REG.NO.: 24BHT0014

VIT
Vellore Institute of Technology
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SCHOOL OF HEALTHCARE SCIENCE AND ENGINEERING
CONTINUOUS ASSESSMENT TEST -II
FALL SEMESTER 2025-2026

SLOT: A2+TA2

Programme Name & Branch	: B.Tech BHT
Course Code	: BHST202L
Course Name	: Signal Processing for Healthcare application
Faculty Name(s)	: Dr. Kishor Lakshminarayanan
Class Number(s)	: VL2025260100963
Date of Examination	: 17/08/2025
Exam Duration	: 90 minutes

Maximum Marks: 50

Q. No	Question	Marks
1.	You decimate a 64-channel EEG from Fs = 960 Hz to 240 Hz using pop_resample(EEG, 240). The anti-aliasing low-pass uses a Hamming window. Assume the passband edge is ≤ 100 Hz and the stopband edge ≥ 120 Hz. Use the rule of thumb N ≈ 3.3·Fs/Δf taps with Δf the transition width. a) What is the new Nyquist after resampling? b) Using the original sampling rate in the rule, estimate N (taps). c) Compute the group delay in milliseconds referenced to the resampled signal (i.e., convert the linear-phase delay to ms at 240 Hz). Then, if you epoch into 1.5 s segments after resampling, what minimum symmetric padding (samples at 240 Hz) would you apply on each side to avoid edge distortion?	10
2.	Design a 0.5–45 Hz band-pass for EEG at Fs = 600 Hz with 2 Hz transitions on both edges (Hamming, linear phase). Use N ≈ 3.3·Fs/Δf. a) Approximate orders (taps) for the high-pass (cut-in 0.5 Hz, Δf = 2 Hz) and low-pass (cut-out 45 Hz, Δf = 2 Hz). b) If implemented as a cascade HP → LP, give the total group delay in samples and milliseconds. c) Your analysis uses 1.5 s epochs. Is this filter practically feasible on epoched data with 2 Hz transitions? If not, propose one concrete redesign (e.g., new Δf, multi-stage approach, or continuous-then-epoch workflow) and re-estimate the dominant delay with your new Δf (show the updated N and delay numbers).	10
3.	You have 72 channels. You remove 3 bad channels (now 69). ASR then reduces the data rank by 4. You perform average reference and run runica. ICLabel flags 9 components as muscle (probability > 0.9). a) What is the effective data rank entering ICA? b) If ICA returns one component per retained rank, what percent of components is removed when rejecting those 9 ICs? c) Suppose instead of average reference you use linked-mastoids reference (two physical reference electrodes combined). Explain quantitatively how this choice affects the data rank and the number of recoverable ICs compared to average-reference in this setup. State any assumptions clearly.	10

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4.	You record surface EMG at Fs = 2500 Hz for 45 s. After full-wave rectification, you compute moving RMS with 40 ms windows and 10 ms hops. a) How many samples per window and per hop? b) How many RMS frames are produced over 45 s? c) A particular window has $\Sigma x^2 = 0.012$ (units: V^2) across its N samples, but you discover a DC offset of +2 mV in that window before rectification. Assuming the RMS should reflect AC power only, recompute the AC-RMS by removing the window mean first (show the formula and numeric value).	10
5.	A 100-sample window of EMG has rectified mean m = 0.012 V. The variance of the unrectified EMG is $\sigma^2 = 2.5\times10^{-4}\ V^2$. Assume the pre-rectified signal is zero-mean and approximately white so $E[x^2] = \sigma^2$. a) Give the moving-average of rectified EMG (use m). b) Compute the RMS of the unrectified EMG in the same window. c) If the pre-rectified EMG were Gaussian with variance σ^2, the theoretical $E[\|x\|] =$ $\sigma\sqrt{(2/\pi)}$. Using the numbers above, compare the theoretical rectified mean to the observed m = 0.012 V and compute the ratio RMS / MA(|x|) for both the theoretical and observed cases. Briefly discuss one reason these ratios might differ in practice.	10