MichiganTech

Spring 2000

BE 306 BioInstrumentation

Final Exam: 18 May 2000, Thursday

This exam:

- Consists of 10 questions,
- Score from this exam will determine 40% of your grade,
- You have 2 hours to complete the exam,
- Closed books, closed notes, but use of calculators is allowed,
- Please mark your answers on the SCORE SHEET using pencils,
- Do not forget to mark your ID NUMBER and TEST FORM code,
- Mark your FAMILY NAME, GIVEN NAME (no middle initials),
- Mark your MTU Student ID number,
- No telephone numbers.

TEST FORM CODE:

GOOD LUCK!

QUESTION 1
4 POINTS

A capacitive sensor was constructed using three parallel plates. The two end plates are fixed, but the center plate is movable by the applied force which is towards the left. If no force is applied, the distance is given by $d_{o.}$ If a force is applied, center plate moves by

$$\Delta d = \frac{F}{K}$$

What is

$$\frac{V_{out}}{V_{in}}?$$

a) $\frac{V_{Out}}{V_{in}} = -\frac{d_0 + \frac{F}{K}}{d_0 - \frac{F}{K}}$ CORRECT ANSWER

b) $\frac{V_{Out}}{V_{in}} = -\frac{d_0 - \frac{F}{K}}{d_0 + \frac{F}{K}}$

c) $\frac{V_{Out}}{V_{in}} = \frac{d_0 + \frac{F}{K}}{d_0 - \frac{F}{K}}$

d) $\frac{V_{Out}}{V_{in}} = \frac{d_0 - \frac{F}{K}}{d_0 + \frac{F}{K}}$

e) $\frac{V_{Out}}{V_{in}} = -\frac{1 + \frac{F}{K}}{1 - \frac{F}{K}}$

QUESTION 2
4 POINTS

A piezoelectric force transducer has the impulse response

$$h(t) = \begin{cases} 0, t < 0 \\ e^{-t}, t \geq 0 \end{cases}$$

In the discrete domain, with a sampling rate of $\Delta T = 0.1$ sec, what is the impulse response?

a) $h(k) = \begin{cases} 0, k < 0 \\ \alpha^k, k \geq 0 \end{cases}$ where $\alpha = e^{-\frac{1}{10}}$ CORRECT ANSWER

b) $h(k) = \begin{cases} 0, k < 0 \\ \alpha^k, k \geq 0 \end{cases}$ where $\alpha = e^{-1}$

c) $h(k) = \begin{cases} 0, k < 0 \\ \alpha^k, k \geq 0 \end{cases}$ where $\alpha = e^{\frac{1}{10}}$

d) $h(k) = \begin{cases} 0, k < 0 \\ \alpha^k, k \geq 0 \end{cases}$ where $\alpha = 0.1$

e) $h(k) = \begin{cases} 0, k < 0 \\ \alpha^k, k \geq 0 \end{cases}$ where $\alpha = -0.1$

QUESTION 3
4 POINTS

If the impulse response for the previous problem was given by:

$$h(k)=\begin{cases}0, k \le 0\\ 1,1 \le k \le 2\\ 0, k \ge 3\end{cases}$$

what would be the response to the pressure waveform shown below:

$$x(k)=\begin{cases}0, k < 0\\ 1,0 \le k \le 1\\ 0, k \ge 2\end{cases}$$

CORRECT ANSWER IS D

a) $y(k)=\begin{cases}0, k<0\\ 1, k=0\\ 2, k=1\\ 1, k=2\\ 0, k>2\end{cases}$ b) $y(k)=\begin{cases}0, k<0\\ 1, k=0\\ 1, k=1\\ 1, k=2\\ 0, k>2\end{cases}$ c) $y(k)=\begin{cases}0, k<0\\ 1, k=0\\ 1, k=1\\ 0, k>1\end{cases}$

d) $y(k)=\begin{cases}0, k\le 0\\ 1, k=1\\ 2, k=2\\ 1, k=3\\ 0, k>3\end{cases}$ e) $y(k)=\begin{cases}0, k\le 0\\ 1, k=1\\ 1, k=2\\ 1, k=3\\ 0, k>3\end{cases}$

QUESTION 4
4 POINTS

A blood flow sensor working with the principles of thermodilution is placed in a blood vessel with a cross sectional area of 1 cm^2. Heater and the temperature sensor are seperated by 2 cm. A 15 Volt supply was connected to a 5 Ω resistor to form the heater element. Temperature sensor was reading 37°C before the heater was turned on and read 39°C one minute after the heat was turned on. What is the blood velocity in the vessel?

