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EXPERIMENT-3

Aim :

To find the impulse response of a system with the transfer function.

Requirements:
Software: MATLAB (or GNU Octave as an open-source alternative)

Theory:
Transfer Function:
The transfer function of a linear time-invariant (LTI) system is defined as the ratio of the Laplace transform of the output to the Laplace transform of the input, assuming all initial conditions are zero. It is commonly represented as:

H(s)= Y(s) / X(s)

- H(s) is the transfer function,
- Y(s) is the Laplace transform of the output signal, and ➢ X(s) is the Laplace transform of the input signal.

Impulse Response:

The impulse response of a system is the inverse Laplace transform of the transfer function H(s). It characterizes how the system reacts to an impulse input, which is mathematically represented as a Dirac delta function δ(t). The impulse response, h(t), is given by: h(t)=L ^−1{H(s)} Where:

L^-1 is the inverse Laplace transform.

Relationship Between Unit Step and Impulse Response:

The unit step function u(t) is related to the unit impulse function δ(t) by the derivative:

/𝑑 (t) = (t)

Thus, the step response can be derived by integrating the impulse response.

Program:
```
% MATLAB script to calculate and plot the impulse response
clc; clear; close all;

% Define the transfer function: H(s) = (numerator) / (denominator)
```

numerator = [1]; % Example: 1 in the numerator denominator = [1 3 2]; % Example: (s^2 + 3s + 2) in the denominator

% Create a transfer function model in MATLAB
sys = tf(numerator, denominator);

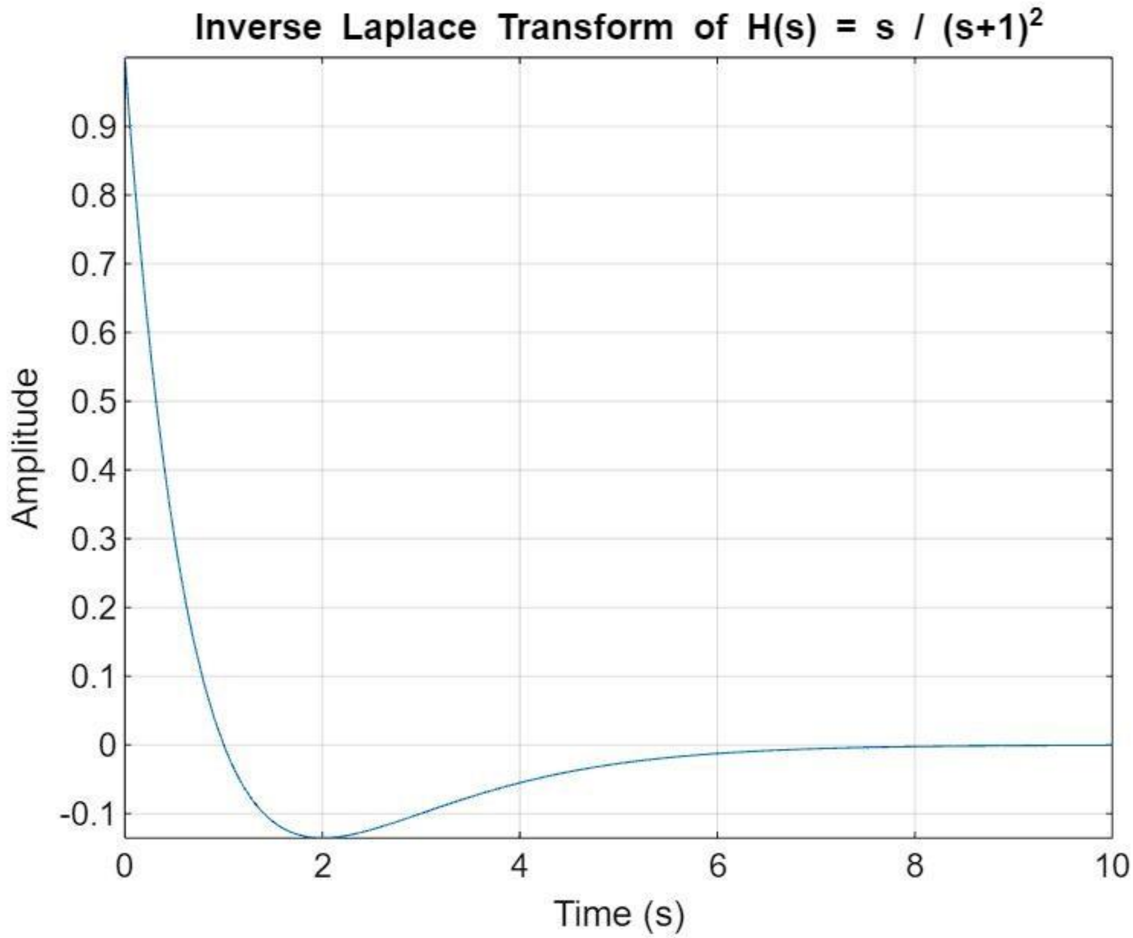
% Calculate and plot the impulse response
figure;
impulse(sys);
title('Impulse Response of the System');
xlabel('Time (seconds)');
ylabel('Amplitude'); grid on;

Result:
After running the MATLAB program, the following plot is obtained:

/MATLAB Drive/Impulse_response.m

```
% Define the transfer function H(s) = s / (s+1)^2
num = [1 1]; % Numerator coefficients of s
den = [1 2 1]; % Denominator coefficients of (s+1)^2

% Create the transfer function
sys = tf(num, den);

% Display the transfer function
disp('Transfer Function:');
disp(sys);

% Plot the impulse response
figure;
impulse(sys);
title('Impulse Response of H(s) = s / (s+1)^2');
xlabel('Time (s)');
ylabel('Amplitude');
grid on;

% Use symbolic math to verify the inverse Laplace transform
syms t s
F_s = s / (s + 1)^2;

% Find the inverse Laplace transform
f_t = ilaplace(F_s, s, t);

% Display the result
disp('Inverse Laplace Transform:');
disp(f_t);

% Plot the inverse Laplace transform
fplot(f_t, [0, 10]);
title('Inverse Laplace Transform of H(s) = s / (s+1)^2');
xlabel('Time (s)');
ylabel('Amplitude');
grid on;
```

OUTPUT:



Observation:

- ➢ The impulse response of the system starts at a high initial value and decays to zero as time progresses.
- ➢ This is consistent with the behavior of second-order systems with overdamping, underdamping, or critical damping depending on the poles of the system.
- ➢ The plot obtained helps in understanding the stability and time-domain performance of the system.

Conclusion:

The experiment successfully demonstrated the calculation and plotting of the impulse response of a system using its transfer function. The impulse response provides valuable insight into the dynamic behavior of the system. In this case, the system shows typical second-order system behavior. While running the experiment, it was observed that:

- ➢ MATLAB simplifies the process of calculating and visualizing system responses.
- ➢ The results obtained align with the theoretical expectations from system dynam