Imperial College London

DE2 Electronics 2

Tutorial 3

System Characterisation Lab 3 Explained

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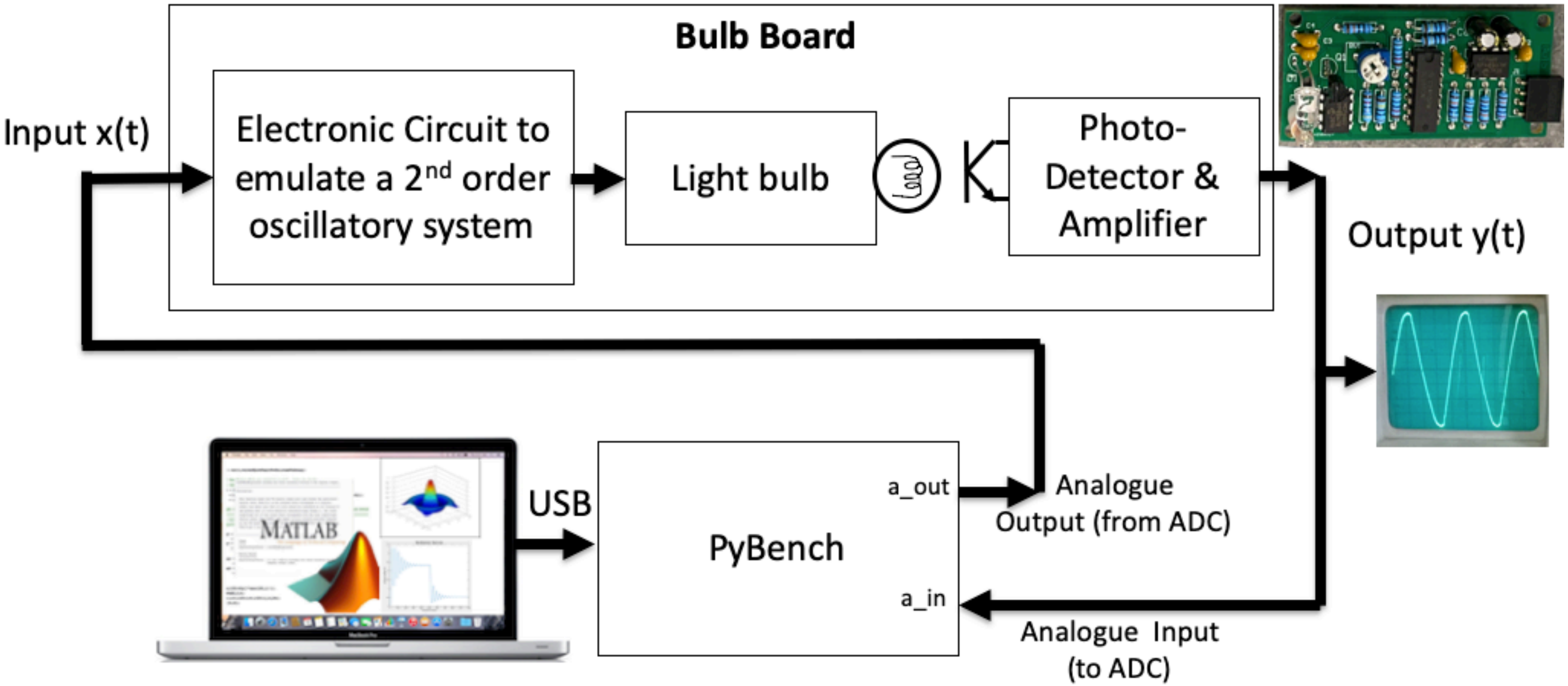
Bulb Board

