Lecture 1 Demo: Introduction to MATLAB

Problem 1. Maniulating audio signals

Task 1. Load the sound file NeuralNet.(To do this, load the MATLAB file NeuralNet.mat.)

```
load('NeuralNet.mat')
```

Task 2. Determine the size of the array NeuralNet. Is it a row vector or a column vector?

```
size_nn = size(NeuralNet)
```

```
size_nn = 1×2
       74162           1
```

```
disp(size_nn); % diplays size without the variable name
```

```
       74162           1
```

```
length(NeuralNet) % presents the length of the vector as the answer
```

```
ans = 74162
```

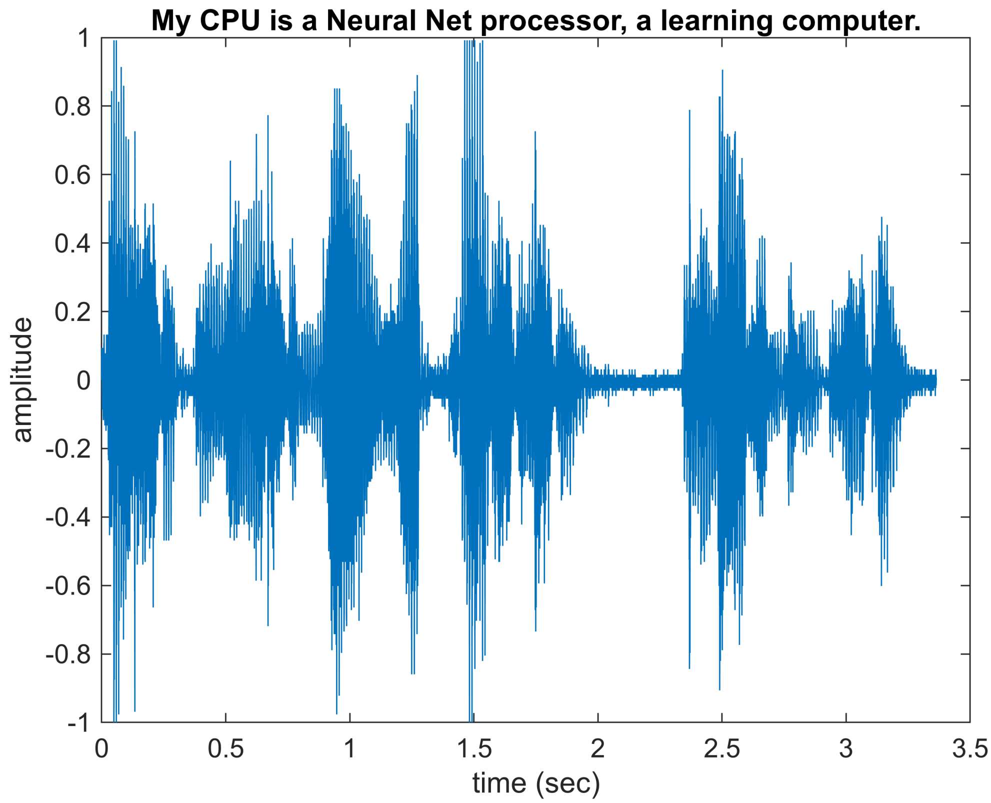
```

% It is a column vector
```

It is a column vector.

