SIGNAL AND SYSTEMS

CAUSAL AND NON-CAUSAL SYSTEMS

AND

TIME VARIANT AND TIME INVARIANT SYSTEMS

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THEORY

A signal is an electrical or electromagnetic current that is used for carrying data from one device or network to another.

In the real world, it refers to any time varying voltage, current.

An output signal is always produced from a system for a set of given known inputs. So, A system is something which performs some mathematical operations on input signals to convert to the output signal.

There are some properties of a systems. But, for the experiment

We will discuss only few of its properties. Those are:

1) *Time variant and time invariant.*
2) *Casual and non-casual.*

DISCUSSION

Time variant and time invariant system

A time-variant system is a system that is not time invariant its output characteristics depend explicitly upon time. In other words, a system in which certain quantities governing the system's behavior change with time, so that the system will respond differently to the same input at different times.

All time scaling cases are examples of time variant system. Similarly, when coefficient in the system relationship is a function of time, then also, the system is time variant.

For a time-invariant system, the output and input should be delayed by the same amount of time. Any delay provided in the input must be reflected in the output for a time invariant system.

Some examples of time variant systems :

1) $y(t) = x(t) / \cos(t)$
2) $y(T) = \cos(t) \times x(t)$

Some examples of time invariant systems are:

1) $y(t) = x(2t)$
2) $y(t) = \sin(x(t))$

Causal and Anti - Casual systems

 A causal system is one whose output depends only on the present and the past inputs.

 A non-causal system is just opposite to that of causal system. If a system depends upon the future values of the input at any instant of the time then the system is said to be non-causal system.

 The output of casual system depends on present and past inputs, it means y(n) is a function of x(n), x(n-1), x(n-2), x(n-3) etc. Some examples of causal systems are given below:

1) $y(n) = x(n) + x(n-2)$

2) $y(n) = x(n-1) – x(n-3)$

3) $y(n) = 7\,x(n-5)$

 The output of non-causal system depends on future inputs, it means y(n) is a function of x(n), x(n-1), x(n-2) etc.

Following are some examples of non-causal systems:

1) $y(n) = x(n) + x(n+1)$

2) $y(n) = 7x(n+2)$

3) $y(n) = x(n) + 9x(n+5)$

Significance of a causal systems

 Since causal systems does not include future input samples; such system is practically realizable. That mean such system can be implemented practically.