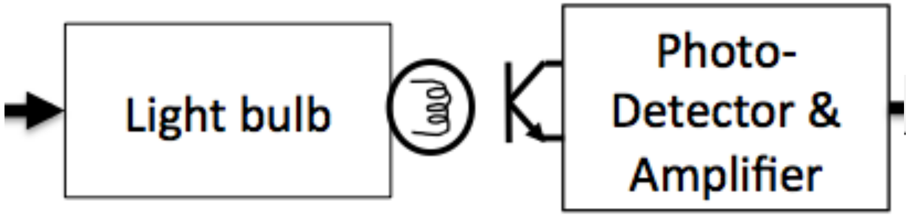


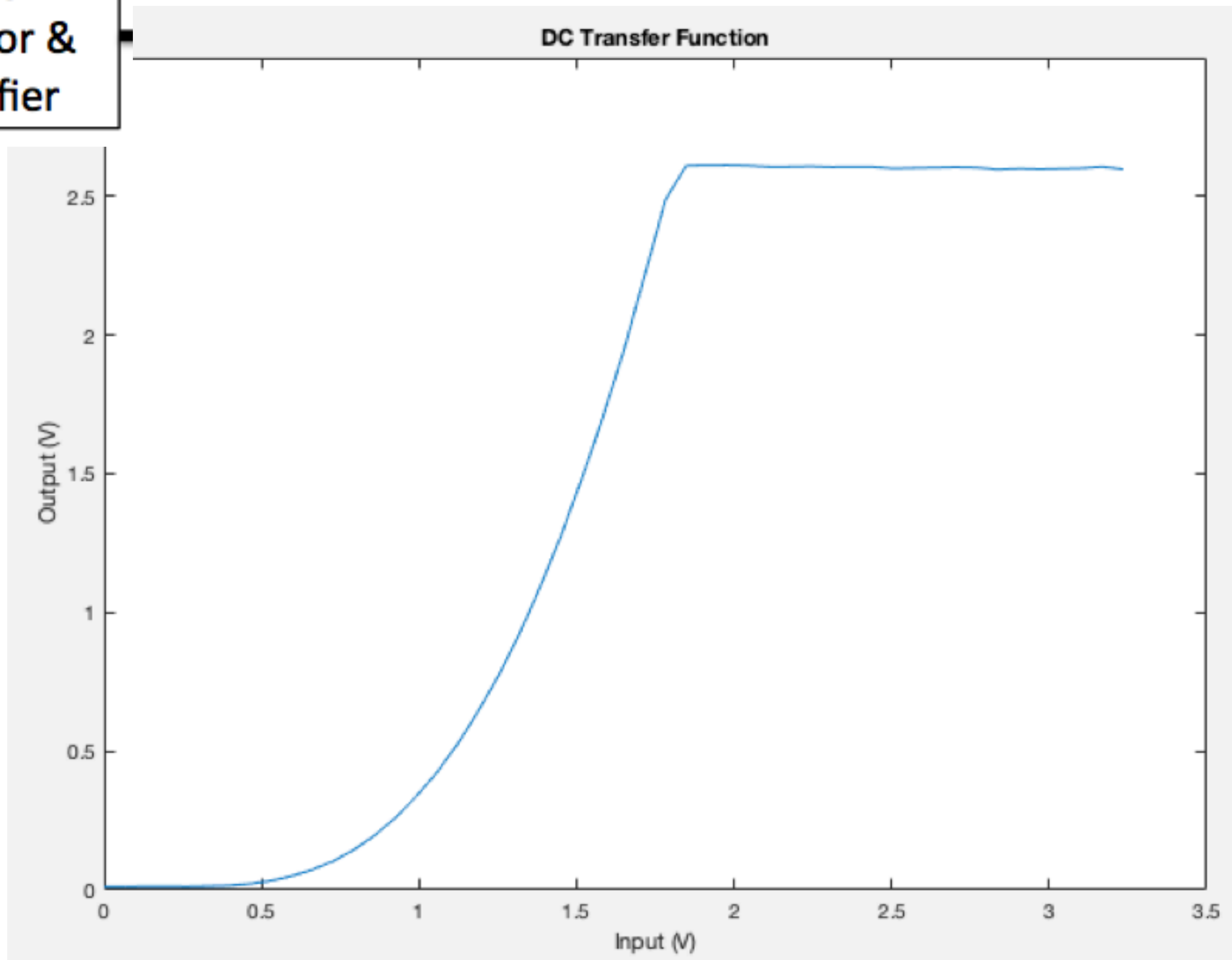
- We are interested in mathematical modelling system.
- Bulb Board is designed to behaviour like a 2nd order system + a non-linear system with some delay (the light bulb)
- We want to verify that the mathematical model is a good representation.
- We also wan to explore the limitations of this model

Key aspects of Lab 3

1. DC characteristics – no time variation. Measure light intensities at different drive voltages.
2. Steady state response to sinusoidal signals at different frequencies – we call this **frequency response**.
3. Use of Matlab for modelling and simulation.
4. Transient behaviour of the system – we call this step response.
5. Impact of non-linearity in the system.