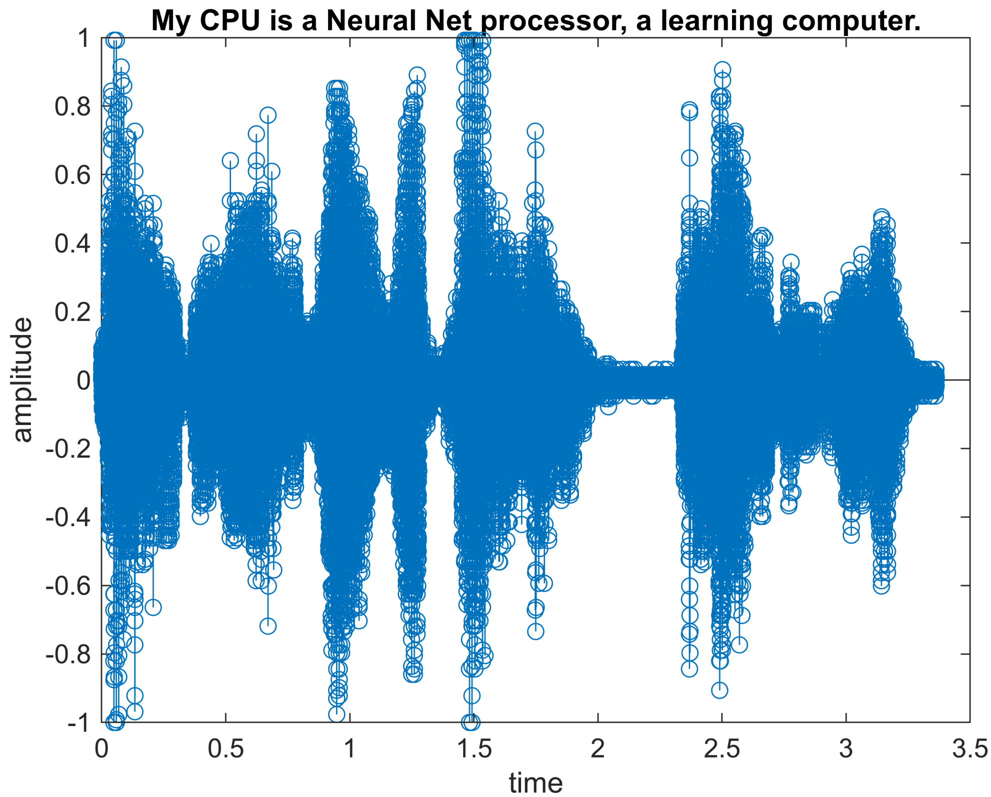
Task 3. Play it, specifying the playback rate to be 22050. Plot it. Label the x-axis 'time', and the y-axis 'amplitude'. Using the title command, write the message contents over the plot.

```
sound(NeuralNet,22050)
n=1:74162;
plot(n/22050,NeuralNet);
xlabel('time (sec)');
ylabel('amplitude');
title('My CPU is a Neural Net processor, a learning computer.');
```



Alternatively, read the file and sample rate directly from a .wav (or .mp3) file using `audioread`. The filename is: t2_learning_computer_x.wav. This time, plot the signal as a stem plot.

```
[NeuralNet,fs]=audioread('t2_learning_computer_x.wav');
sound(NeuralNet,fs);
n=1:74162;
stem(n/22050,NeuralNet);
xlabel('time');
ylabel('amplitude');
title('My CPU is a Neural Net processor, a learning computer.');
```



Task 4. Play it again, with a playback rate of 11025. How has the character of the sound changed?

```
sound(NeuralNet,11025);
```

Task 5. Play it once more, now with a playback rate of 44100. What does this do to the character of the sound?

```
sound(NeuralNet,44100);
```

Task 6. Finally, play the sound in reverse, by "flipping" the array. Which command should you use to "flip" it: fliplr or flipud?

```
NN_flip=flipud(NeuralNet);
size(NN_flip)
```