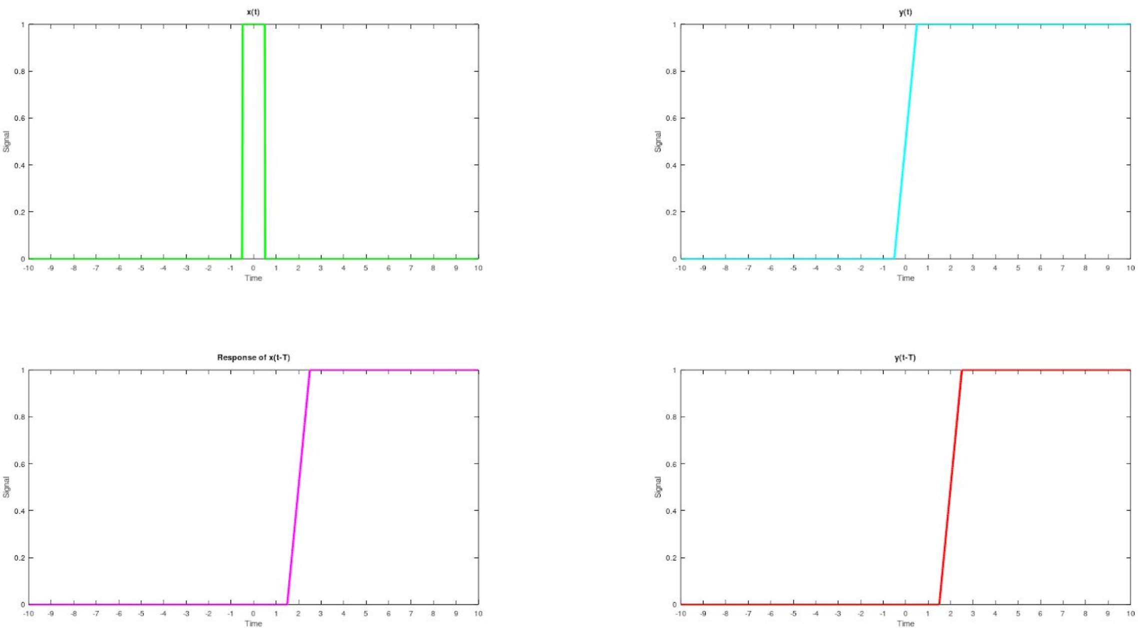
Significance of non-causal systems

 Since non-causal systems require future inputs, a non-causal system is practically not realizable. That means in practical cases it is not possible to implement a non-causal system.

RESULTS

1.

$$y(t) = \int_{-\infty}^{t} x(t)$$

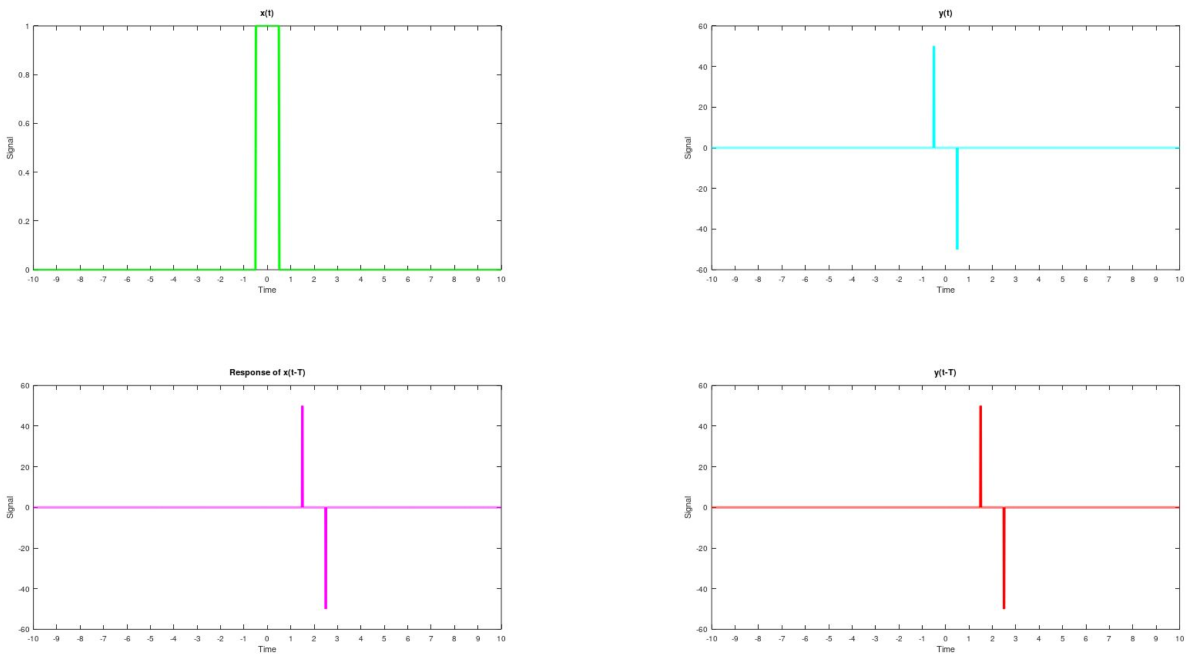


The given function is time-invariant.

The given function is causal.

