*Name* : .....

*Roll No.* : .....

*Invigilator's Signature* : .....

**CS/B.TECH (BME)/SEM-3/BME-301/2010-11**

# 2010-11

## BIOPHYSICAL SIGNALS & SYSTEMS SIMULATION

*Time Allotted* : 3 Hours *Full Marks* : 70

*The figures in the margin indicate full marks.*
*Candidates are required to give their answers in their own words as far as practicable.*

### GROUP – A
### ( Multiple Choice Type Questions )

1. Choose the correct alternatives for the following : $10 \times 1 = 10$

   i) A system will be linear of it obeys the principle of
      a) filtering b) superposition
      c) rectification d) none of these.

   ii) Noise in a semiconductor is due to
      a) diffusion of electrons and holes
      b) diffusion of holes and protons
      c) collision of electrons and holes
      d) collision of holes and protons.

   iii) By using negative feedback in a system we can reduce
      a) Noise
      b) Distortion
      c) External sensitivity to system
      d) All of these.

iv) Sensitivity of a system having system Transfer function T & subsystem transfer function G is represented as

a) $S_T^G$ b) $S_G^T$

c) $\left(S^T\right)^G$ d) $\left(S^G\right)^T$.

v) y[n] = x[n] + x[n – 1] + x[n – 2] is a

a) Causal System b) Non-Causal System

c) Stable System d) Both (a) & (c).

vi) The capacitor has

a) No memory b) Memory

c) Both (a) & (b) d) None of these.

vii) To eliminate the interference of power line signal during measurement of Bio-signal we need

a) Low-pass Filter b) High-pass Filter

c) Band-pass Filter d) Notch Filter.

viii) Average frequency range of P.C.G. signal is

a) 0·5 Hz – 30 Hz b) 0·05 Hz – 100 Hz

c) 4 Hz – 250 Hz d) 80 Hz – 3 kHz.

ix) In cardiovascular system the electrical equivalent of pressure drop across a blood vessel is

a) Charge b) Voltage

c) Current d) Capacitance.

x) If $f_c$ be the central frequency, $f_L$ be the low cut-off frequency and $f_H$ be the high cut-off frequency of a band-pass filter then the Q-factor this filter is defined as

a) $f_c/(f_H - f_L)$ b) $f_c/(f_H + f_L)$

c) $f_c/(f_H \times f_L)$ d) $(f_H - f_L)/f_c$.

## GROUP – B

### ( Short Answer Type Questions )

Answer any *three* of the following.

$3 \times 5 = 15$

2. Show that in a two stage cascade amplifier the equivalent noise factor ($F_n$) is defined as $F_n = F_1 + (F_2 - 1)/A_1$. Where $F_1$ and $F_2$ are the corresponding noise factor of each amplifier and $A_1$ is the gain of the first stage amplifier. 5

3. Prove the following :

a) $\delta[n] = \upsilon[n] - u[n-1]$

b) $u[n] = \Sigma\, \delta[k]$ where $k = -\infty$ to n. $(2\frac{1}{2} + 2\frac{1}{2})$

4. In a resistor, if maximal thermal energy is generated when the ratio of $\omega/\alpha$ is 0·025, then, what is the angular frequency ($\omega$) of the Brownian motion of free electrons ? If the present value of $\omega$ is increased by 2·5 times, then, what is the ratio of $\omega/\alpha$ [$\alpha = 10^{14}$] 5

5. Design an active B.R.F. having gain 5 and $f_H$ = 400 $H_Z$ and $f_L$ = 1*kHz*. 5

6. Briefly discuss the procedure for recording Nerve action with proper diagram. 5

7. What is feedback system ? What is the significance of negative and positive feedback ? Which one you should prefer to use in Bio-physical system and why ?

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## GROUP – C

### ( Long Answer Type Questions )

Answer any *three* of the following. 3 × 15 = 45

8. a) Determine the Fourier Series (FS) representation for the continuous time signal x [t] where,

$x[t] = 3 \cos(\pi t/2 + \pi/4)$

b) In case of recording E.M.G. signal with interfering E.C.G. signal, the frequency bands of the two signals are roughly 40-2000 Hz and 0·05 to 80 Hz respectively. In such situations, what type of filter you should prefer for retaining as much of the E.M.G. signal and why ?

Design that filter with proper circuit diagram.

c) In Bio-potential amplifiers, several amplifiers are used in cascade form those are generating noise to the output signal. Consider a two stage E.C.G. amplifier the gain of the first stage is $A_1$ and that of second $A_2$ and first stage has a total input noise resistance $R_1$, the second $R_2$ and the output resistance is $R_3$. The corresponding noise voltages are $V_{n1}$, $V_{n2}$, and $V_{n3}$ respectively.

Show that the equivalent noise resistance of this E.C.G. amplifier will be

$R_{eq} = R_1 + R_2/A_1^2 + R_1/A_1^2 A_2^2$ 5 + 5 + 5

9. a) With schematic diagram describe the immune response to an infection.

   b) Describe by block diagram, the closed loop operation of the cardiovascular system representing the four chamber of heart.

   c) Develop the equation for the arterial pressure dynamics with its transfer function. 5 + 5 + 5

10. a) What do you mean by modulation of a signal ? Explain it with proper mathematical support. 5

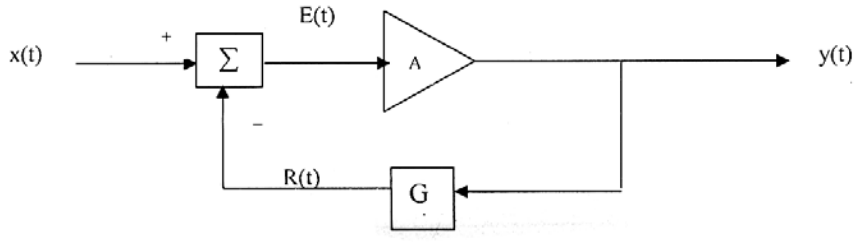
    b) Show that time shifting in time domain signal is equivalent to phase shifting in frequency signal. 4

    c) An LTI system with input x(t) and impulse response h(t) is described by the following differential equation :

    $\frac{dy(t)}{dt} - 3y(t) = 3x(t)$.

    Obtain the transfer function, impulse response, frequency response of the system. 6

11. a) Consider a single loop feedback amplifier, the block diagram of which is shown in the given figure : 7




It consists of a linear amplifier with gain A and a negative feedback, network. The later component feeds a controllable fraction G of the output signal back to the input. It is given that the gain of the amplifier is 1000.

i) Determine the value of G that will result in a closed loop gain T = 3.

ii) Suppose the gain *A* changes by 5%, what is the corresponding % change in the closed loop gain ?

b) What is voltage divider ? Design a circuit to obtain 3V from a 5V power supply. 5

c) The signal $x(t)$ is defined as $x(t) = e_j^{2t} + e_j^{3t}$. Find out the magnitude of $x(t)$ and plot it. 3

12. a) Briefly discuss about the Huxley model of skeletal muscle contraction. 5

b) Draw and discuss the equivalent model of nerve membrane. 6

c) Draw the block diagram of E.M.G. modeling. 4

13. Write the short notes on any ***three*** of the following : $3 \times 5$

a) System memory

b) Time scaling and time shifting

c) Energy signals and power signals

d) Distortion analysis using Feedback system.

e) Properties of Fourier Transform.