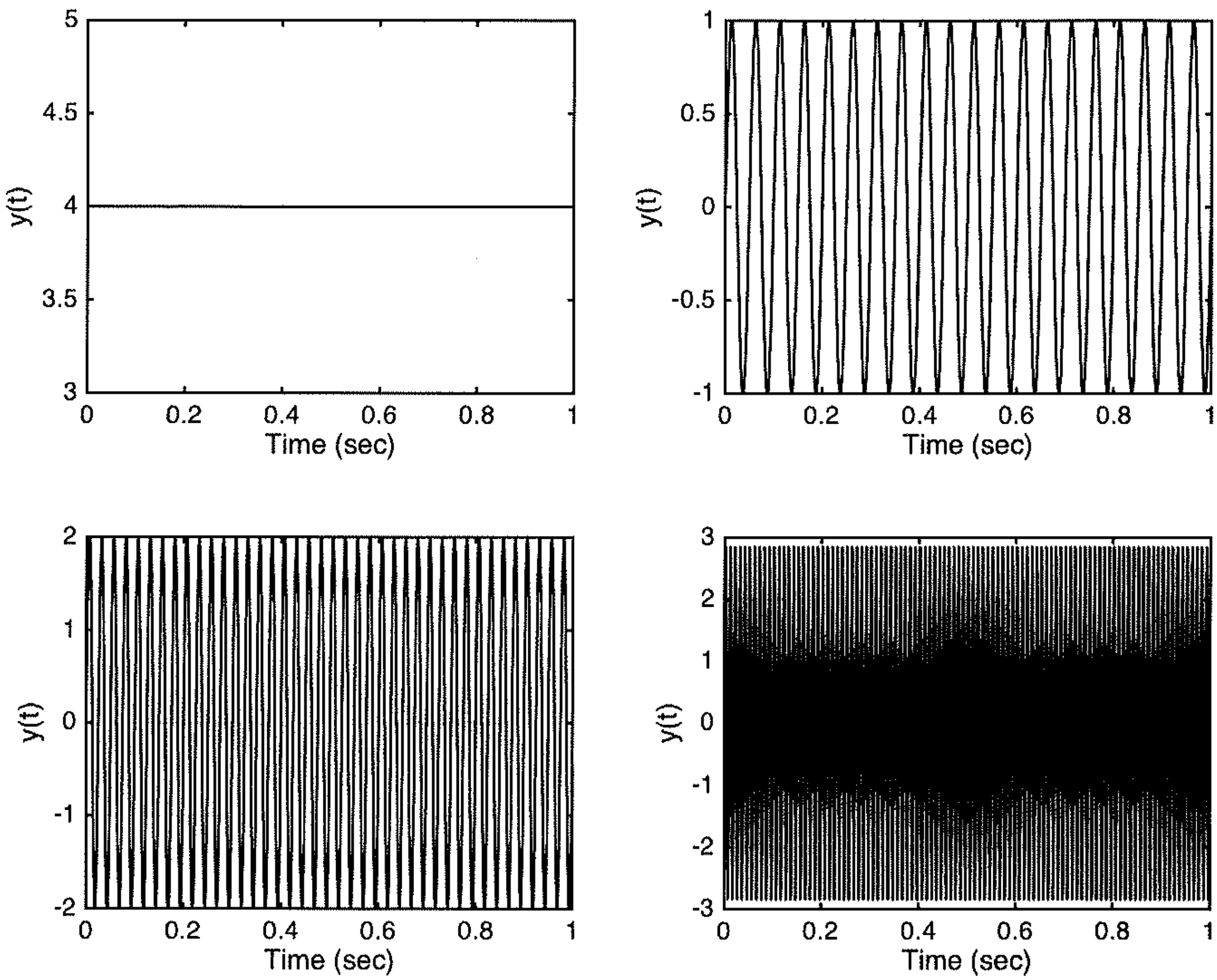
Problam #1


```
% fourier example
% victor m zavala, UW-Madison, 2016
clc
clear all
close all hidden

Fs = 1000;            % Sampling frequency (Hz)
T = 1/Fs;             % Sampling period (sec)
L = 1000;             % Length of signal
t = (0:L-1)*T;        % Time vector (sec)

% Signal containing a 10 Hz sinusoid of amplitude 0.7 and
% a 120 Hz sinusoid of amplitude 1.

y1=4.0*cos(2*pi*0*t);
y2=1.0*sin(2*pi*20*t);
y3=2.0*sin(2*pi*40*t);
y4=3.0*sin(2*pi*100*t);

X = y1 + y2 + y3 + y4;

% plot signal in time domain
figure(2)
subplot(2,1,1)
plot(t,X)
xlabel('Time (sec)')
ylabel('y(t)')
set(gca,'FontSize',12)
axis([min(t) max(t) min(X) max(X)])
grid on

% Compute the Fourier transform of the signal
Y = fft(X);

% Compute magnitudes (can throw away half due to symmetry)
P2 = abs(Y/L);
P1 = P2(1:L/2+1);
P1(2:end-1) = 2*P1(2:end-1);

% plot magnitude as function of frequency
figure(2)
subplot(2,1,2)
f = [-1 Fs*(0:(L/2))/L];
P1 = [0 P1]
plot(f,P1)
xlabel('\omega (Hz)')
ylabel('|y(j\omega)|')
set(gca,'FontSize',12)
axis([-2 200 0 4.5])
grid on
print -dpdf hw4fouriersine.pdf

figure(3)
subplot(2,2,1)
plot(t,y1)
grid on
xlabel('Time (sec)')
ylabel('y(t)')
subplot(2,2,2)
plot(t,y2)
grid on
xlabel('Time (sec)')
ylabel('y(t)')
subplot(2,2,3)
plot(t,y3)
grid on
xlabel('Time (sec)')
ylabel('y(t)')
subplot(2,2,4)
plot(t,y4)
grid on
xlabel('Time (sec)')
ylabel('y(t)')
print -dpdf hw4fouriersinesolI.pdf
```