Task 1 – DC Characteristic



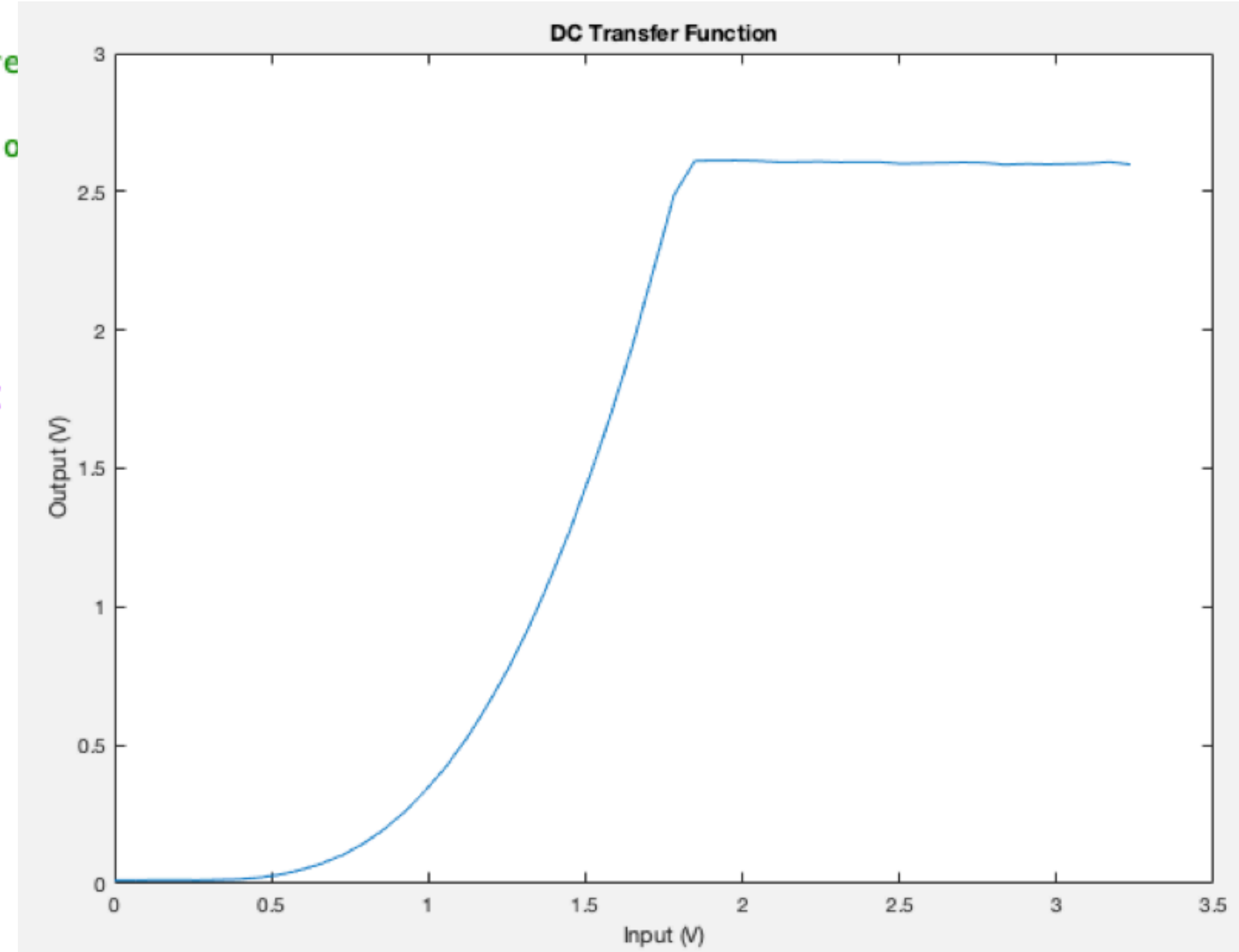


- $y = F(x)$
- F is a non-linear function.
- F is a quadratic function because:

