**Module 2**

**Expected Course Outcomes:** Understand the system like causal, dynamic, linear, time invariant and stable system also students will be able to perform impulse response of both continuous time and discrete time system.

**Reference books**

Signals and systems, second edition-Alan. V. Oppenheim, Alan. S. Willsk,S. Hamid Nawab, PHI learning Pvt ltd,2001

Signals and systems, second edition - Simon Haykin, Barry VanVeen, Wiley, Wiley India, 2007.

**Systems Concepts**

A system refers to any physical device that produces an output signal y(t) (or y[n]) in response to an input signal x(t) (or x[n]).

Eg :

* + Speaker recognition system
  + Communication system
  + Aircraft landing system etc.,

**Classification of Systems**

* Continuous time(CT) system and Discrete Time (DT) System
* Linear and non-linear
* Time-variant and time-invariant
* Memoryless (static) and memory (dynamic)
* Causal and non-causal
* Stable and unstable

1. **Continuous time(CT) system and Discrete Time (DT) System** 
   * A CT system is one which operates on a CT signal and produces CT output signal
   * A DT system is one which operates on DT signal and produces DT output signal



H denotes the action of the system

* + y(t) = H { x(t) }
  + y[n] = H { x[n] }
  + A mixed system is one which operates on CT / DT signal and produces DT / CT signal respectively

1. **Linear and non-linear System**

* For the systems y1(t) = H { x1(t) } and y2(t) = H { x2(t) }
* A system is said to be linear if the `superposition' principle holds(summation and scaling property),

i.e., for the input signal x3(t) = a1x1(t) + a2x2(t),

then the output signal is

y3(t) = a1y1(t) + a2y2(t), for any constants a1 and a2

* System is said to be linear if, the weighted sum of several inputs produces the weight sum of outputs

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* If not, the system is non linear

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**Ex.** Test the Linearity of the system

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Let

 Then,

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For,

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** Hence the system is Non-Linear**

Linear

** Ex.** Test the Linearity of the system

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**** For,

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Then,

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For,

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**Hence the system is Linear**

1. **Time-variant and time-invariant System**

* A system is said to be time invariant if its input and output characteristics do not change with time
* A system is time-invariant if for any delayed input (i.e. x(t - T)), the output is also delayed by the same amount (i.e. y(t - T))

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**Ex.** Test whether the system y(t) = t x(t) is Time-Invariant or not

* y(t, t0) = H{ x(t-t0) } = y(t)|x(t)=x(t-t0)

y(t, t0) = t x(t-t0)

* y(t-t0) = y(t)|t = t – t0

y(t-t0) = (t-t0) x(t-t0)

Therefore y(t,t0)≠ y(t-t0)

Hence, the system is Time variant

**Ex.** Test whether the system y(t) = ex(t)  is Time-Invariant or not

* y(t, t0) = ex(t-t0)
* y(t-t0) = y(t)|t = t – t0

y(t-t0) = ex(t-t0)

Therefore, y(t,t0) = y(t-t0)

Hence, the system is Time Invariant

1. **Memoryless (static) and memory (dynamic) System**

* A system is memoryless (i.e. static) if its output signal depends only on the present value of the input signal. Examples include

**Example**

* y(t) = x(t) sin (2t)
* y[n] = u[n]
* A system is said to possess memory (i.e. dynamic) if its output signal depends on past or future values of the input signal.

**Example**

* + y(t) = x(t+1) + 5
* y[n] = x[n] + x[n-1]

1. **Causal and non-causal System**

* A system is causal if the present value of the output signal depends only on the present or past values of the input signal.





* A system is noncausal if the present value of the output signal depends on the future values of the input signal.





**Ex.** Find the causality of the system

 Soln:



At time t=1; depends on t=2, hence, it is Anti-Causal system.

1. **Stable and unstable System**

* A system is said to be bounded-input bounded-output (BIBO) stable

if and only if every bounded input

|x(t)| < 1 for all t or |x[n]| < 1 for all n

results in a bounded output

|y(t)| < 1 for all t or |y[n]| < 1 for all n.

i.e., the impuse response

* Examples of a BIBO stable system







* Examples of a BIBO Unstable system:





**Practice Problems**

* Book Authors: Oppenheim and wilsky

Problem no: 1.17 and 1.27

* Book Authors: Simon Haykin and Van been

Problem no: 1.64