BRAC University

Department of Electrical & Electronic Engineering

Assignment

EEE/ECE282: Numerical Techniques

Question 1 [CO2 (P1, P3)]: **[Marks: 5+15]**

A student is analyzing a voice signal containing frequency components of upto $4\ kHz$. At the time of sampling the signal, s/he chose the Sample Time, $T_s = 0.25\ ms$ and the obtained the following data table:

Table - 1

$v\ (volts)$	0	2.696	3.939	4.511	4.775
$t\ (ms)$	0	0.25	0.5	0.75	1

But according to Nyquist's Sampling Theorem, s/he must sample the signal with a sampling rate of at least twice the maximum frequency component of the signal. So, the sampling frequency must have to be at least $8\ kHz$ and thus the Sample Time, T_s should be $0.125\ ms$, for perfect reconstruction (i.e. the signal values should exist at time $t = 0\ ms, 0.125\ ms, 0.25\ ms, 0.375\ ms, 0.5\ ms$ ... ... and so on).

i. Can you help the student to correct the error? If so, which numerical technique are you going to use? Explain in brief.

ii. Derive the equation of voltage as a function of time considering suitable Numerical approach (use Table – 1). Then, complete the following data table (Table – 2) with the unknown voltage values.

Table - 2

$v\ (volts)$	0	**?**	2.696	**?**	3.939	**?**	4.511	**?**	4.775
$t\ (ms)$	0	0.125	0.25	0.375	0.5	0.625	0.75	0.875	1

Question 2 [CO3 (P1, P3)]: **[Marks: 10+10]**

The next task of the student is to calculate the RMS value of the signal. For any signal $v(t)$, RMS value is defined as:

$$V_{RMS} = \sqrt{\frac{1}{t_2 - t_1} \int_{t_1}^{t_2} v^2(t)\, dt}$$

i. Determine the RMS value of the voltage signal from the completed data table (Table – 2) obtained from Question 1. Which numerical approach would be more appropriate for this scenario to get better accuracy?
If the true value is 3.6908, determine the error of your Numerical approach.

ii. Again, determine the RMS value of the voltage signal from the equation of the voltage obtained from Question 1(ii). Which numerical approach would you choose now to ensure better accuracy?
Considering the true value mentioned previously, determine the error in this case.

Question 3 [CO3 (P1, P3)]: **[Marks: 5+15]**

At the reconstruction process, the voltage is applied across a R-C filter. To determine the current through the capacitor, following equation is considered:

$$i_C(t) = C\, \frac{dv_C(t)}{dt}$$

i. Explain the applicability of different Numerical Differentiation approaches to determine the current from the completed data table (Table – 2) obtained from Question 1.

ii. Considering the value of capacitor C = 10 μF, determine the current for each of the time instants.

If the true values of the current are as follows,

Table - 3

$i_C\ (mA)$	155	105.207	71.409	48.469	32.898	22.330	15.156	10.287	6.983
$t\ (ms)$	0	0.125	0.25	0.375	0.5	0.625	0.75	0.875	1

plot the true current (Table – 3) and your approximated current obtained from Question 3(ii) in the same figure window to make a comparison.

Question 4 [CO2 (P1, P3)]: [Marks: 10]

After running the voice analyzing device for certain duration of time, the student observed that the device started to malfunction. Exploring the datasheet, s/he found that the optimum operating voltage for the device is 3.3V and the maximum voltage that it can sustain for long duration is 4.0V.

With the help of the equation obtained from Question 1(ii), determine the time instant at which the voltage across the device crosses 4.0V, using a suitable Numerical approach.