2.

$$y(t) = \frac{\mathrm{d}}{\mathrm{d}t}(x(t))$$

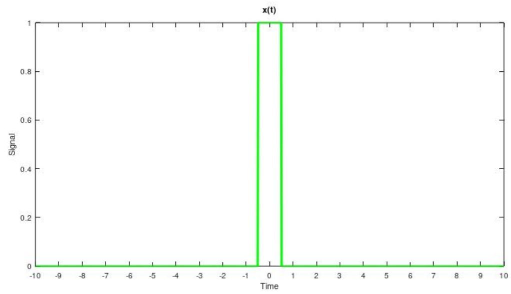


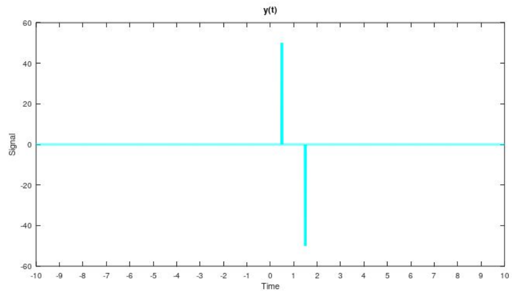
The given function is time-invariant.

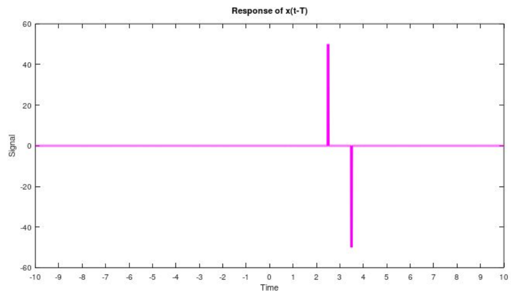
The given function is non-causal.

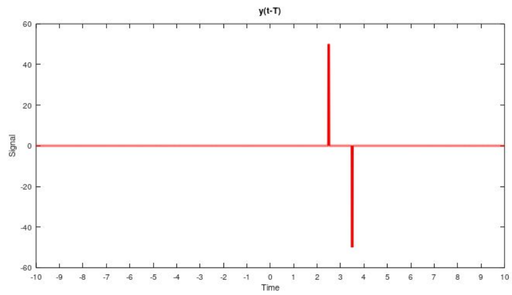
3.

$$y(t) = \frac{d}{dx}(x(t-1))$$







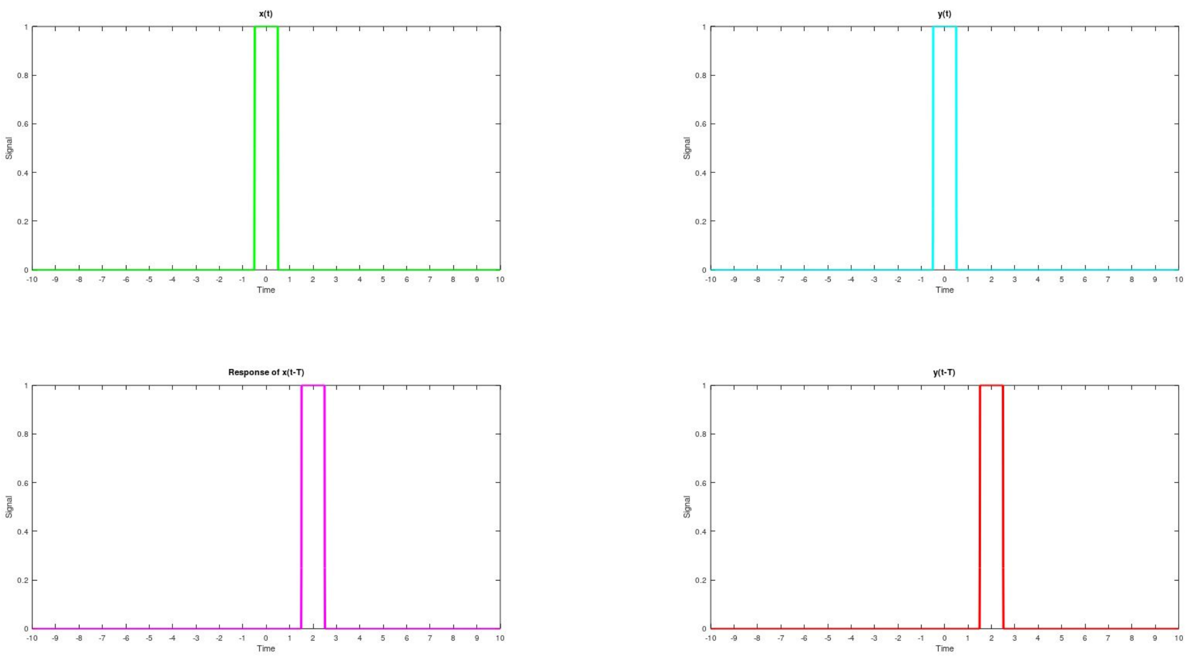


The given system is time-invariant.