analytical form, & Plot attached

1)



y(t)
Time (sec)
5
4.5
4
3.5
3
0
0.2
0.4
0.6
0.8
1
y(t)
Time (sec)
1
0.5
0
-0.5
-1
y(t)
Time (sec)
2
1
0
-1
-2
y(t)
Time (sec)
3
2
1
0
-1
-2
-3

Problem #2

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```
% system identification example
% victor m zavala, uw-madison, 2016
clc
clear all
close all hidden

load data_eh2255.dat;
t = data_eh2255(:,1);
u = data_eh2255(:,2);
y = data_eh2255(:,3);
L = length(t);
T = (t(2)-t(1));

% visualize output
figure(1)
subplot(2,1,1)
plot(t,u,'.-')
hold on
xlabel('Time [min]')
ylabel('u(t)')
grid on
axis([0 max(t) 0 70])
subplot(2,1,2)
plot(t,y,'.-')
hold on
xlabel('Time [min]')
ylabel('C(t)')
grid on
axis([0 max(t) min(y) max(y)])
set(gca,'FontSize',12)
print -dpdf hw4co2.pdf

% adjust using reference of 400 ppm
y = y-400;

% get experimental mag(u) using (13.85)
freq = logspace(-3,0,100); % frequency range (rad/s)

for k=1:length(freq)
    sum1 = u.*cos(freq(k)*t);
   B1(k) = trapz(sum1);
    sum2 = u.*sin(freq(k)*t);
   B2(k) = trapz(sum2);
 magu(k) = sqrt(B1(k)^2 + B2(k)^2);
end

% get experimental mag(y) using (13.86)
for k=1:length(freq)
    sum1 = y.*cos(freq(k)*t);
   A1(k) = trapz(sum1);
    sum2 = y.*sin(freq(k)*t);
   A2(k) = trapz(sum2);
 magy(k) = sqrt(A1(k)^2 + A2(k)^2);
end

