Duration: 90 minutes   **Max. Marks: 50**

General Instructions:

1. All questions are mandatory.

2. Write concise answers to the point for both theoretical and numerical questions. Do not write an essay that is irrelevant to what is asked in the theory questions. For numerical questions, mention important steps and do not write the final answer directly.

Q1a. Sketch the waveform of action potential when it is measured from the outer surface of the membrane. Explain the important phases of the waveform.   **[5]**

Q1b. The EEG signals recorded from a subject are shown in the following figure. The following figure represents the anterior-posterior bipolar montage.
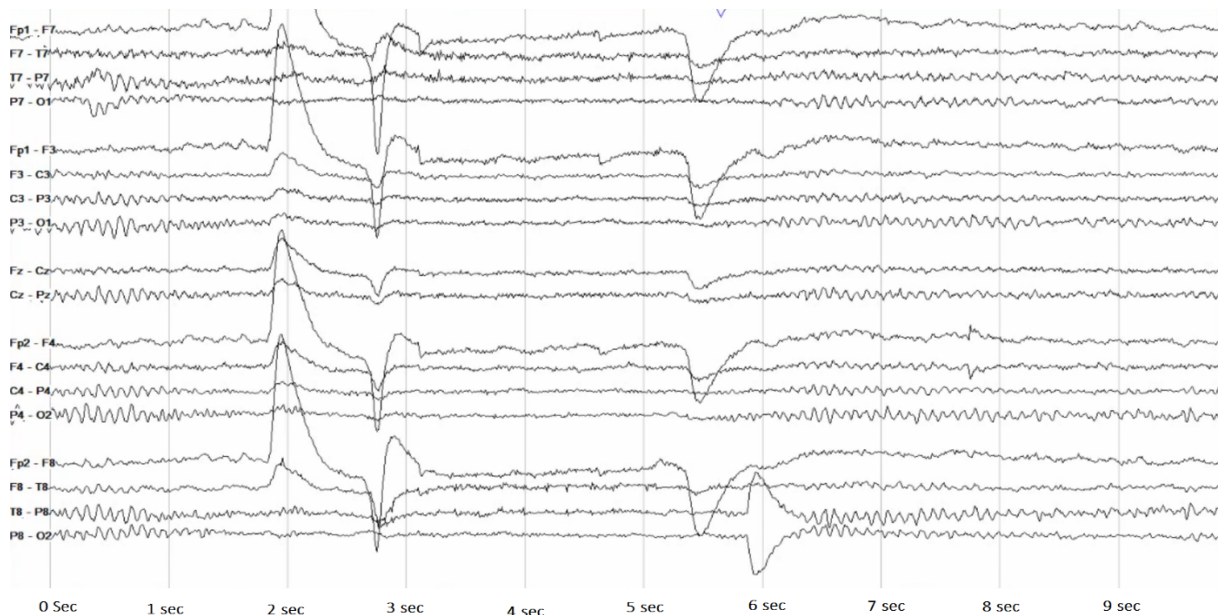
Observe the above figure and answer the following questions with justification.

    i)   Which rhythm of EEG signal is active between 0 and 1 sec?
    ii)   What subject is doing at t=2 sec?
    iii)   At t=2sec, Why the upward deflection of Fz-Cz waveform is less than the upward deflection of Fp1-F3
    iv)   What subject is doing between 5 sec and 6 sec?
    v)   Between 3 sec and 5 sec, the subject is looking at something. True or false. Give reason in support of your answer.   **[1×5]**

Q2a A stochastic process $x(t)=\cos(2\pi Ft+\theta)$ is defined. Here, F and θ are statistically independent random variables. The θ is uniformly distributed over $[-\pi,\pi)$ and F can assume one of the values 1, 2, or 3 with equal probability. A random process y(t) is generated through following process:
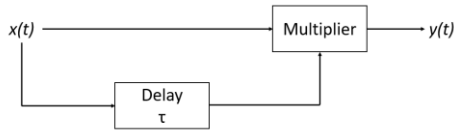
Where delay block provides the delay of τ to the input signal and multiplier block multiplies the input signals. Compute the mean of output y(t). Is x(t) is wide sense stationary process? Give reason. **[5+2]**