The given function is causal.

4.

$$y(t) = x(t)^2$$

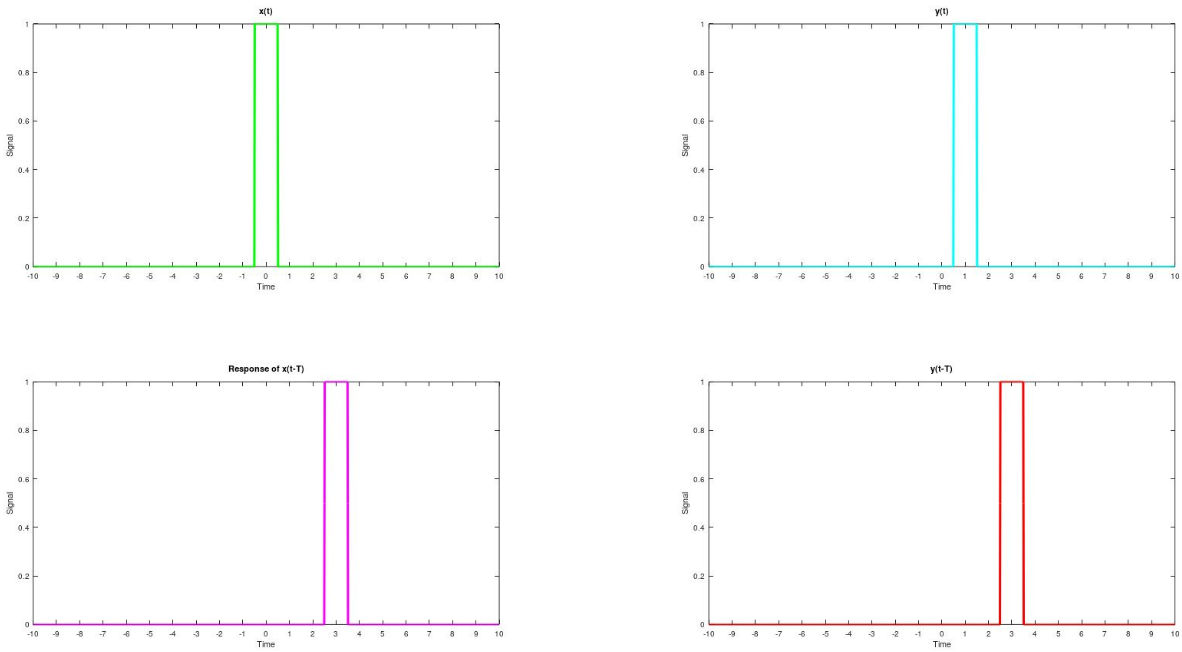


The given system is time-invariant.

The given function is causal.

5.

$$y(t) = x(t-1)$$



The given system is time-invariant.

The given function is causal.

CONCLUSION

CAUSAL AND NON-CAUSAL SYSTEM

A system mapping x to y is causal, if and only if, for any pair $x_1(t)$ and $x_2(t)$ such that

$$x_1(t) = x_2(t), \quad \forall\, t < t_0,$$

The corresponding outputs satisfy

$$y_1(t) = y_2(t), \quad \forall\, t < t_0.$$

Otherwise the system is non-causal.

TIME-VARIANT AND TIME INVARIANT SYSTEM

A time invariant system always gives the same output after the same delay with respect to the input, if the input is the same. Consider a system S that transforms x(n) to y(n), if it is time invariant, then delayed version of input, say x(n-N) produces output y(n-N), i.e. a delayed version of the previous output.

