BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-1 B. Sc. Engineering Examinations 2020-2021

Sub: **BME 301** (Bioelectricity)

Full Marks: 210 Time: 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.

1. (a) Consider a short cylindrical segment of a cardiac pacemaker cell of a frog. The segment has a circular cross-section with diameter d (15 μm) and length L (98 μm). The membrane capacitance of the cell is 1.2 μF/cm^2. There is no variation of membrane potential along the axial coordinate. The ionic concentrations, conductance and mobility for different ions are given below: **(25)**

Table for Q. 1(a)

Ionic Concentrations (recorded at 30°C)		
Ions	Intercellular (mM)	Extracellular (mM)
K^+	285	12
Na^+	63	394
Ca^{2+}	0.008	2.4
Cl^-	51	476

$g_k = 0.243$ mS/cm^2 $u_k = 7.62 \times 10^{-4}$ cm^{2}V^{-1}s^{-1}

$g_{Na} = 0.018$ mS/cm^2 $u_{Na} = 5.19 \times 10^{-4}$ cm^{2}V^{-1}s^{-1}

$g_{Cl} = 0.672$ mS/cm^2 $u_{Cl} = 7.91 \times 10^{-4}$ cm^{2}V^{-1}s^{-1}

$g_{Ca} = 2.405$ pS/cm^2 $u_{Ca} = 6.16 \times 10^{-4}$ cm^{2}V^{-1}s^{-1}

(i) Find E_K, E_{Na}, E_{Cl}, E_{Ca}.

(ii) Find the resting membrane potential.

(iii) Find the channel current for all the ion species and state which ions are in equilibrium.

(iv) Draw the equivalent circuit for the parallel conductance model. Clearly label all the components and show their values on your drawing. Also, give the values of all the potentials, with correct polarities, and all the currents, with correct directions.

(v) What is the total capacitance and resistance of the given pacemaker cell? [Assume cell membrane exists only in the curved surface of the fiber]

Contd P/2

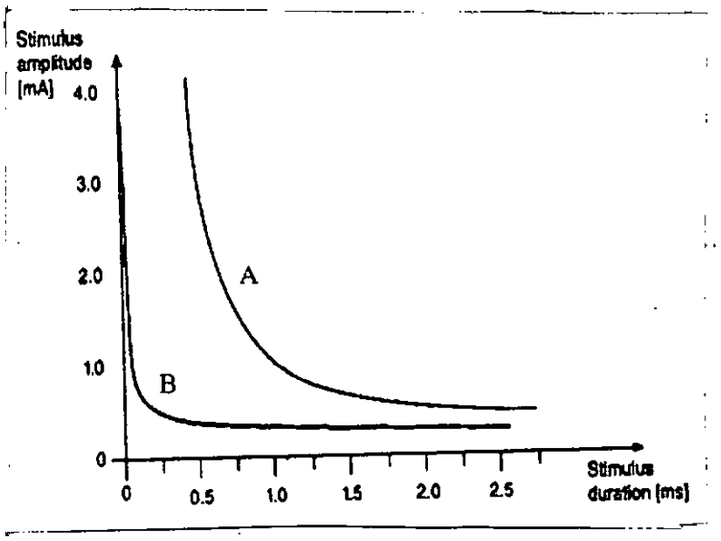
BME 211
Contd... Q. No. 1(a)

(vi) Suppose Ca^{2+} and K^+ channels are blocked with drugs Amlodipine and Repaglinide, respectively. This makes them seemingly absent from the cellular environment. What is the transference number of Cl^-? At 73% dissociation rate, what would be the equivalent conductance of the solution?

(vii) If the membrane thickness is 0.48 Å and the permeability coefficient for Na^+ is 0.03, find the partition coefficient for Na^+ exchange through the channel.

(b) Define rheobase and chronaxie. Figure 1(b) shows two strength-duration curves denoted by A and B. One of them is obtained for a high-speed motor fiber and another is for a low-speed pain receptor fiber. Identify and logically explain which curve represents which fiber. **(10)**

Fig. for Q. 1(b)



2. The tables below show the Hodgkin-Huxley membrane and environmental parameters and initial values of state variables respectively. **(35)**

Table I for Q. 2(a)

Maximum K^+ conductivity	39 mS/cm^2
Maximum Na^+ conductivity	117 mS/cm^2
Leakage conductivity	0.25 mS/cm^2
Membrane capacitance	1.0 μF/cm^2
K^+ Nernst potential	-74.3 mV
Na^+ Nernst potential	+55.2 mV
Leakage Nernst potential	-47.4 mV
Resting potential	-64.5 mV
Stimulus current	0 μA/cm^2
Total membrane current for patch if no stimulus	0 μA/cm^2

Contd P/3

BME 211

Contd... Q. No. 2

Table II for Q. 2(a)

V_m	−11.5	mV	Transmembrane potential
n	0.509	—	gating probability n
m	0.955	—	gating probability m
h	0.104	—	gating probability h

Find V_m^2 for a time step of 72 μs. Assume, $m^0 = m$, $n^0 = n$, $h^0 = h$.

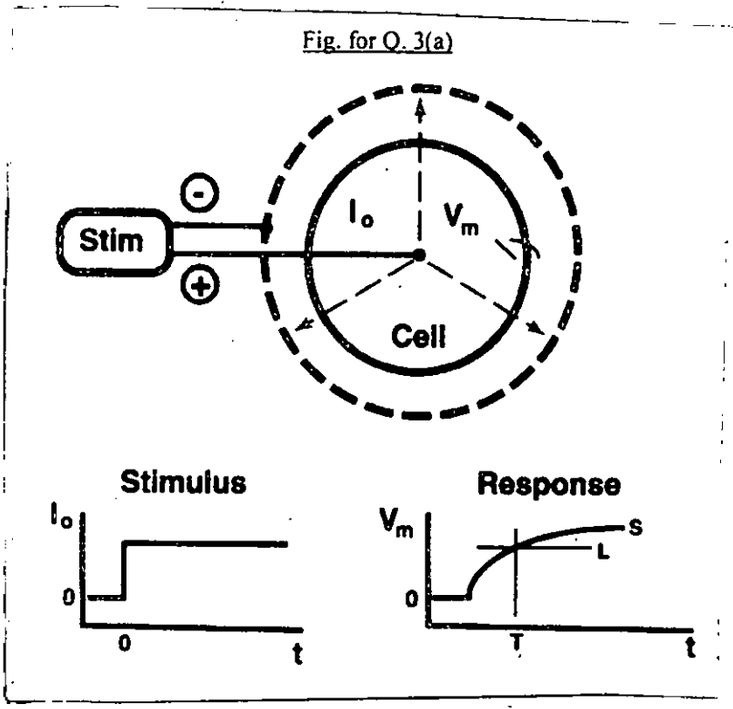
Use the following expressions for the rate constants.

$$\alpha_n = \frac{0.01(10 - v_m)}{\left[\exp\left(\frac{10 - v_m}{10}\right) - 1\right]} \qquad \alpha_m = \frac{0.1(25 - v_m)}{\exp[0.1(25 - v_m)] - 1} \qquad \beta_m = 4\exp\left(-\frac{v_m}{18}\right)$$

$$\beta_n = 0.125\exp\left(\frac{-v_m}{80}\right) \qquad \alpha_h = 0.07\exp\left(-\frac{v_m}{20}\right) \qquad \beta_h = \left\{\exp\left[\frac{(30 - v_m)}{10}\right] + 1\right\}^{-1}$$

3. (a) Figure 3(a) shows the spherical cell model, the simplest way to analyze a cell's response to an external stimulus. If a current step of magnitude I_0 is applied (lower left) indefinitely between the intracellular and extracellular electrodes, a rising transmembrane voltage (V_m) is observe. Assume, the stimulus reaches a threshold voltage level L at stimulus duration T and then gradually reaches at the steady-state and achieves the maximum stimulus strength, S. **(13)**

Fig. for Q. 3(a)



From the relationship between maximum stimulus strength and the threshold voltage, derive the expression for the minimum stimulus duration required for stimulation. Do we observe any difference between the experimental findings and theoretical studies for the spherical cell model? If yes, explain the causes/criteria of the differences briefly.

Contd P/4

BME 211
Contd... Q. No. 3(a)

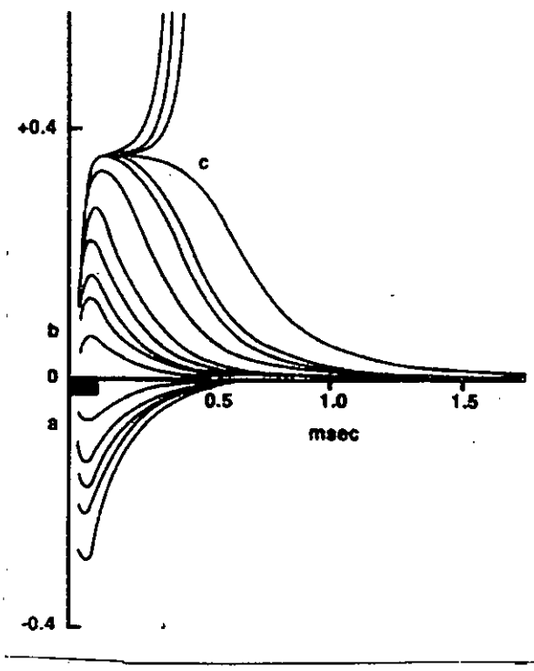
(b) Using Boltzmann's distribution, show that the fraction of open ion channels is give by: **(10)**

$$\frac{[open]}{[open + closed]} = \frac{1}{1 + \exp[(w - z_q q_e V_m)/kT]}$$

where, w is the energy required to open the channel when the transmemberane potential (V_m) is zero, q_c is the charge and z_q is the valence.

