What is interrupt latency? Describe 3 techniques that can be used to decrease it?

Interrupt latency is the time taken by the processing system to respond to an interrupt. Here are a collection of responses from the exam.

1) Minimize the amount of time the CPU runs with interrupts disabled (eliminate spinlocks, etc.).
2) Increase the priority of the interrupt whose latency you want to be lower.
3) Make the top-half of the other interrupt handlers smaller (or lower their priorities, if feasible).

1) Reduce the number of critical sections in your code where interrupts are disabled
2) Give the interrupt handler a higher priority to ensure it gets serviced before other handlers
3) Split long-running interrupt handlers into a top and bottom half, where the top half schedules the bottom half for later, and the bottom half does most of the work while allowing other interrupts to be handled

1) Try to avoid high-latency instructions if possible, such as multiplies and divides, as interrupts can only be addressed once an instruction has finished execution, and multiplies and divides take multiple cycles to finish.
2) Avoid disabling interrupts if possible or minimize the time they are disabled, e.g. disabling interrupts to protect a critical section, as any interrupts will need to wait until interrupts are re-enabled before being responded to.
3) Keep high priority ISRs short, as lower priority ISRs will have to wait (i.e. will have higher latency) until the higher priority ISR completes.