1 calorie = 4.19 Joules, density of blood = 1 $gram/cm^3$
Specific heat of blood = 1°C / gram - calorie

a) 45.01 cm/sec

b) 22.51 cm/sec

c) 10.74 cm/sec

d) 5.37 cm/sec CORRECT ANSWER

e) 0.36 cm/sec

QUESTION 5
4 POINTS

If the blood flow velocity was given as 10 cm/sec for the system described above, what is the waveform seen on the temperature sensor when the heating unit is turned on at t = 0 ? (You can ignore the heat capacity of the heater and temperature sensor)

QUESTION 6
4 POINTS

We need an optical encoder used as a 3 bit ganiometer with 45°/bit resolution. Which one of the devices shown below would do the job? Note that the light goes through the holes shown as regions with no shade.

QUESTION 7
4 POINTS

We are measuring the concentration of ions in a solution using the setup shown below. [X] is the unknown concentration of the ions in the solution, and [K] is the known concentration of ions in the reference solution. If the half cell potential of the reaction is given as ε_0, and there is only one electron involved in the reaction, find the relationship between the measured voltage and the ion concentration. Please note that the both electrodes are made out of the same metal.

a) $[X] = [K]\frac{F}{RT}e^{-V}$

b) $[X] = [K]e^{\frac{VF}{RT}}$ CORRECT ANSWER

c) $[X] = [K]\frac{F}{RT}e^{V}$

d) $[X] = V[K]e^{\frac{F}{RT}}$

e) $[X] = e^{\frac{VF}{RT}}$

QUESTION 8
4 POINTS

In a MRI (magnetic resonance imaging) machine, we have

a) three magnetic fields:
a constant one along the z direction with magnitude B_0,
second one applied with the RF pulse, $\Delta B_x(x) = G_z z$, along the x direction
third one applied during reading, $\Delta B_r = G_z z + G_y y$, along the z direction

b) three magnetic fields: (CORRECT ANSWER)
a constant one along the z direction with magnitude B_0,
second one applied with the RF pulse, $\Delta B_z(z) = G_z z$, along the z direction
third one applied during reading, $\Delta B_r = G_x x + G_y y$, along the z direction

c) three magnetic fields:
a constant one along the z direction with magnitude B_0,
second one applied with the RF pulse, $\Delta B_x = G_z z + G_y y$, along the x direction
third one applied during reading, $\Delta B_r(z) = G_r z$, along the z direction

d) three magnetic fields:
a constant one along the z direction with magnitude B_0,
second one applied with the RF pulse, $\Delta B_z = G_x x + G_y y$, along the z direction
third one applied during reading, $\Delta B_r(z) = G_r z$, along the z direction

e) three magnetic fields:
a constant one along the z direction with magnitude B_0,
second one applied with the RF pulse, $\Delta B_x = G_z z + G_y y$, along the x direction
third one applied during reading, $\Delta B_r(x) = G_x z$, along the x direction

QUESTION 9
4 POINTS

An XRAY CT (Computer Tomography) scanner is being used to image the object shown below with density values as specified. Calculate the Radon Transforms along the horizontal and vertical axes.

1	2	3	4
5	6	7	8
9	10	11	12
13	14	15	16

QUESTION 10
4 POINTS

For this problem, assume that the horizontal and vertical radon transforms were given as shown below.

CORRECT ANSWER IS E

Estimate the density values using the summation method of reconstruction.

a)

1	2	2	1
2	3	4	2
2	4	3	2
1	2	2	1

b)

1/8	2/8	2/8	1/8
2/8	3/8	4/8	2/8
2/8	4/8	3/8	2/8
1/8	2/8	2/8	1/8

c)

0	0	0	0
0	0	0	0
0	0	0	0
0	0	0	0

Initial values are chosen as shown above and will be iterated until convergence.

d)

12	17	17	12
17	22	22	17
17	22	22	17
12	17	17	12

e)

12/8	17/8	17/8	12/8
17/8	22/8	22/8	17/8
17/8	22/8	22/8	17/8
12/8	17/8	17/8	12/8