(c) The Fig. 3(c) show the subthreshold response recorded extracellularly from a crab axon in the vicinity of the stimulating electrodes. The axon was placed in paraffin oil, and, consequently the measured extracellular potential is directly related to the transmembrane potential (according to the linear core-conductor model). The heavy bar indicates the stimulus period, which was approximately 50 μs in duration. With reference to the figure, explain the membrane response to an increasing stimulus. **(12)**

Fig. for Q. 3(c)



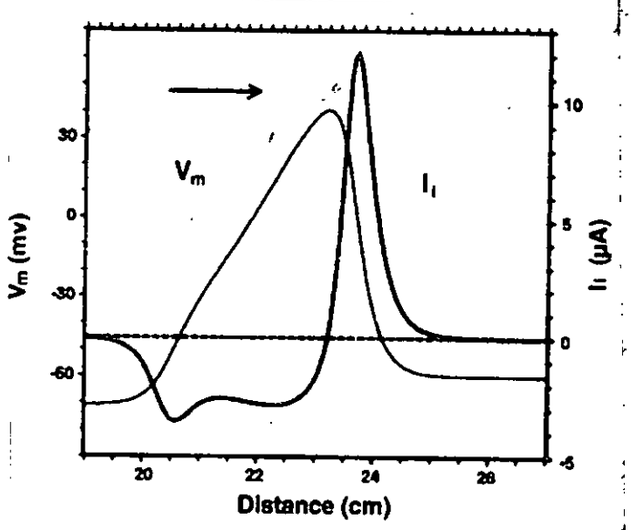
4. (a) What is core-conductor model? How does it alter for subthreshold and trans-threshold conditions? Using the core-conductor model, derive the relationship between axial currents & transmembrane potential and explain the plot shown in Fig. 4(a). **(15)**

Contd P/5

BME 211

Contd... Q. No. 4(a)

Fig. for Q. 4(a)



(b) Suppose a single small electrode is placed in the bounded extracellular space just outside a cylindrical fiber, while a pair of electrodes to remove the current lie extracellular at ±∞. Suppose the fiber is at rest, infinitely long, the location of the proximal electrode identifies the coordinate origin (x = 0), and the fiber structure satisfies the assumptions of the core-conductor model. The current entering the preparation from the electrode can be idealized as a spatial delta-function source, that is, (10)

$$i_p = I_0 \delta(x)$$

where,

$$\delta(x) = 0 \text{ for } x \neq 0$$

$$\delta(0) = \infty$$

$$\int_{-\infty}^{\infty} \delta(x)dx = 1$$

The steady state solution of such a system is given by:

$$v_m = -\frac{r_e \lambda I_0}{2} e^{-|x|/\lambda}$$

where,

$$\lambda = \sqrt{\frac{r_m}{r_i + r_e}}$$

V_m = transmembrane
r_e = extracellular resistance
r_m = membrane resistance
r_i = intracellular resistance

Define space constant. Show that, the space constant is proportional to the square-root of the fiber diameter. What can deduced from the steady-state solution of the system?

(c) What are the limitations of the traditional patch-clam techniques? What is voltage - clamp? How does voltage-clamp resolve the issues of patch-clamp? **(10)**

Contd P/6

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**.

5. (a) Suppose you are assigned the task of developing a device that utilizes the body's biopotential to restore the lower limb mobility of a patient with a spinal cord injury. Which biopotential signal will you select for that device? Explain the reasons behind your choice. Also, describe the challenges you will face during handling that signal. **(13)**

(b) Suppose the brick-like heart cell has a length of 0.001 mm with a cross-section of 64 μm^2. If a heart has volume equal to that of a cube of length 8 cm on a side, how many cells are in the heart? Estimate the number of cells as the number required to make the aggregate cell volume equal to 75% of the heart volume. Suppose these cells are placed side by side and excitation moves in the transverse direction with a transverse direction with a transverse velocity of 10 cm/sec. On average, how much time is required for excitation to move from one end to the other end of this cardiac cell arrangement? **(10)**

(c) Write short notes on the following: **(12)**

1. Sliding filament theory
2. Mean cardiac electric axis (CEA)
3. Local field potential (LFP)

6. (a) Suppose you went to get an EEG. You were strictly forbidden by the doctor from moving your eye. But suddenly, you noticed something on the ceiling and also looked at the clock that was placed on your right side. The doctor said that he got some artifacts on your EEG. Why were there artifacts in your EEG? Which electrodes in the 10-20 system were most affected by these artifacts? Schematically depict the bioelectrical processes that produce these artifacts. **(12)**

(b) "The transmitter release arising from nerve stimulation at presynaptic site can be described probabilistically. Since there are a large number of vesicles and the probability of release of any one vesicle is small, the overall response to any stimulus can be described by a Poisson distribution" - validate the statement mathematically. **(12)**

(c) The figure 6(c) depicts the Parallel-Conductance model of postsynaptic membrane of muscle cell. Briefly describe the significance of the switch component in this model. **(4)**

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BME 211

Contd... Q. No. 6(c)

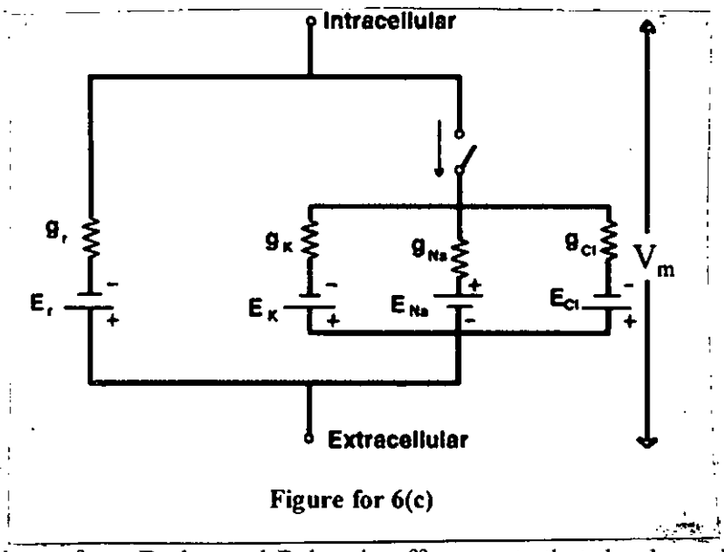

Figure for 6(c)

(d) Expremental evidence from Dodge and Rahamimoff suggests that the dependence of EPP amplitude on $[Ca^{++}]$ can be given by **(7)**

$$EPP\ amplitude = k\left(\frac{\frac{[X_0]}{k_1}[Ca]}{1+\frac{[Ca]}{k_1}+\frac{[Mg]}{k_2}}\right)^4$$

Now show that $(\text{EPP amplitude})^{-1/4}$ is linear with $[Ca]^{-1}$

7. (a) Suppose you only have access to the measurements of the augmented leads (aVR, aVF, aVL). However, for your application, you need the measurement from the limb lead that best represents the bioelectrical changes of the heart. Is it possible to get that lead information from the available augmented leads? If possible, derive it mathematically. **(10)**

(b) "Propagation of neuronal activity (from source to electrode) only occurs as a result of the volume conduction phenomenon." – Do you agree with this claim? Give proper evidence to support your answer. **(13)**

(c) Write short notes on the following: **(12)**

1. Phrenic nerve stimulator
2. Cochlear implants
3. Neural coding

8. (a) Prove that the minimum charge that can be delivered through the electrode (Q_{min}) is 28.06% lesser than the charge needed to stimulate the nerve at chronaxie (Q_{th}). **(12)**

Contd P/8

BME 211
Contd... Q. No. 8

(b) Recent studies have found that a certain type of electrical stimulation can accelerate the wound healing process. Suppose you are assigned to design a rehabilitation device that will be used for wound healing. What factors will you consider when deciding on **(13)**

1. Type of stimulation waveform
2. Electrode material
3. Operating region of the electrode

for this device? Also draw the pulse train that your device will generate.

(c) The figure 8(c) depicts the fast voltage independent chemical synapse. Here the value of g_{syn} (t) follows alpha function: **(5)**

$$g_{syn}(t)\ Ate^{-\frac{t}{t_{peak}}}, t > 0$$

Prove that the conductance reaches its maximum value of g_{syn} (t) = g_{peak} at time peak t = t_{peak}.