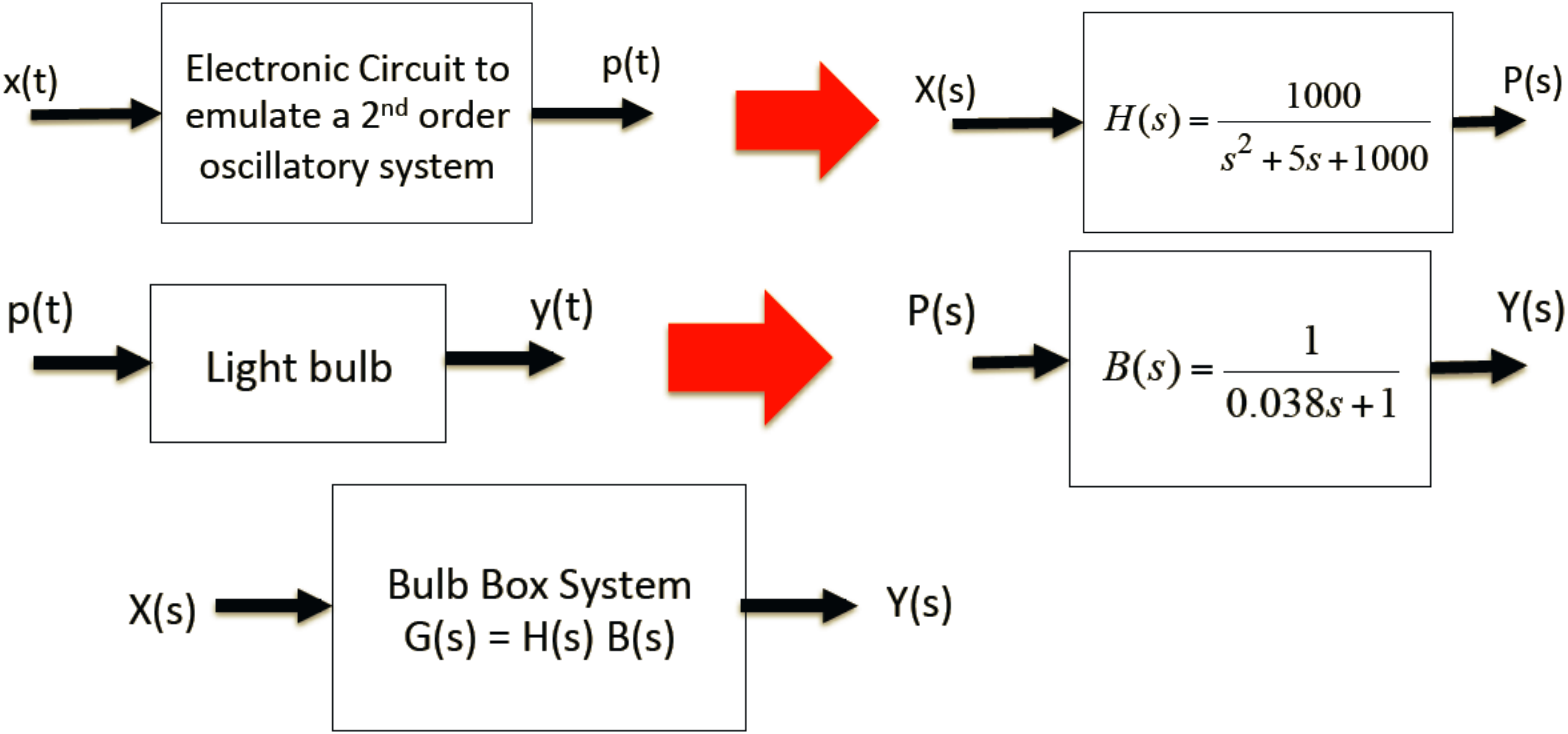
  light intensity $\propto x^2$
- Light is dependent temperature of filament in bulb
- Temperature is dependent on energy consumed
- Energy is proportional to x^2.

Task 1 – Solution

```
% Lab 3 – Task 1 DC characteristics of the Bulb Boardl
clear all
ports = serialportlist;
pb = PyBench(ports(end));  % cre

%  measure the steady-state DC o
pb.samp_freq = 200;
NSTEPS=50;
input = zeros(NSTEPS,1);
output = zeros(NSTEPS,1);
tic
disp('Sweeping DC output for DC
for i = [1:NSTEPS]
    v = (i-1)*3.3/NSTEPS;
    input(i) = v;
    pb.dc(v);
    pause(0.5);
    data = pb.get_block(10);
    output(i) = mean(data);
end
pb.dc(0.0);
toc
plot(input,output)
xlabel('Input (V)');
ylabel('Output (V)');
title('DC Transfer Function');
fclose(instrfind());
```