Q2b Sketch the autocorrelation waveform of a white noise. Explain the waveform. **[1+2]**

Q3a The short time Fourier transform (STFT) of a speech signal is shown in the following figure. In the given STFT, the time span Δt=10 sec and frequency span Δf=10 Hz.
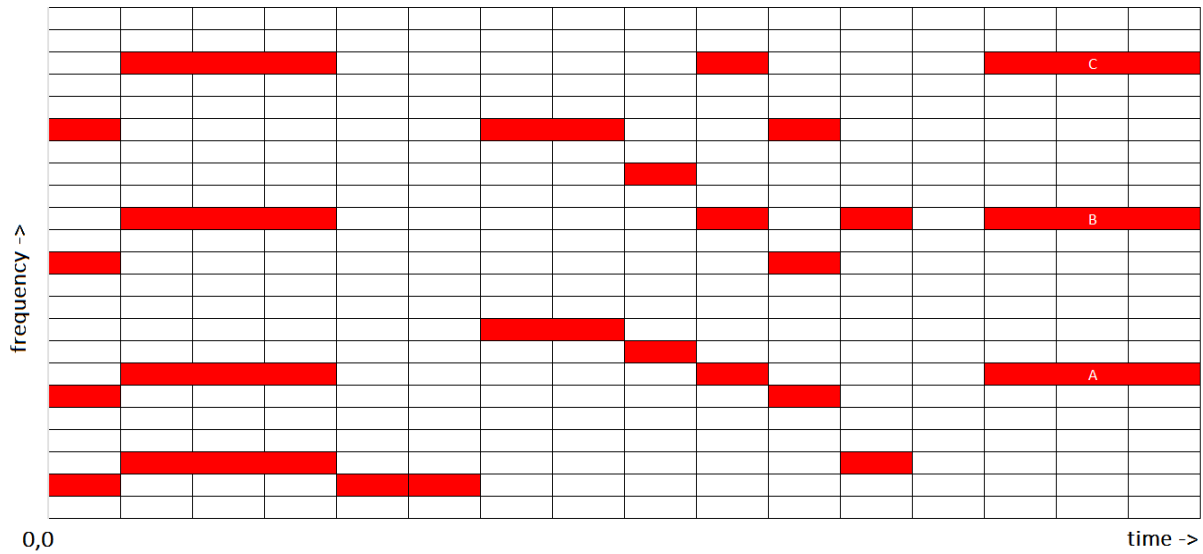
Observe the above STFT and answer the following questions with justification.

    i)   What is the Pitch range between 0 sec to 40 sec?
    ii)   What signal is present between 111 sec and 120 sec and between 21 Hz and 30 Hz?
    iii)   What is the relation between signals A, B, and C?
    iv)   Between 41 to 60 sec, is the speaker is speaking or he/she is quiet? Give reason.
    v)   Speaker is male or female? **[1×5]**

Q3b Obtain a digital filter $H(z)$ from analog filter $H_a(s) = \dfrac{4s}{s^2+0.4s+2}$ when sampling rate is $T = 2$sec. Write $H(z)$ in terms of z^{-k} (k is integer) and in sum of product form. [Note: Do not consider $T = 1$ sec in your solution] **[5]**

Q4 Develop the LMS algorithm using steepest descent method and setting the cost function $J(n) = e^2(n)$, where $e(n)$ is the difference between desired signal and filtered output. **[10]**

Q5a What will be the effect on Wiener filter with steepest descent algorithm if error $e(n) = y(n) - d(n)$. Here, $d(n)$ is the desire response and $y(n)$ is the output of the filter. **[5]**

Q5b A signal $x(t) = A$ for $0 \le t < 0.5$ sec, $x(t) = B$ for $0.5 \le t < 1$ sec and $x(t) = Ct$ for $2 \le t < 3$ sec. The value of A is half of the value of B. Only mother Haar wavelet (H(1,0)) is used to analyse this signal. After analysis, the obtained wavelet coefficients are -0.5 and 0.2 corresponding to H(1,0) and H(1,2), respectively. Determine the value of A, B, and C.

[1+1+3]