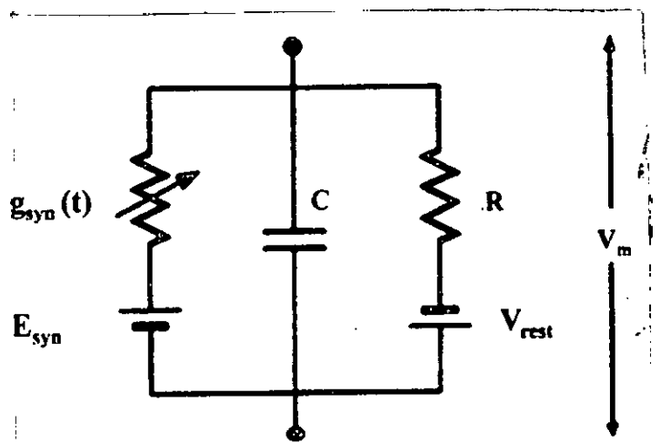

Figure for 8(c)

(d) Figure 8(d) depicts the signals that are collected from the heart. Why are they different in shape? **(5)**

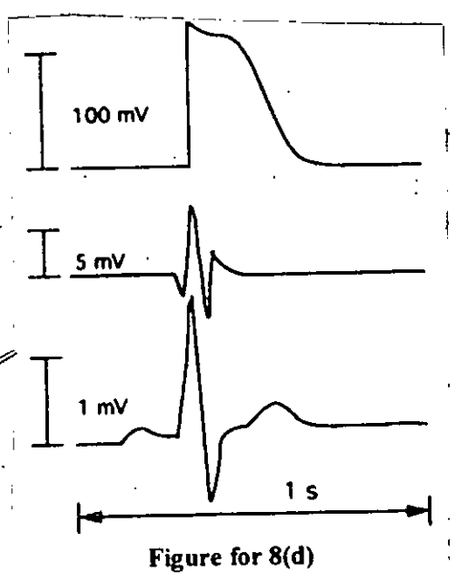

Figure for 8(d)

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BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-1 B. Sc. Engineering Examinations 2020-2021

Sub: **BME 303** (Biomedical Instrumentation and Measurements)

Full Marks: 210 Time: 3 Hours

The figures in the margin indicate full marks

The symbols have their usual meanings.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE** questions.

1. (a) Given an RC circuit where Vin(t) is the input voltage and Vout(t) is the output voltage. Determine the system transfer function H(jω). Now choose the values of C1, C2, R1 and R2 such that the bandpass frequency is 100 Hz to 1 KHz. Sketch the magnitude response. **(12)**

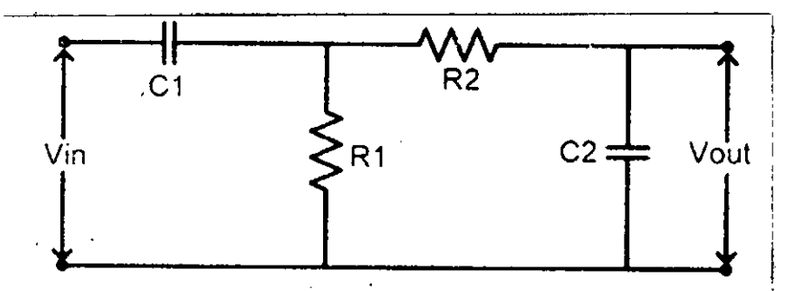

Fig. 1(a)

(b) Explain a technique (feedback) of compensating modifying input with mathematical derivation. **(8)**

(c) For a piezoelectric sensor plus cable that has 1 nF capacitance, design a voltage amplifier by using only one noninverting amplifier that has a gain of 20. It should handle a charge of 1 μC generated by the carotid pulse without saturation. It should have a frequency response from 0.05 to 100 Hz. Add necessary components to achieve the design specifications. **(15)**

2. (a) Suppose you have two strain gage sensors (Fig. 2a): A 2-element strain gage sensor in alternative configuration and a 4-element strain gage sensor. Show with appropriate derivations that the sensitivity of the 2-element strain gage sensor (alt) is ½ the sensitivity of the 4-element strain gage sensor when sensed using a Wheatstone bridge. **(10)**

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BME 303

Contd.... for Q. No. 2(a)

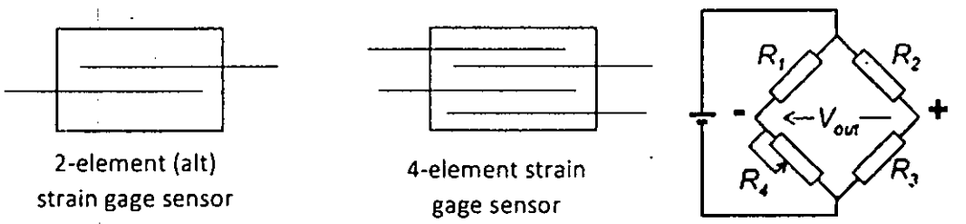


Fig. 2 (a)

(b) Explain the working mechanism of the following blood velocity meters: **(20)**

(i) Chamber plethysmography

(ii) Electromagnetic flowmeter

(iii) Electrical impedance plethysmography

(iv) Photoplethysmography

(c) For a 1 cm^2 capacitance sensor, R is 100 MΩ (Fig. 2(c)). Calculate x, the plate spacing required to pass sound frequencies above 20 Hz. **(5)**

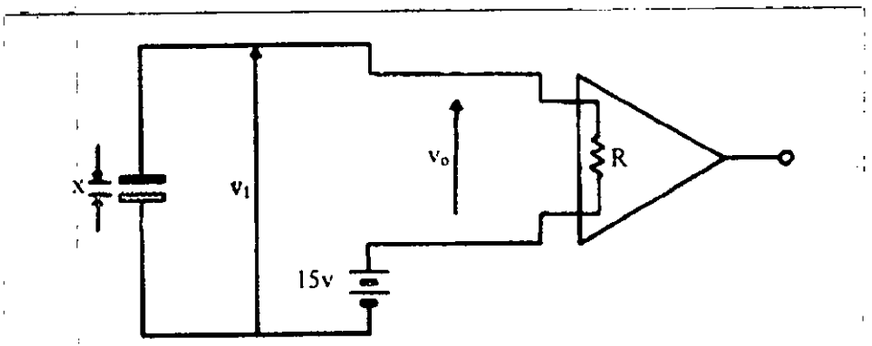


Fig. 2(c)

3. (a) Imagine you want to measure the cardiac output of a patient with indicator-dilution technique that does not require arterial puncture. Explain the technique with a proper equation for calculating cardiac output. **(10)**

(b) Describe the two methods of measuring the system response of a catheter-sensor BP measurement system with necessary illustrations. **(15)**

(c) A patient's cardiac output was measured by thermodilution as 5000 ml/min and the heart rate as 80 (beats/min). Calculate the approximate area of the aortic valve for the patient with the average pressure drop of 7.33 kPa between the aorta and left-ventricular and the ejection period of 0.31 (sec/beat). The density of Blood is 1060 kg/m^3. **(10)**

Contd P/3

BME 303

4. (a) The diagram Fig. 4(a) shows the schematic of a transit time ultrasound flowmeter for measurement of velocity of blood from a blood vessel. Derive a relation between transit time and velocity of the blood stream. **(8)**

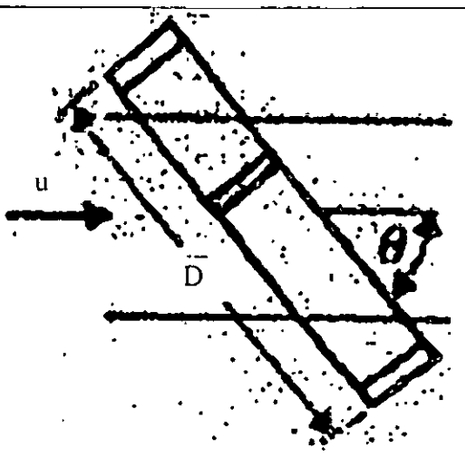


Fig. 4(a)

(b) The diagram Fig. 4(b) shows the schematic of a continuous wave doppler flowmeter for measurement of velocity of blood from a blood vessel. **(7)**

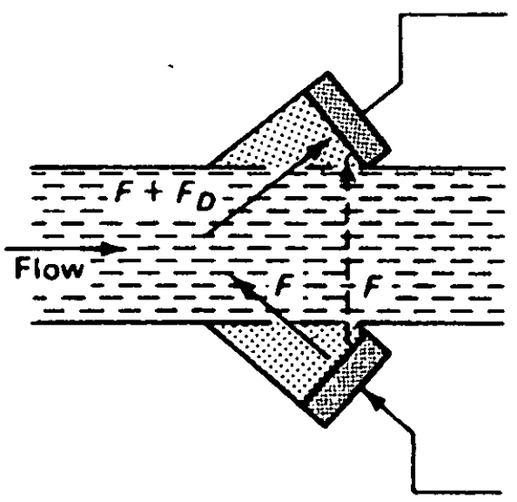


Fig. 4(b)

The transducer source frequency f_0=5 MHz, the transducer angle with the stream is 45°, the ultrasound velocity is 1500 m/s and the Doppler frequency f_d=10 kHz. Determine the velocity of the blood.

(c) Explain the working mechanism of a thermal-convection velocity meter with an appropriate circuit (Wheatstone bridge with noninverting Opamp). **(12)**

Contd P/4

BME 303

Contd.... for Q. No. 4

(d) Given the complete circuit of a photoplethysmography (Fig. 4d). The LED requires a forward current of 15 mA, the phototransistor passes a maximum of 150 μA and the high-pass cut-off frequency should be 0.05 Hz. Now choose the values of R_L, R_0, C_1, and R_1 to achieve the required design specification. **(8)**

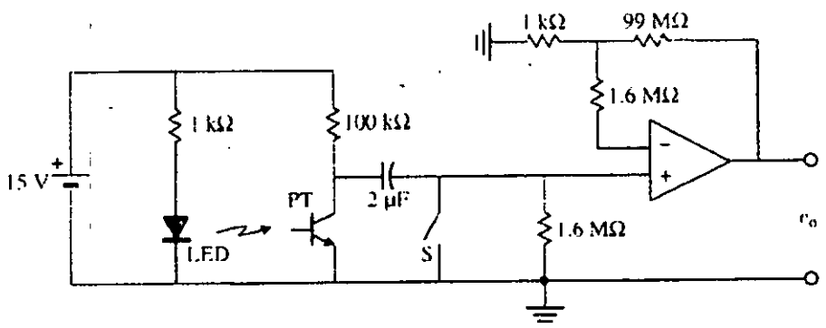


Fig. 4(d)

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE** questions.