% get frequency vs. y and u magnitudes
figure(2)
subplot(2,2,1)
semilogx(freq,magu)
hold on
xlabel('Frequency \omega [rad/min]')
ylabel('|u(j\omega)|')
grid on
subplot(2,2,2)
semilogx(freq,magy)
hold on
xlabel('Frequency \omega [rad/min]')
ylabel('|y(j\omega)|')
grid on

% get experimental amplitude ratio
AR = magy./magu;

% get experimental bode diagram
figure(3)
semilogx(freq,AR,'redo','MarkerFaceColor','w')
```

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```
hold on
xlabel('Frequency \omega [rad/min]')
ylabel('AR')

%%%%%%%% ask system identification toolbox to try to get K,\tau

% create data object using y(t),u(t)
 data = iddata(y,u,T);

% identify system (fit it to 1st-order system)
sys_estimated = procest(data,'P1')

% get estimated bode diagram
[mag,phase]=bode(sys_estimated,freq);
  mag = squeeze(mag);
phase = squeeze(phase);
semilogx(freq,mag,'blue')
hold on
grid on
axis([min(freq) max(freq) min(mag) max(mag)*1.1 ])
legend('Experimental','Model')

% compute q and G
  V = 10000;
tau = 10.1;
  K = 11.11;
  q = V/tau
  G = K*q
```

1) $K = 11.11$, $\tau = 10.1$

2) & 3) $q = 990$ cfm

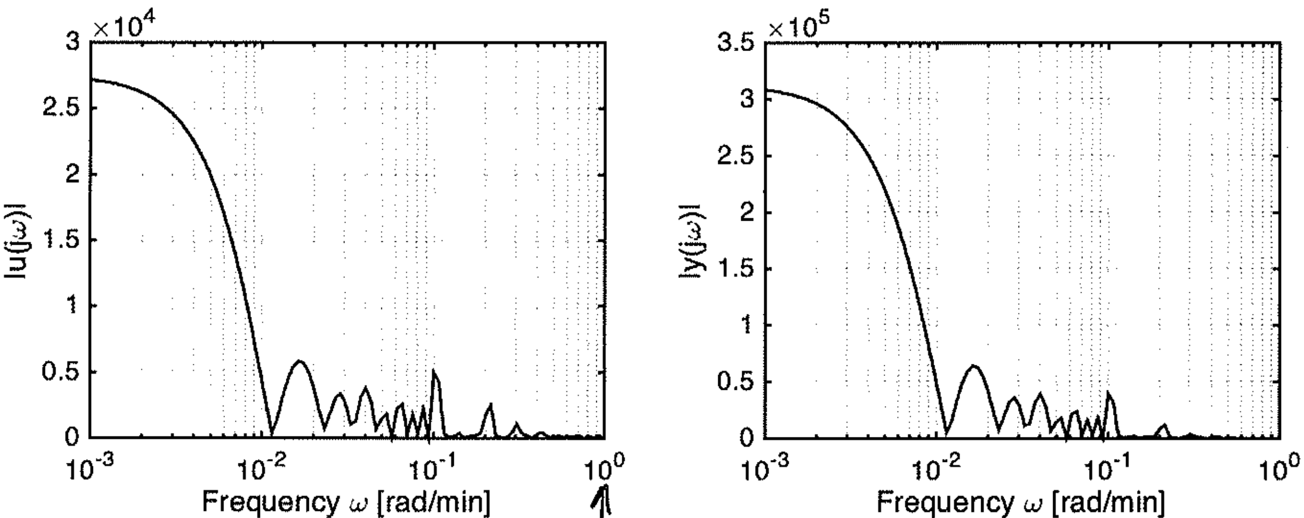
$G = Kq = 1.1 \times 10^4$ ppm-ft/min

4) Attached. Most activity in $\omega \in [10^{-3}, 10^{-1}]$

No activity after $\omega \geq 10^0 = 1 \frac{1}{min}$ because data is collected at that frequency