Task 2 – Modeling dynamics in a system



$$G(s) = \frac{1000}{0.038s^3 + 1.19s^2 + 43s + 1000}$$

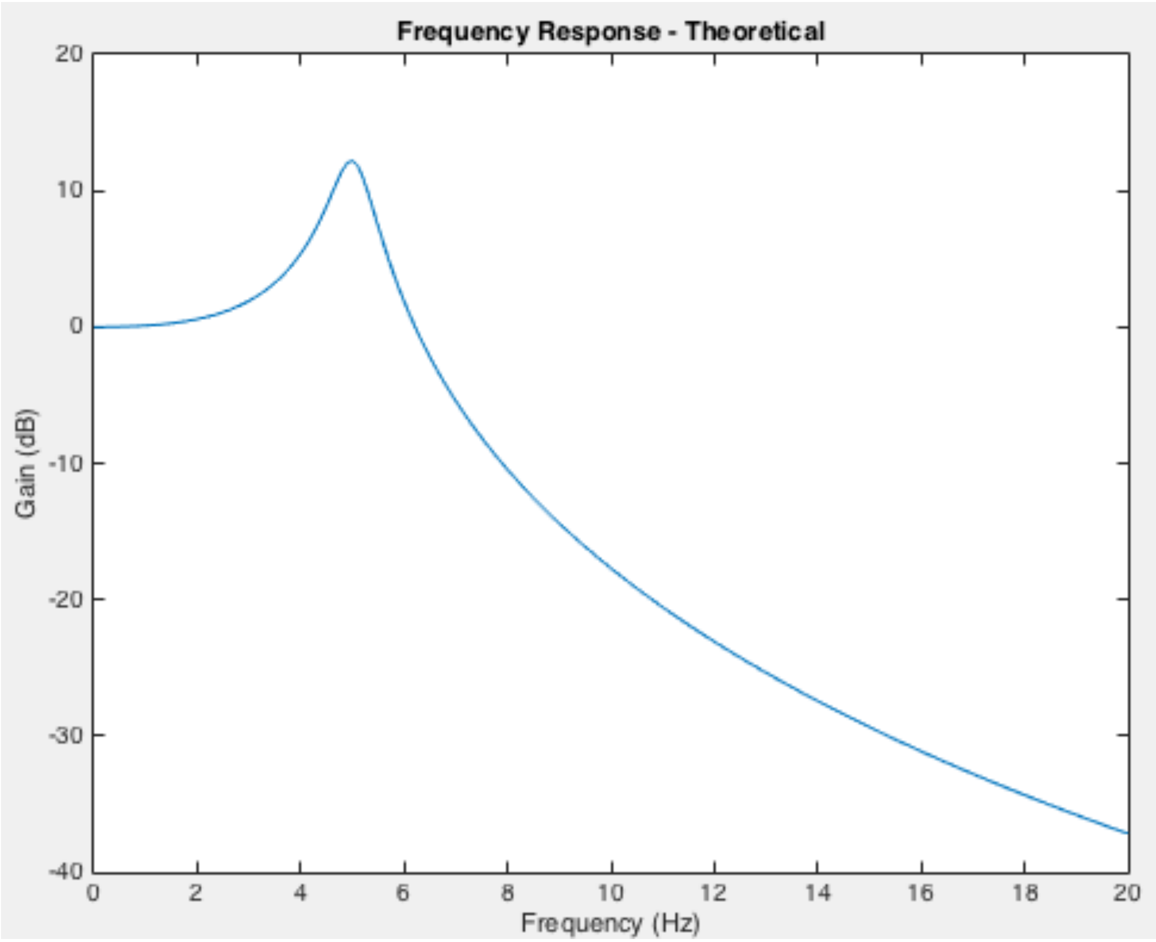
Task 2 – Predict the frequency response

```
%  Lab 3 Task 2 - Plot theoretical freq. response of Bu
f = (0:0.1:20);
D = [0.038 1.19 43 1000];    % specify denominator
s = 1i*2*pi*f;                % s = jw (1i is sqrt(-1))
G = 1000./abs(polyval(D,s));  % polynomial evaluation
Gdb = 20*log10(G);           % Gain in dB
figure;
plot(f,Gdb);
xlabel('Frequency (Hz)');
ylabel('Gain (dB)');
title('Frequency Response - Theoretical');
```