5. (a) A pH meter, shown in Figure 5(a), is used to measure acidity level in a sample of blood. One Ag/AgCl electrode is immersed in one chamber with the blood sample at room temperature, and a second Ag/AgCl electrode inside a separate chamber containing a solution of 100 mmol/L HCl in water. The glass membrane separating the two chambers is permeable to H^+ only. For each Ag/AgCl electrode, the half-cell potential is E_{hc} = 0.223 V and the impedance parameters are, R_d = 10 kΩ, C = 1nF, and R_S = 100 Ω. **(12)**

(i) Find the pH inside the second chamber containing HCl.

(ii) The voltage on the electrode in the HCl chamber relative to the electrode in the blood chamber measures –400 mV. Find the pH of the blood sample.

(iii) If the Ag/AgCl electrode in the HCl chamber were replaced with a saturated calomel electrode, how would this affect the measurement of pH? Explain briefly.

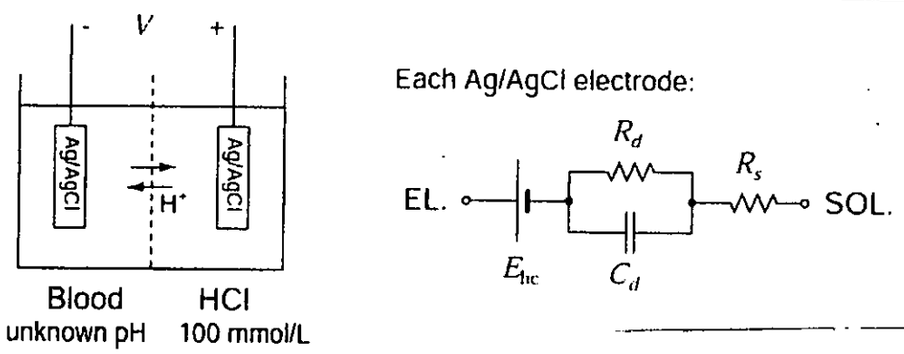


Figure: Question 5 (a)

Contd P/5

BME 303

Contd.... for Q. No. 5

(b) Determine the parameters in the electrode-tissue model from the following experimental observations on the electrode relative to another reference electrode in contact with the same tissue in close vicinity, which has known half-cell potential –150 mV, double-layer capacitance 1 nF, double-layer resistance 25 kΩ, and electrolytic series resistance 3 kΩ: **(15)**

- The voltage measured by a voltmeter between the electrode and the reference electrode is +350 mV.
- The impedance measured by a multimeter between the two electrodes at 0.1 Hz is 102 kΩ.
- The impedance between the two electrodes now measured at 100 MHz is 7 kΩ.
- The transient in the current measured by an ammeter between the two electrodes, for a 100 mV step applied by a voltage source across the electrodes, settles with two-time constants: the shortest one is 25 μs, and the longest one is 70 μs.

(c) What are the major differences between suction electrode and floating electrode? **(8)**

6. (a) Consider the bioinstrumentation amplifier and driven right leg (DRL) system is Figure: Question 6(a) with resistances R_a = 10 kΩ, R_b = 1 kΩ and R_f = 2 MΩ and with electrode resistances R_{RA} = 90 kΩ, R_{LA} = 110 kΩ, and R_{RL} = 100 kΩ. **(15)**

(i) Find the effective resistance between the RL terminal and ground.

(ii) Find the differential gain, A_d, Common mode gain, A_c and Common mode rejection ratio, CMRR.

(iii) Explain the importance of R_o.

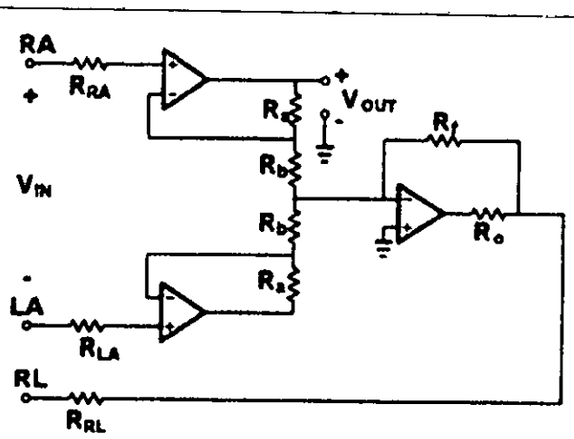


Figure: Question 6 (a)

BME 303

Contd.... for Q. No. 6

(b) An exotic new animal, recently discovered, has an unusual electrolyte makeup. Its major anion is Br^- instead of Cl^- as in the most animals on earth. Scientists tried to measure the EEG of this new animal, which is found to be 25 uV and very noisy if using electrodes made of Ag/AgCl. Can you suggest a better electrode composite and briefly explain why it is better? **(8)**

(c) With a schematic diagram describe a fetal heart rate monitoring system. **(12)**

7. (a) Design a circuit to perform the RBC counting function in a Coulter Counter including the voltage logic. **(12)**

(b) The following table represents the absorptivity of two similar compounds in the substance as a function of wavelength. **(15)**

Compound	500 nm	800 nm
A	3 l/mmol m	2 l/mmol m
B	1 l/mmol m	2 l/mmol m

You test a particular compound and find it to have equal absorbance of 0.1 at 500 nm and 800 nm wavelength, through 1 cm of tissue. Beer's law of volume absorbance:

$$A(\lambda) = W\ L\ a(\lambda)$$

(i) What is the concentration of the combined substance?

(ii) What are the relative amounts of the two compounds?

(iii) What is the isosbestic wavelength for these two compounds?

(c) What are the major advantages and disadvantages of cellulose acetate electrophoresis? **(8)**

8. (a) A power engine receives a lethal macroshock while standing in water and simultaneously touching the ungrounded metal casing on a high-voltage, 60 Hz power transformer. Assume that the resistance of the skin on the engineer's hand is 100 k Ohm and that the resistance of the skin on the engineer's feet is negligible. A capacitance of 25 nF is measured between the transformer casing and the high-voltage conductors. Find the minimal value of the high voltage, assuming that 75 mA is the minimal fibrillating macroshock. Draw an equivalent circuit. **(15)**

(b) A nurse noticed that one electrode of a pair of Ag/AgCl cardiac electrodes used on a chronic cardiac monitor was dirty and cleaned it by scraping it with steel wool (Brillo) until it was shiny and bright. The nurse then placed the electrode back on the patient. How will this procedure affect the signal observed from the electrode and electrode impedances? **(6)**

(c) Draw the block diagram of a basic arrhythmia monitoring system and explain the procedure in brief. **(14)**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-1 B. Sc. Engineering Examinations 2020-2021

Sub : **BME 311** (Biomedical Signals and Systems)

Full Marks : 210 Time : 3 Hours

The figures in the margin indicate full marks.

The symbols have their usual meanings.

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE**.

1. (a) A defibrillator device uses a biphasic signal $f(t)$ on the patient as defined below within the time window $[0, \pi]$. **(25)**

$$f(t) = \begin{cases} \exp\left(-\frac{t}{2}\right); & 0 \le t \le \frac{\pi}{2} \\ -\exp\left(-\frac{t}{2}\right); & \frac{\pi}{2} < t \le \pi \\ 0; & \text{otherwise} \end{cases}$$

(i) Draw the signal $f(t)$.

(ii) Calculate the trigonometric Fourier series of $f(t)$ in the compact form.

(iii) Draw the frequency and phase spectrum.

(b) If the signals $x(t)$ and $y(t)$ are orthogonal with energies E_x and E_y then find the energy of the signals $z_1(t) = x(t) + y(t)$, $z_2(t) = x(t) - y(t)$ and $z_3(t) = x(t)\,y(t)$. **(10)**

2. (a) An EEG machine is used to capture the brainwaves of a sleep study patient. The captured signal is represented by $x(t)$. The various brain-waves are typically defined according to their frequency bands as given in Table 2(a). **(20)**

Table for Q. No. 2(a)

Name	**Bandwidth**
Alpha wave	8-12 Hz
Beta wave	13-30 Hz
Gamma wave	> 30 Hz
Theta wave	4-8 Hz
Delta	< 4 Hz

(i) Design an ideal filter $H(\omega)$ that can be used to extract only the alpha waves. Show its magnitude and phase spectrum.

(ii) Calculate the impulse response $h(t)$ of the filter designed in part (i).

(iii) Modify the filter designed in part (i) so that it is a practical filter. You may make any suitable assumptions about the filter's impulse response.

Note: The bandwidth is provided in Hz, but the Fourier spectrum should be shown in angular frequency (ω).

(b) Prove the time and frequency convolution property of the Fourier transform. **(15)**

Contd P/2

BME 311

3. (a) Derive the equations of Fourier transform for an aperiodic signal. Explain in qualitative terms what the Fourier transform signifies. **(20)**

(b) The Fourier transform of a voltage signal $f(t)$ is given by $F(\omega) = \frac{1}{a + j\omega}$. **(15)**

(i) Compute the inverse Fourier transform to find $f(t)$.