APPENDIX

1.x1

```
function y = x1(t)

    y = heaviside(t+0.5, 1) - heaviside(t-0.5, 1);
```

3.x2

```
function y = x2(t)

    y = 2*(heaviside(t, 1) - heaviside(t-3, 1));
```

4. xc1

```
function y = xc1(t)

    y = abs(t);
```

5.xc2

```
function y = xc2(t)

    y = -t;
```

6. Function 1

```
function y = fun1(f, t)

    n = length(t);
    y = zeros(1, n);
    d = t(2) - t(1);

    for i = 2:n
      y(i) = y(i-1) + f(t(i))*d;
    end
```

7.Function 2

```
function y = fun2(f, t)

    n = length(t);
    y = zeros(1, n);
    d = t(2) - t(1);

    y(n) = (f(t(n)) - f(t(n-1)))/d;
```

```
for i = 1:n-1
  y(i) = (f(t(i+1)) - f(t(i)))/d;
end
```

8.Function 3

```
function y = fun3(f, t)

    f = @(t) f(t-1);
    y = fun2(f, t);
```

9.Function 4

```
function y = fun4(f, t)

    y = (f(t)).^2;
```

10.Function 5

```
function y = fun5(f, t)

    f = @(x) f(x-1);
    y = f(t);
```

11. Check_Time

```
function check_time(Of, If, tmin, tmax)

    t = tmin:0.01:tmax;
    k = 2;
    xran = [tmin tmax];

    If1 = @(t) If(t);
    y1 = Of(If1, t-k);

    If2 = @(t) If(t-k);
    y2 = Of(If2, t);

    if (y1 == y2)
        fprintf('\nThe given function is time-invariant.\n');

    else
        fprintf('\nThe given function is time-variant.\n');

    end
```

```
subplot(2, 2, 1)
plot(t, If(t), '-g', 'LineWidth', 3);
xlabel('Time');
ylabel('Signal');
title('x(t)');
xlim(xran);
xticks([tmin:1:tmax]);

subplot(2, 2, 2)
plot(t, Of(If, t), '-c', 'LineWidth', 3);
xlabel('Time');
ylabel('Signal');
title('y(t)');
xlim(xran);
xticks([tmin:1:tmax]);

subplot(2, 2, 3)
plot(t, y2, '-m', 'LineWidth', 3);
xlabel('Time');
ylabel('Signal');
title('Response of x(t-T)');
xlim(xran);
```

```
    xticks([tmin:1:tmax]);

    subplot(2, 2, 4)
    plot(t, y1, '-r', 'LineWidth', 3);
    xlabel('Time');
    ylabel('Signal');
    title('y(t-T)');
    xlim(xran);
    xticks([tmin:1:tmax]);
```

12. Check_causal

```
function check_linearity(if1, if2, fun, tmin, tmax)

    tol = 0.001;
    t = tmin:0.01:tmax;
    xran = [tmin tmax];

    f = @(t) (if1(t));
    f1 = fun(f, t);

    f = @(t) (if2(t));
```

```
f2 = fun(f, t);

f = @(t) (if1(t) + if2(t));
f3 = fun(f, t);

subplot(2, 2, 1)
plot(t, x1(t), '-g', 'LineWidth', 3);
xlabel('Time');
ylabel('Signal');
title('x1(t)');
xlim(xran);

subplot(2, 2, 2)
plot(t, x2(t), '-c', 'LineWidth', 3);
xlabel('Time');
ylabel('Signal');
title('x2(t)');
xlim(xran);

subplot(2, 2, 3)
plot(t, f1+f2, '-m', 'LineWidth', 3);
xlabel('Time');
```

```
ylabel('Signal');
title('y(x1(t))+y(x2(t))');
xlim(xran);

subplot(2, 2, 4)
plot(t, f3, '-r', 'LineWidth', 3);
xlabel('Time');
ylabel('Signal');
title('y(x1(t)+x2(t))');
xlim(xran);

error = abs(f3 - (f1+f2));
error = find( error > tol);
if (sum(error) == 0)
    fprintf('\nThe given system is Linear.\n');

else
    fprintf('\nThe given system is Non-Linear.\n');
end
```