$$G(s) = \frac{1000}{0.038s^3 + 1.19s^2 + 43s + 1000}$$

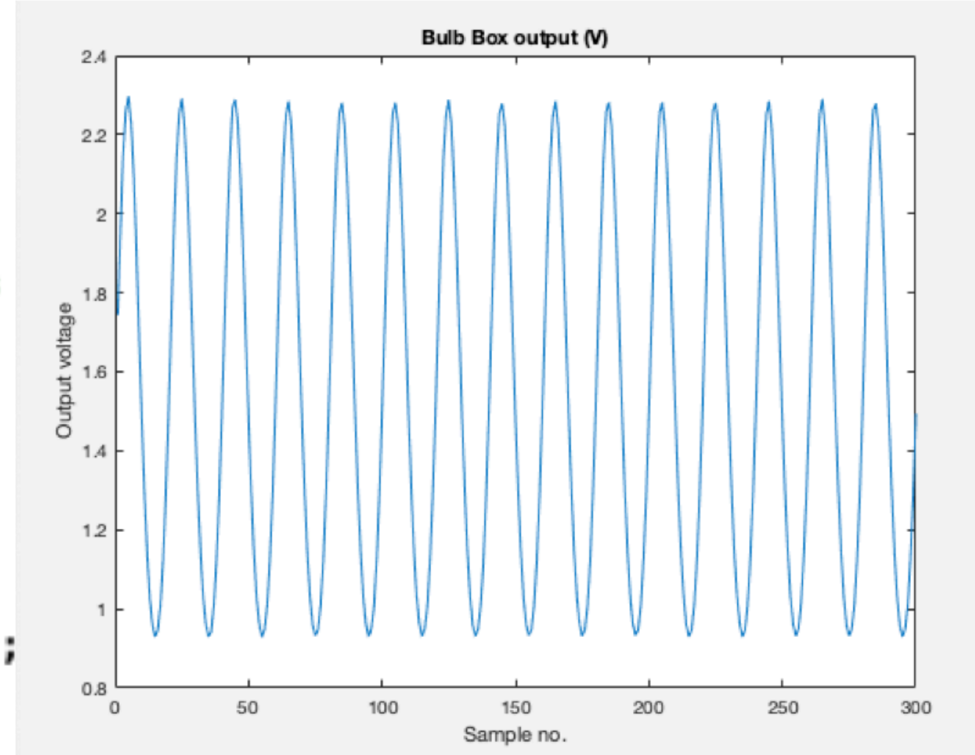
Task 2 – Predict the frequency response

$$G(s) = \frac{1000}{0.038s^3 + 1.19s^2 + 43s + 1000}$$



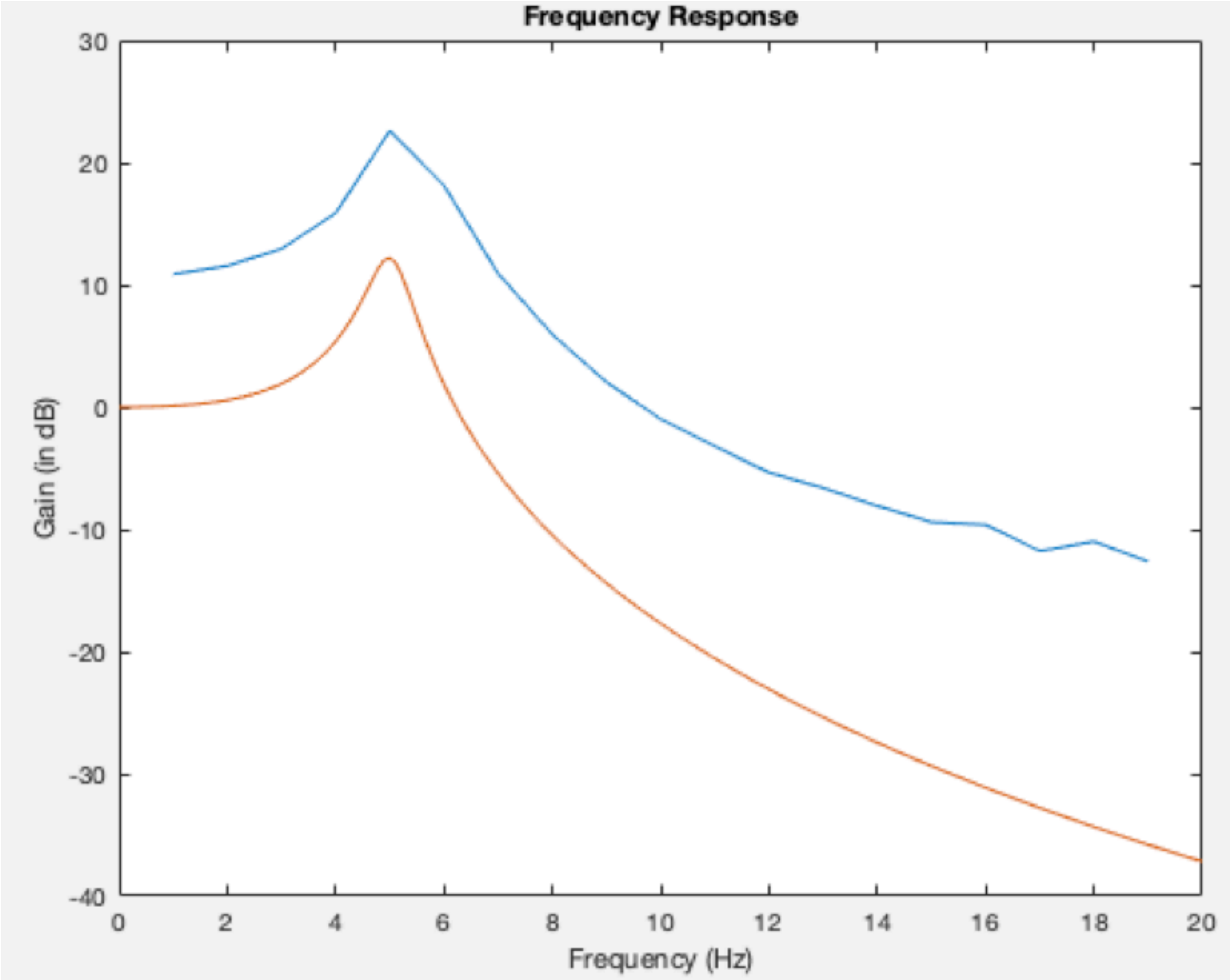
Task 3 – Measure Real Gain at 5Hz

```
% Generate a sine wave at sig_freq Hz
max_x = 1.55;
min_x = 1.45;
f_sig = 5.0;
pb=pb.set_sig_freq(f_sig);
pb=pb.set_max_v(max_x);
pb=pb.set_min_v(min_x);
pb.sine();
pause(2)
% Capture output y(t)
pb=pb.set_samp_freq(100);  %
N = 300;      % no of samples
y = pb.get_block(N);
% plot signal
plot(y);
xlabel('Sample no.');
ylabel('Output voltage');
title('Bulb Box output (V)');
% Compute Gain
x_pk2pk = max_x - min_x;
y_pk2pk = max(y) - min(y);
G = y_pk2pk/x_pk2pk
G_dB = 20*log10(y_pk2pk/x_pk2pk)
```