(ii) Considering that the Fourier transform $F(\omega)$ consists of a summation of sinusoids that results in $f(t)$ what is the magnitude of the sinusoidal component of the exact frequency 1 Hz?

If a DC components of 5 V is added to the signal $f(t)$ draw sketch the Fourier magnitude spectrum of the new signal with a DC component.

4. (a) Find the inverse Laplace transform of: **(12)**

$$F(s) = \frac{(s+2)e^{-2s}}{s(s+1)^2}$$

(b) For a causal LTIC system having a transfer function of $H(s) = \frac{1}{s+1}$, find the output $y(t)$ if the input signal is $f(t) = e^{t}u(t) + e^{2t}u(-t)$. **(10)**

(c) Using the Laplace transform, find the system transfer function represented as the differential equation: **(13)**

$$(D^2 + 11D + 24)\,y(t) = (5D + 3)\,f(t)$$

Find $y(t)$ given that $f(t) = u(t)$ and $y(0^-) = \dot{y}(0^-) = 0$.

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**.

5. (a) (i) Write the electrical stimulus, v(t) in terms of unit step and/or ramp functions. **(18)**

(ii) Find v(2-t) and draw the curve.

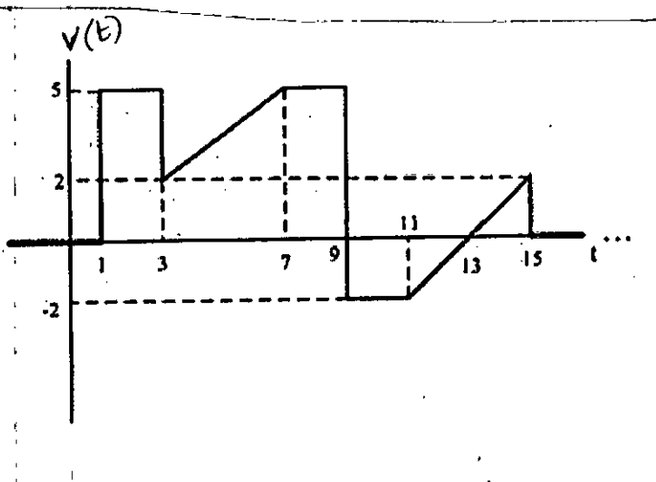


Figure: Question 5 (a)

Contd P/3

BME 311

Contd ... Q. No. 5

(b) Determine whether following signals are energy or power signals and hence find the appropriate value. **(12)**

(i) $x(t) = rect(t)\cos(4\pi t)$

(ii) $x(t) = (2e^{-t} - 6e^{-2t})\,u(t)$

(c) Simplify the following expression: **(5)**

$$\left(\frac{\sin\left[\frac{\pi}{2}(t-2)\right]}{t^2+4}\right)\delta(t-1)$$

6. (a) A simplistic model of an ultrasound field equation may be given by the following differential equation: **(10)**

$$p'''(t) + 3p''(t) - p'(t) - 2p(t) = 3v'(t) - v(t)$$

Where, $p(t)$ and $v(t)$ are the ultrasound pressure and velocity fields, respectively. Draw the Direct Form-I and Direct Form-II realizations of the system.

(b) Use state variable techniques to find the impulse response of the temperature control system in a neonatal incubator. **(20)**

$$w''(t) + 7w'(t) + 12w(t) = r''(t) - 3r'(t) + 4r(t)$$

Where, r(t) and w(t) are the external temperature and the temperature inside the incubators, respectively.

(c) Determine whether the impulse response is invertible or not and find its inverse system. **(5)**

$$h(t) = e^{-t}\,u(t)$$

7. (a) Derive the closed-form expression for the complete response of a viscoelastic muscle system governed by the differential equation: **(15)**

$$\frac{dy(t)}{dt} + y(t) = -\frac{dx(t)}{dt} + x(t)$$

With the initial condition $y(0-) = 3$ and the input, $x(t) = 2\cos(t)\,u(t)$.

(b) Fig. 7(b) shows the lumped-parameter mechanical model of a block of tissue extracted from a cancerous mass (mass, m_m) that is placed on an elastic platform (platform mass, m_t). The malignant tissue is being tested for its mechanical response to a variable force F applied to it. k_m and b represent the elastic stiffness and viscous damping, respectively, of the tissue, whereas k_t represents the elastic stiffness of the platform. x_m and x_t represent the vibrational displacements of the tissue and platform, respectively, in response to F. **(20)**

Contd P/4

BME 311

Contd ... Q. No. 7(b)

(i) Derive the ordinary differential equations that characterize the dynamics of m_m and m_t.

(ii) Develop the electrical analog of this model. Briefly, explain why the various components are in parallel or series. Label the elements.

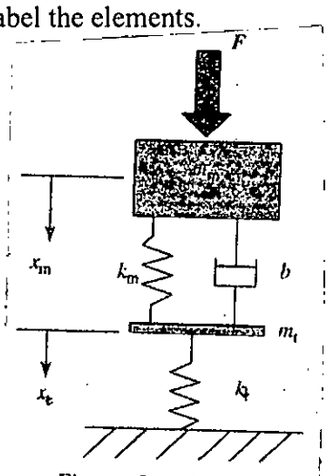


Figure: Question 7 (b)

8. (a) If a simple linear model of the vascular blood flow is assumed, an RLC electrical equivalent can be obtained. Consider a section of arteriole of length, l = 6 cm, diameter, d = 0.1 cm, and vessel wall thickness, h = 0.05 mm. Use $\nu = 0.04$ g cm^{-1}, $\rho = 1.0$ g/cm^3, and $E = 2 \times 10^6$ g $cm^{-1}s^2$. Due to deposits on the vessel, the diameter decreases to 0.08 cm, vessel thickness increases to 0.06 cm, and the Young's modulus, E, increases to 2.5×10^6 g $cm^{-1}s^2$. Calculate the electrical equivalent of this segment of blood vessel in the normal and diseased states. If the input and output pressures to the vessel are $P_1(t)$ and $P_2(t)$, respectively, and are the same in the normal as well as the diseased state, what is the effect of the disease on the flow? Explain these using expressions for the current flow. **(15)**

(b) In coronary circulation the blood vessels within the myocardium are subjected to compressive pressure during systole. Therefore, the coronary network from the coronary artery to the right atrium may be modeled as shown below. Here, $P_a(t)$ is the aortic pressure, and $P_{im}(t)$ is the intramyocardial pressure. **(20)**

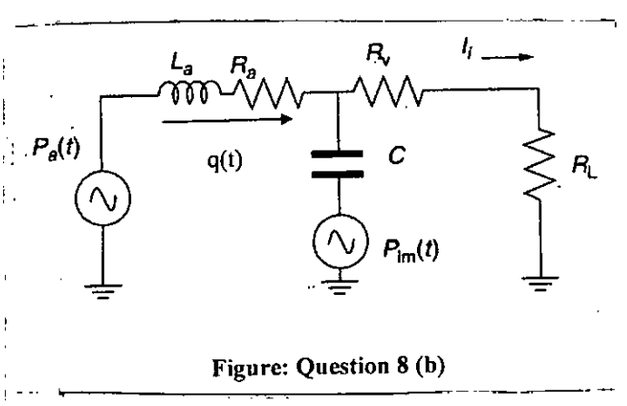


Figure: Question 8 (b)

(i) Obtain an expression for the flow through the vessels, q(t).

(ii) Find the impulse response of the system at rest.

L-3/T-1/BME **Date: 19/10/2022**

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-1 B. Sc. Engineering Examinations 2020-2021

Sub: **MATH 313** (Probability and Statistics)

Full Marks: 210 Time: 3 Hours

The figures in the margin indicate full marks

Symbols used have their usual meaning

USE SEPARATE SCRIPTS FOR EACH SECTION

SECTION – A

There are **FOUR** questions in this section. Answer any **THREE** questions.

1. (a) A company dealing in 60 products, while establishing an inventory control system, classified products according to price as shown in the frequency table below: **(18)**

Unit cost (in hundreds of TK):	3-5	6-8	9-11	12-14	15-17	18-20	21-23
No. of items:	6	8	10	20	8	5	3

Prepare suitable diagram for the distribution on a graph paper. Use the graph to determine second decile (D_2) and eightieth percentile.

(b) The shareholder Research Bureau of Bangladesh recently conducted a research study on the price (Tk.) behavior of three leading industrial shares X, Y, Z for the period 2018 to 2021, the result of which are published as follows in the quarterly journal: **(17)**

Share:	Average Price	Standard Deviation	Current selling price
X:	1800	5.40	36.00
Y:	2250	4.50	34.75
Z:	2400	6.00	39.00

Which share in your opinion appears to be more stable in value?

2. (a) Explain clearly how the Moments help in describing the characteristics of a frequency distribution. Using moments calculate the coefficients of Skewness and Kurtosis from the following distribution and comment on the results obtained. **(18)**

Profits (in Taka):	10-20	20-30	30-40	40-50	50-60
No. of companies:	18	20	30	22	10

(b) The following data related to advertising expenditure (in lakhs of taka) and their corresponding sales (in crores of taka). Find equations of both regression lines, regression coefficients and correlation coefficients between them **(17)**

Advertising expenditure:	10	12	15	23	20
Sales:	14	17	23	25	21

Estimate:

(i) the sales corresponding to advertising expenditure of Tk. 30 lakhs

(ii) the advertising expenditure for a sales target of Tk. 35 crores.