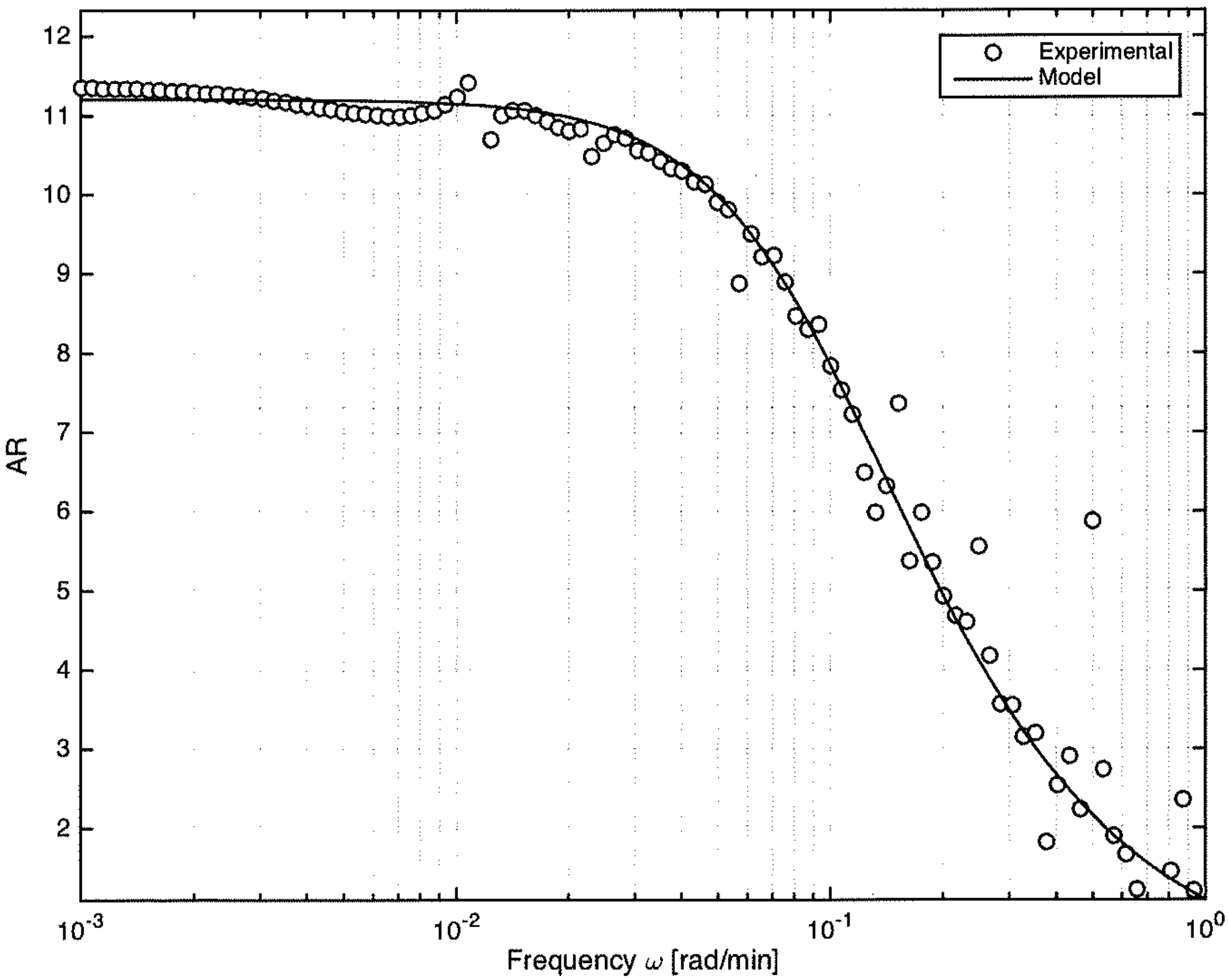
5) Attached

4)



↑ data collected at this frequency

5)



Experimental
Model
AR
Frequency ω [rad/min]
12
11
10
9
8
7
6
5
4
3
2
10^-3
10^-2
10^-1
10^0