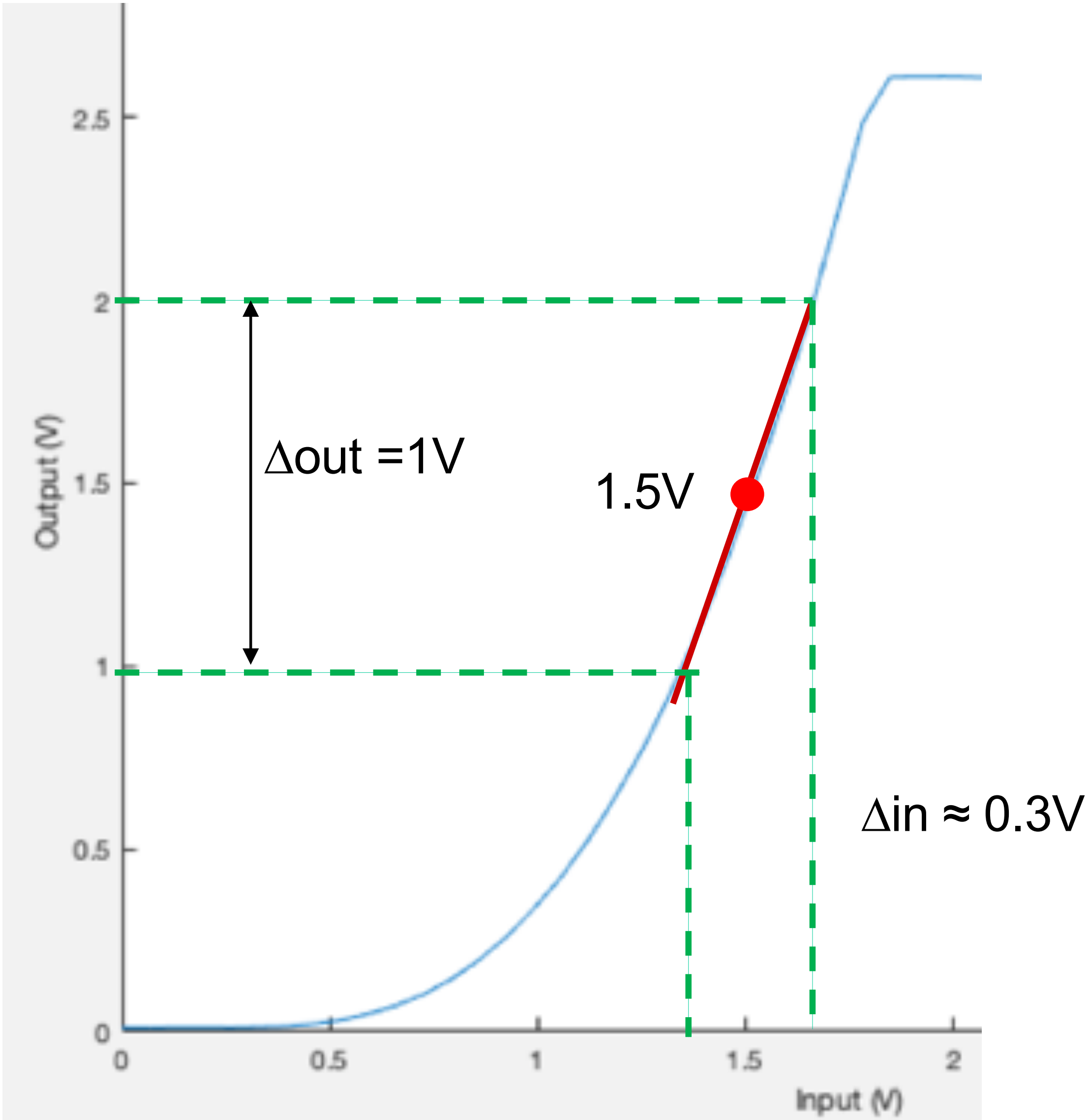



```
G =

   13.6802


G_dB =

   22.7218
```