Contd P/2

3. (a) The average zinc concentration recovered from a sample of measurements taken in 36 different locations in a river is found to be 2.6 grams per milliliter. Find the 95% and 99% confidence intervals for the mean zinc concentration in the river. Assume that the population standard deviation is 0.3 gram per milliliter. Show the error in estimating μ by $\bar{x}$ in a figure. (Given that $z_{0.025} = \pm 1.96$ and $z_{0.005} = \pm 2.58$) **(18)**

(b) An experiment is performed to compare the abrasive wear of two different laminated materials. Twelve pieces of material 1 are tested by exposing each piece to a machine measuring wear. Ten pieces of material 2 are similarly tested. In each case, the depth of wear is observed. The samples of material 1 give an average (coded) wear of 85 units with a sample standard deviation of 4, while the samples of material 2 give an average of 81 with a sample standard deviation of 5. Can you conclude at the 0.05 level of significance that the abrasive wear of material 1 exceeds that of material 2 by more than 2 units? Assume the populations to be approximately normal with equal variances. (Critical value of $t_{0.05} = 1.725$) **(17)**

4. (a) Six different machines are being considered for use in manufacturing rubber seals. The machines are being compared with respect to tensile strength of the product. A random sample of four seals from each machine is used to determine whether the mean tensile strength varies from machine to machine. The following are the tensile-strength varies measurements in kilograms per square centimeter $\times 10^{-1}$. Perform the analysis of variance at the 0.05 level of significance and indicate whether or not the mean tensile strengths differ significantly for the six machines. (Given that $f_{0.05} = 3.07$) **(20)**

	Machines					
Seals	1	2	3	4	5	6
I	7.5	16.4	20.3	14.6	17.5	18.3
II	16.9	19.2	15.7	16.7	19.2	16.2
III	15.8	17.7	17.8	20.8	16.5	17.5
IV	18.6	15.4	18.9	18.9	20.5	20.1

(b) Suppose that you wish to test the hypothesis H_0: $\mu = 68$ kilograms, H_1: $\mu > 68$ kilograms for the weights of male students at a certain college, using an $\alpha = 0.05$ level of significance, when it is known that $\sigma = 5$. Find the sample size required if the power of your test is to be 0.95 when the true mean is 69 kilograms. (Critical value of $z = -1.645$ or 1.645) **(15)**

Contd P/3

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE** questions.

5. (a) For special security in a certain protected area, it was decided to put three lighting bulbs on each pole. If each bulb has a probability p of burning out in the first 100 hour of the services, calculate the probability that at least one of them is still good after 100 hours. If $p = 0.3$, how many bulbs would be needed on each pole to ensure 99% safety so that at least one is good after 100 hours? **(12)**

(b) Find the mean and variance of the Binomial distribution. **(13)**

(c) The incidence of occupational disease in an industry is such that the workers have a 20% change of suffering from it. What is the probability that out of six workers 4 or more will contract the disease? **(10)**

6. (a) A book contains 100 misprints distributed randomly throughout its 100 pages. What is the probability that a page observed at random contains at least 2 misprints? **(11)**

(b) Give the statement of the Baye's theorem. Given the probabilities of three events A, B, and C are $p(A)=0.35$, $p(B)=0.45$ and $p(C)=0.2$. Assuming that A, B, and C have occurred, the conditional probabilities of another event, X, occurring are $p(X/A)=0.8$, $p(X/B)=0.65$ and $p(X/C)=0.3$. Find $p(A/X)$, $p(B/X)$ and $p(C/X)$. **(13)**

(c) Write down some important properties of the normal curve. The scores made by a candidate in a certain test are normally distributed with mean 500 and standard deviation 100. What percent of candidates receive scores (i) less than 400, (ii) between 400 and 600? (Necessary table-1 Attached) **(11)**

7. (a) An oil company conducts a geological study that indicates that an exploratory oil well should have a 40% chance of striking oil. What is the probability that the first strike comes on the third well drilled? **(11)**

(b) In a sample of 400 population from a village 230 are found to be eaters of vegetarian items and the rest non-vegetarian items. Can we assume that both vegetarian and non-vegetarian food and equally popular? **(12)**

(Given that for 5% level of significance, z = 1.96)

(c) The probabilities are 0.45, 0.12, 0.25, and 0.18, respectively, that a delegate to a certain convention arrived by air, bus, automobile, or train. What is the probability that among 12 delegates randomly selected at this convention, 3 arrived by air, 3 arrived by bus, 4 arrived by automobile, and 2 arrived by train? **(12)**

Contd P/4

8. (a) To compare the price of a certain commodity in two towns, ten shops were selected at random in each town. The following figures give the prices found. **(15)**

Town A:	61	63	56	63	56	63	59	56	44	61
Town B:	55	54	47	59	51	61	57	54	64	58

Test whether the average price can be said to be the same in the two towns.

(Given that for $v = 18$, $t_{0.05} = 2.10$)

(b) Explain the analysis of variance. The three samples below have been obtained from normal population with equal variances. Test the hypotheses at 5% level of significance that the population means are equal. **(20)**

8	7	12
10	5	9
7	10	13
14	9	12
11	9	14

(The table value of F at 5% level of significance for $v_1 = 2$ and $v_2 = 12$ is 3.88)

For question No 6 (c)

Table 1: Area under the Standard Normal curve from 0 to z.

Z	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
0.0	.50000	.50399	.50798	.51197	.51595	.51994	.52392	.52790	.53188	.53586
0.1	.53983	.54380	.54776	.55172	.55567	.55962	.56356	.56749	.57142	.57535
0.2	.57926	.58317	.58706	.59095	.59483	.59871	.60257	.60642	.61026	.61409
0.3	.61791	.62172	.62552	.62930	.63307	.63683	.64058	.64431	.64803	.65173
0.4	.65542	.65910	.66276	.66640	.67003	.67364	.67724	.68082	.68439	.68793
0.5	.69146	.69497	.69847	.70194	.70540	.70884	.71226	.71566	.71904	.72240
0.6	.72575	.72907	.73237	.73565	.73891	.74215	.74537	.74857	.75175	.75490
0.7	.75804	.76115	.76424	.76730	.77035	.77337	.77637	.77935	.78230	.78524
0.8	.78814	.79103	.79389	.79673	.79955	.80234	.80511	.80785	.81057	.81327
0.9	.81594	.81859	.82121	.82381	.82639	.82894	.83147	.83398	.83646	.83891
1.0	.84134	.84375	.84614	.84849	.85083	.85314	.85543	.85769	.85993	.86214
1.1	.86433	.86650	.86864	.87076	.87286	.87493	.87698	.87900	.88100	.88298
1.2	.88493	.88686	.88877	.89065	.89251	.89435	.89617	.89796	.89973	.90147
1.3	.90320	.90490	.90658	.90824	.90988	.91149	.91309	.91466	.91621	.91774
1.4	.91924	.92073	.92220	.92364	.92507	.92647	.92785	.92922	.93056	.93189
1.5	.93319	.93448	.93574	.93699	.93822	.93943	.94062	.94179	.94295	.94408
1.6	.94520	.94630	.94738	.94845	.94950	.95053	.95154	.95254	.95352	.95449
1.7	.95543	.95637	.95728	.95818	.95907	.95994	.96080	.96164	.96246	.96327
1.8	.96407	.96485	.96562	.96638	.96712	.96784	.96856	.96926	.96995	.97062
1.9	.97128	.97193	.97257	.97320	.97381	.97441	.97500	.97558	.97615	.97670
2.0	.97725	.97778	.97831	.97882	.97932	.97982	.98030	.98077	.98124	.98169
2.1	.98214	.98257	.98300	.98341	.98382	.98422	.98461	.98500	.98537	.98574
2.2	.98610	.98645	.98679	.98713	.98745	.98778	.98809	.98840	.98870	.98899
2.3	.98928	.98956	.98983	.99010	.99036	.99061	.99086	.99111	.99134	.99158
2.4	.99180	.99202	.99224	.99245	.99266	.99286	.99305	.99324	.99343	.99361
2.5	.99379	.99396	.99413	.99430	.99446	.99461	.99477	.99492	.99506	.99520
2.6	.99534	.99547	.99560	.99573	.99585	.99598	.99609	.99621	.99632	.99643
2.7	.99653	.99664	.99674	.99683	.99693	.99702	.99711	.99720	.99728	.99736
2.8	.99744	.99752	.99760	.99767	.99774	.99781	.99788	.99795	.99801	.99807
2.9	.99813	.99819	.99825	.99831	.99836	.99841	.99846	.99851	.99856	.99861
3.0	.99865	.99869	.99874	.99878	.99882	.99886	.99889	.99893	.99896	.99900

L-3/T-1/BME Date: 29/09/2022

BANGLADESH UNIVERSITY OF ENGINEERING AND TECHNOLOGY, DHAKA

L-3/T-1 B. Sc. Engineering Examinations 2020-2021

Sub: **CSE 391** (Embedded System and Interfacing)

Full Marks: 210 Time: 3 Hours

USE SEPARATE SCRIPTS FOR EACH SECTION

The figures in the margin indicate full marks

SECTION – A

There are **NINE** questions in this section. Answer any **SEVEN** questions.

