# 1 Solutions: Lab Assignment-1

## 1.1 Exp-1

**Theory:**

**1. Continuous-Time Sinusoidal Signal:** A continuous-time sinusoidal signal is given by the equation:

$$x(t) = A \cdot \sin(2\pi f t)$$

where: - $A$ is the amplitude of the signal, which determines the peak value. - $f$ is the frequency of the signal in Hertz (cycles per second). - $t$ is the continuous time variable.

This signal is characterized by its periodic nature, where it repeats itself after each period $T = \frac{1}{f}$. The amplitude $A$ determines how "tall" the peaks and troughs of the signal are, and the frequency $f$ determines how many cycles occur in one second.

**2. Discrete-Time Unit Step Signal:** The discrete-time unit step signal, often denoted as $u[n]$, is defined as follows:

$$u[n] = \begin{cases} 1, & \text{for } n \geq 0 \\ 0, & \text{for } n < 0 \end{cases}$$

This signal starts from $n = 0$ and takes on the value 1 for non-negative values of $n$ and 0 for negative values of $n$. It represents a sudden change or "step" in value at $n = 0$, which is why it's called a unit step signal.

**3. Continuous-Time Impulse Signal:** The continuous-time impulse signal, represented by $\delta(t)$, is a mathematical construct known as the Dirac delta function. It has the following properties: - $\delta(t) = 0$ for all $t \neq 0$. - $\int_{-\infty}^{\infty} \delta(t)dt = 1$.

In essence, the impulse signal is "infinitely tall" at $t = 0$ but has an area of 1. It's used to model instantaneous events, like an idealized point force or an impulse in a physical system.

**4. Discrete-Time Exponential Signal:** The discrete-time exponential signal is given by:

$$x[n] = \alpha^n$$

where: - $x[n]$ is the signal value at discrete time $n$. - $\alpha$ is a constant between 0 and 1.

This signal represents exponential growth or decay depending on the value of $\alpha$. If $\alpha > 1$, the signal grows exponentially as $n$ increases. If $0 < \alpha < 1$, the signal decays exponentially as $n$ increases.

## 1.2 Exp-2

**Theory:**

**1. Time Scaling:** When you scale the time variable $t$ of a continuous-time signal by a factor $a$, you get a new signal $x(at)$. The effect of time scaling on the signal depends on the value of $a$: - If $a > 1$, the signal is compressed horizontally (in time) by a factor of $1/a$. The signal will complete a cycle faster. - If $0 < a < 1$, the signal is stretched horizontally by a factor of $1/a$. The signal will complete a cycle more slowly.

**2. Time Shifting:** A time-shifted signal $x(t - t_0)$ is obtained by moving the original signal $x(t)$ horizontally (along the time axis) by an amount $t_0$: - If $t_0 > 0$, the signal is delayed or shifted to the right. - If $t_0 < 0$, the signal is advanced or shifted to the left.

**3. Amplitude Scaling:** Multiplying a continuous-time signal $x(t)$ by a constant $a$ results in an amplitude-scaled signal $ax(t)$: - If $a > 1$, the signal's amplitude is amplified by a factor of $a$. - If $0 < a < 1$, the signal's amplitude is attenuated (reduced) by a factor of $1/a$. - If $a < 0$, the signal's amplitude is inverted (flipped about the x-axis).

**4. Time Reversal:** Reversing the time variable of a continuous-time signal $x(t)$ results in the signal $x(-t)$. This is equivalent to reflecting the signal about the y-axis. The reversed signal represents the original signal ”played backward in time.”

## 1.3 Exp-3

## 3.1 Theory:

**Energy and Power Signals:** The energy $E$ of a continuous-time signal $x(t)$ over the interval $[t_1, t_2]$ is given by $\int_{t_1}^{t_2} |x(t)|^2 dt$. The power $P$ of $x(t)$ is defined as the average value of $|x(t)|^2$ over time, i.e., $P = \lim_{T\to\infty} \frac{1}{T} \int_{-T/2}^{T/2} |x(t)|^2 dt$.

## 3.2 Theoretical Explanation

**Even and Odd Signals** An even signal $x(t)$ satisfies $x(-t) = x(t)$ for all $t$, while an odd signal satisfies $x(-t) = -x(t)$ for all $t$. A signal with both even and odd components can be constructed by summing an even function and an odd function.

## 3.3 Theoretical Explanation

A causal signal's value at $t$ depends only on its values for $t' < t$. In contrast, non-causal signals can depend on future values, making them more complex. Piecewise functions can help represent signals with distinct causal and non-causal parts.