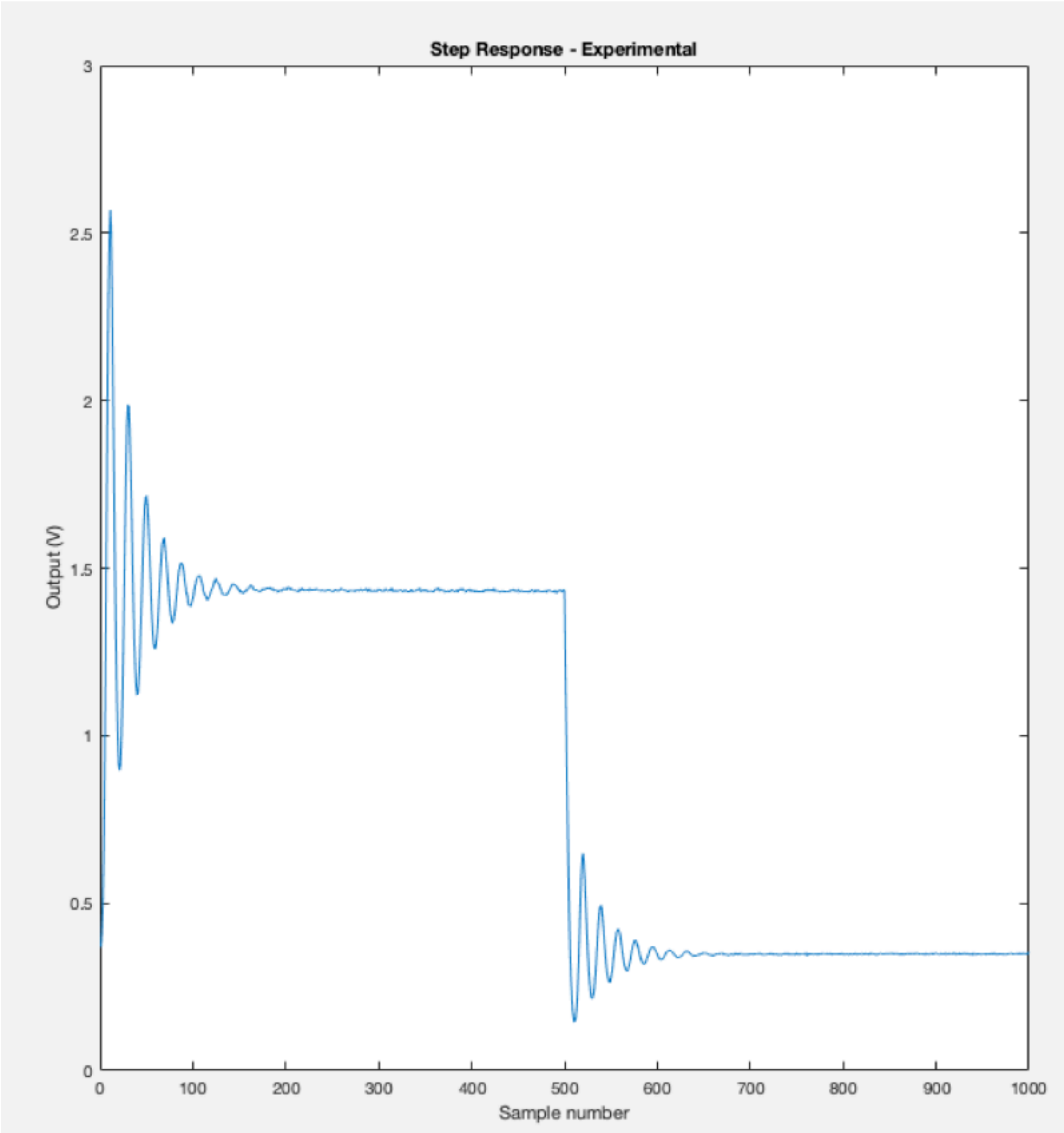
Task 3 – Theory vs Measurements



Task 3 – Explain theory vs practice



Task 4 – Step Response



Task 4 – Explained