Find the pin configuration of ATmega32 MCU and its different configurations at the end of the questions. If configuration for any of the required registers are missing, just assume a configuration and clearly show the assumed configuration.

1. Briefly discuss five basic components of a Raspberry Pi single board computer **(5×3=15)**

2. Discuss the advantages of using a Printed Circuit Board (PCB) over a breadboard for embedded system. **(15)**

3. Describe the salient features of NRF24L01 transceiver module relevant to wireless communication. **(15)**

4. Let us assume we want to interface a button and an LED with Raspberry Pi in such a way that as long as the button is pressed, the LED will remain lit up. When we remove pressure from the button, the LED will turn off. Let us further assume the button is attached to BROADCOM pin number 7 with a pullup resistor and the LED is attached to BROADCOM pin number 8 with a current limiting resistor. Write a python program for Raspberry Pi to accomplish this task utilizing the RPi. GPIO module. **(15)**

5. (a) Consider that you have configured the ATmega32 ADC with a reference voltage of 4V and ADLAR =1. What is the step size when: **(3×3=9)**

   i) You are only reading ADCH.

   ii) You are reading ADCL first and then ADCH

   iii) You are reading ADCH first and then ADCL

   (b) Suppose, you are using an 8-bit ADC. The reference voltage is set to 3.56V. Calculate the digital values in binary format when the analog input is

   (i) 1.7V

   (ii) 3.2V

Contd P/2

CSE 391/BME

6. Suppose an 8086 system is connected to a keyboard and a printer via an 8255 PPI. The printer is connected to PORT A and operates in double handshake mode. The keyboard is connected to PORT B and operates in single handshake mode. Clearly specify the control register of 8255 to support such configuration. For you convenience, the control register format for I/O mode is given in Figure for Question 6. **(15)**

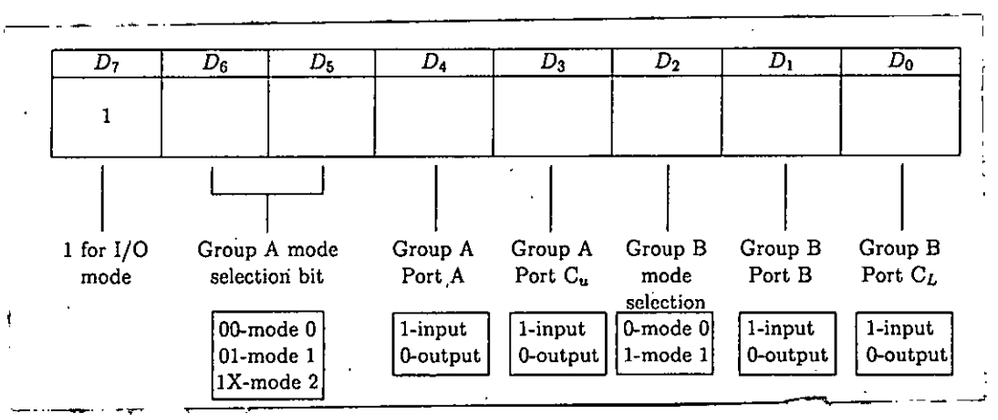


Figure for Question 6: Configuration of Control Register of 8255 PPI for I/O Mode

7. Suppose, 8086 is reading data bytes from a tape reader through Port A of the 8255 using strobed input mode (mode 1). The timing diagram for one byte of data transfer is shown in Figure for Question 7.

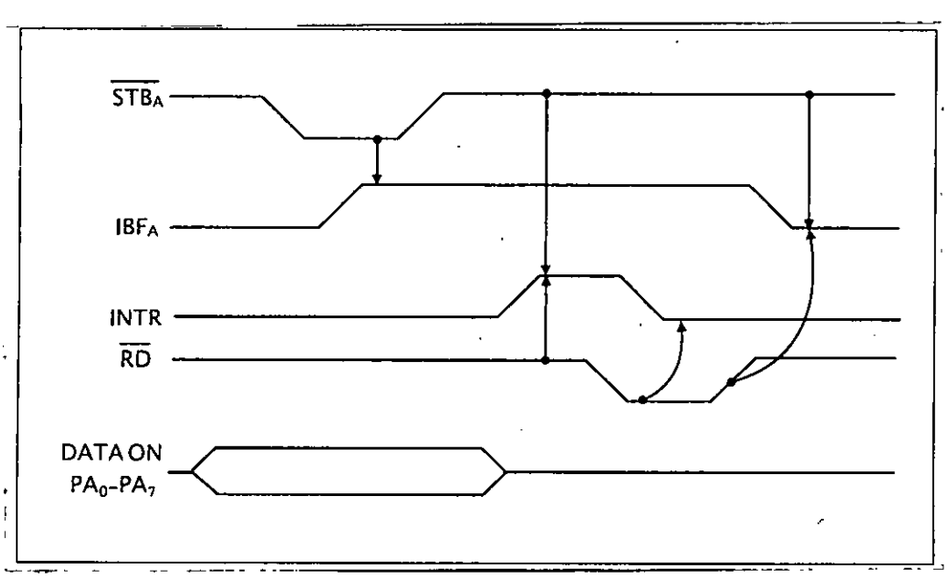


Figure for Question 7: 8255 Timing Diagram.

Contd P/3

CSE 391/BME

Contd... Q. No. 7

Now redraw the same timing diagram in your answer script and mark the first occurrence of each of the following events with the corresponding event ID surrounded by a circle on the timing diagram. **(2.6×5=15)**

Event ID	Event Description
1	8255 loads data into its input latch
2	The typewriter indicates that data is no more valid
3	The typewriter sends data to port's data line
4	8255 forbids the typewriter to send next data
5	CPU starts reading the data
6	8255 informs CPU about the data by generating interrupt signal

8. Suppose for an 8086 architecture, we have the following instruction set.

Instruction Type	Description of Instruction	OPERATING Code
ADD A, B	A = A + B	90
ADD A, immediate	A = A+ immediate	91
SUB B, [address]	A = B - memory[address]	92
MOV A, immediate	A = immediate	93
OR A, B	A = A OR B	94
JMP [address]	The next instruction to be executed is the one written at memory[address]	95

Now consider the following Assembly code.

```
MOV A, 25H
ADD A, B
ADD A, 36H
SUB B, [X]
OR A, B
JMP 1887H
MOV A, 255H
ADD A, 511H
ADD A, B
JMP 1996H
```

You have to write the machine code related to the above assembly code in the 1MB main memory of 8086 in a tabular formation shown below. The Instruction (right) column should contain the machine code to be written while the Address (left) column

Contd P/4

CSE 391/BME
Contd... Q. No. 8

should contain the address of the main memory where you are writing the corresponding code. Your table should have row(s) for each of the given 10 assembly instructions. The values of Code Segment Register and Data Segment Register are 1800H and 9000H respectively and both of the segments are of 64KB of size. Give a probable value of the variable 'X' of the 4th instruction and justify your value picking. **(15)**

Address	Instruction

9. Suppose two Arduino Uno boards are communicating with each other through NRF24L01 transceiver modules. The sender Arduino is continuously reading the value of potentiometer attached to it and sending that to the receiver Arduino. Upon receiving the value, the receiver Arduino continuously prints that to the Serial Monitor. The C program for the sender Arduino based on RF24, RF24Network, and SPI libraries is given in Figure for Question 9. Write down the C program for the receiver Arduino that is compatible with the given program. **(15)**

```
#include <RF24.h>
#include <RF24Network.h>
#include <SPI.h>

RF24 radio(10, 9);              // nRF24L01 (CE,CSN)
RF24Network network(radio);     // Include the radio in the network
const uint16_t this_node = 00;  // Address of this node in Octal format ( 04,031, etc)
const uint16_t node01 = 01;

void setup() {
  SPI.begin();
  radio.begin();
  network.begin(90, this_node); //(channel, node address)
}

void loop() {
  network.update();
  unsigned long potValue = analogRead(A0); // Read the potentiometer value
  RF24NetworkHeader header(node01); // (Address where the data is going)
  bool ok = network.write(header, &potValue, sizeof(potValue)); // Send the data
}
```

Figure for Question 9: C Program for the sender Arduino Uno.

Contd P/5

CSE 391/BME

SECTION – B

There are **FOUR** questions in this section. Answer any **THREE**.

10. (a) Walter is currently working on an amazing embedded systems project. He is planning to use the 8086 microprocessor for his project. While studying the architecture of 8086, Walter is really impressed with segment:offset method for memory addressing. He is fascinated with the concept of overlapping segments but finding multiple logical address from a single physical address seems a bit overwhelming to him. **(10)**

How many representations does the physical address, 2A3B4h have in segment:offset form?

Determine the first five (5) and last five (5) of those logical addresses in segment:offset form. Write the addresses in HESADECIMAL format i.e., AAAAh.BBBBh.

(b) Walter has learned about the following four I/O modes while studying for his project. **(10)**

i. Simple I/O

ii. Simple strobe I/O

iii. Single handshake I/O

iv. Double handshake I/O

Now he is trying to interface a printer with his microprocessor over an unreliable network where he must check the availability of the printer before sending the data and acknowledgement from the printer upon receiving the data. He was wondering which I/O mode to use.

Which data transfer mode should Walter use? Explain the mode with a timing diagram.

(c) Annoyed with printer being so unreliable, Walter has interfaced the printer with the microprocessor through an 8255. So, he need not worry over the availability of the printer. He has planned to assign address 0500H-0503H to the 8255. The timing diagram is shown below. Explain the operations 1, 2, 3, 4, and 5 marked in the following timing diagram. **(10)**

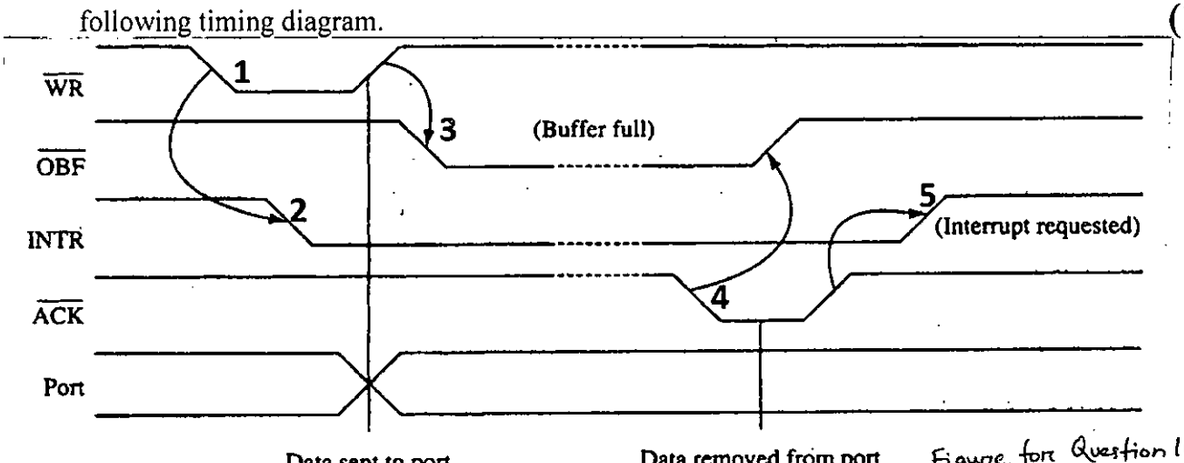


Figure for Question 10(c)

(d) What determines whether a microprocessor is a 16-bit or 32-bit device? **(5)**

Contd P/6

CSE 391/BME

11. (a) O'Brien is interfacing a button with Arduino. He wants to print "Hello, Scorpion!!!!" once for each button press. But he finds that "Hello, Scorpion!!!" is printed multiple times for each press. Explain possible reasons of this incident. **(10)**

(b) What are the various Analog References available to use in Arduino's ADC? What should be kept in mind in case one wants to switch back and forth among them? **(10)**

(c) What is resistive sensor? "Readings from any resistive sensors can be obtained from two different circuit constructions"-do you agree? Justify your answer with necessary diagram. **(15)**

12. (a) Suppose you are using a 128-position OTP digital potentiometer to control the brightness of an LED. This device can communicate with Arduino using 12C protocol. AD0 and AD1 pins are there to control the address of the device. The W pin gives the voltage output according to the value of wiper register and the reference voltage given at A and B pins. How many such devices can be used in a single 12C setup? Construct a circuit which will control the brightness of LED (form darkest to brightest) using this digital potentiometer and Arduino. Also write down the corresponding code. **(3+7+5=15)**

(b) What is ***Clock Stretching*** and ***Repeated Start*** in case of I2C communication? Explain with timing diagrams. **(6+6=12)**

(c) Describe the necessity of using the diode in parallel to the motor (in the following figure). **(8)**

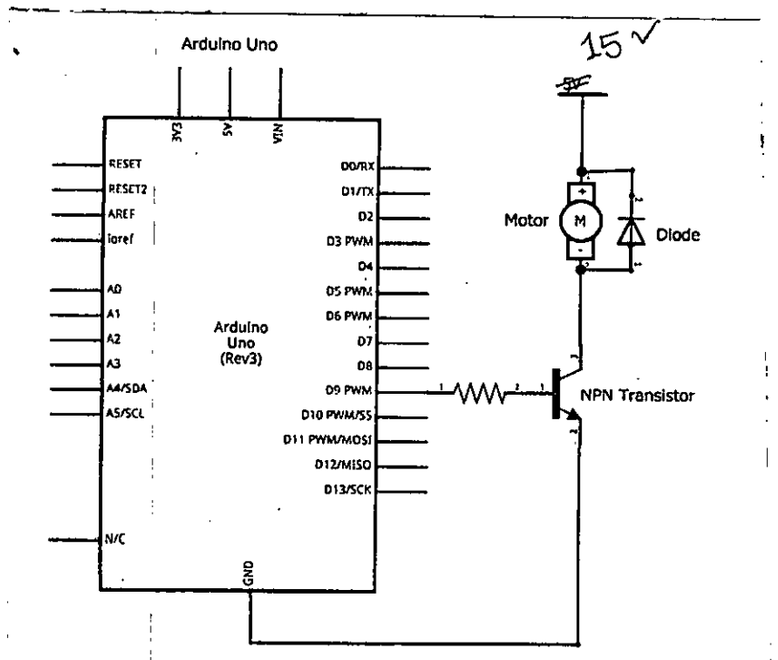


Figure for Question 12(c)

Contd P/7

CSE 391/BME

13. (a) Why partitioning schedulers are needed in RTOS? Explain different types of partitioning schedulers. **(10)**

(b) What is priority inversion and blocking chain? What is the mechanism that RTOS follows to mitigate these phenomena? Explain with necessary timing diagram(s). **(15)**

(c) Morgan has connected two Transmitters and one receiver for communication according to the following figure using the Asynchronous Serial Communication protocol. Will it work properly? Justify your answer. **(10)**

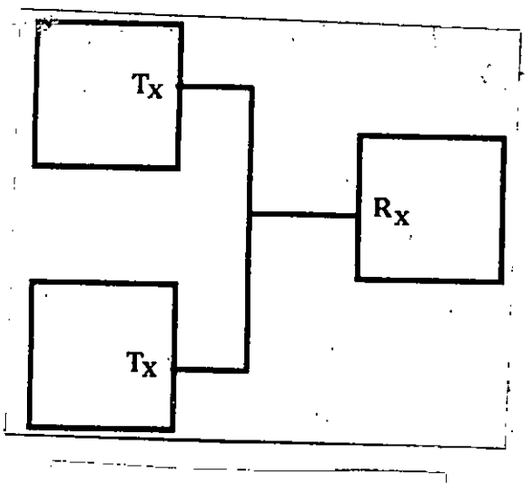
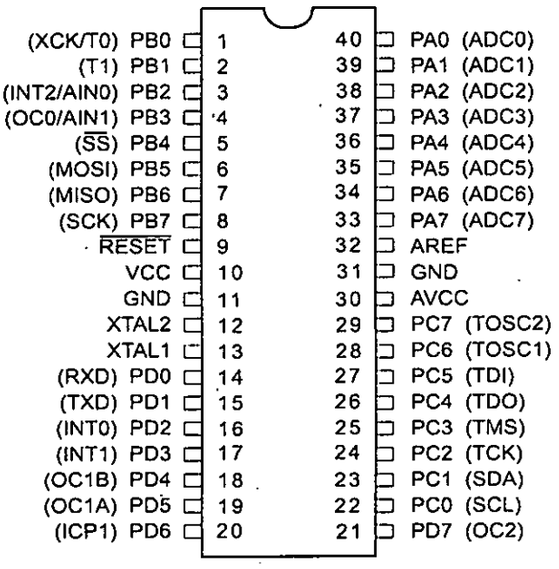


Figure for Question 13(c)

CSE 391/BME



ATMega32 Pin Out

Register Name	Configuration							
GICR	INTF1	INTF0	INTF2	-	-	-	-	-
GIFR	INTF1	INTF0	INTF2	-	-	-	-	-
MCUCR	SE	SM2	SM1	SM0	ISC11	ISC10	ISC01	ISC00
MCUCSR	JTD	ISC2	-	JTRF	WDRF	BORF	EXTRF	PORF
TCCR1A	COM1A1	COM1A0	COM1B1	COM1B0	FOC1A	FOC1B	WGM11	WGM10
TCCR1B	ICNC1	ICES1	-	WGM13	WGM12	CS12	CS11	CS10
TIMSK	OCIE2	TOIE2	TICIE1	OCIE1A	OCIE1B	TOIE1	OCIE0	TOIE0
TIFR	OCF2	TOV2	ICF1	OCF1A	OCF1B	TOV1	OCF0	TOV0
UCSRA	RXC	TXC	UDRE	FE	DOR	PE	U2X	MPCM
UCSRB	RXCIE	TXCIE	UDRIE	RXEN	TXEN	UCSZ2	RXB8	TXB8
UCSRC	URSEL	UMSEL	UPM1	UPM0	USBS	UCSZ1	UCSZ0	UCPOL
SPCR	SPIE	SPE	DORD	MSTR	CPOL	CPHA	SPR1	SPR1
SPSR	SPIF	WCOL	-	-	-	-	-	SPI2X
ADMUX	REFS1	REFS0	ADLAR	MUX4	MUX3	MUX2	MUX1	MUX0
ADCCSRA	ADEN	ADSC	ADATE	ADIF	ADIE	ADPS2	ADPS1	ADPS0
EEARH	-	-	-	-	-	-	EEAR9	EEAR8
EEARL	EEAR7							EEAR0
EEDR	MSB							LSB
EECR	-	-	-	-	EERIE	EEMWE	EEWE	EERE

List of Registers of ATMega32