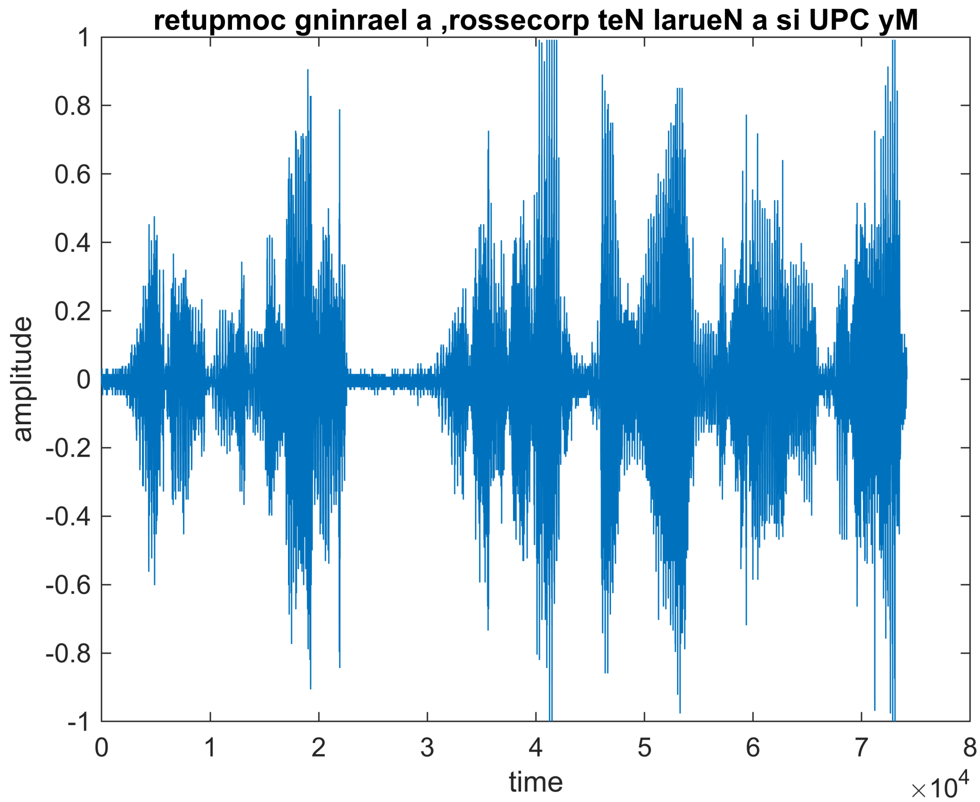
```
ans = 1×2
       74162           1
```

```
sound(flipud(NeuralNet),22050);
```

Task 7. Plot the flipped sound file.

```
plot(NN_flip);
xlabel('time');
ylabel('amplitude');
```

```
title(['retupmoc gninrael a ,rossecorp teN larueN a si UPC yM']);
```



Problem 2. Complex arithmetic and complex signals

Task 1. Compute ((4 + j2)(1 - j)) / ((2 + j3)(3 - 2j)) using MATLAB and express your answer in both rectangular and polar coordinates.

```
a = ((4 + 2j)*(1 - j)) / ((2 + 3j)*(3 - 2j));
%a = re + i*im
re = real(a)
```

```
re = 0.3669
```

```
im = imag(a)
```

```
im = -0.3195
```

```
%
a==re+j*im
```

```
ans = logical
   1
```

```
%
%a=abs(a)exp(j*angle(a)
```

```
rad = abs(a)
```

```
rad = 0.4865
```

```
th = angle(a)
```

```
th = -0.7165
```

```
%
a==rad*exp(j*th)
```

```
ans = logical
   1
```

Task 2. Then compute the real and imaginary parts by hand, expressing them as rational numbers. Finally, compute the magnitude by hand, expressing it as the square root of a rational number, and express the angle as the arctangent of a rational number. Compare your hand calculations to the MATLAB output.

$$\frac{(4+2j)(1-j)}{(2+3j)(3-2j)} = \frac{6-2j}{12+5j}$$
$$= \frac{(6-2j)(12-5j)}{(12+5j)(12-5j)} = \frac{62-54j}{169}.$$

Real part: $\frac{62}{169}$ Imaginary part: $-\frac{54}{169}$

```
62/169
```

```
ans = 0.3669
```

```
-54/169
```

```
ans = -0.3195
```

Magnitude $\sqrt{(62^2+(-54)^2)/169^2}$

```
sqrt((62^2+(-54)^2)/(169^2))
```

```
ans = 0.4865
```

arctan(-54/62)

```
atan(-54/62)
```

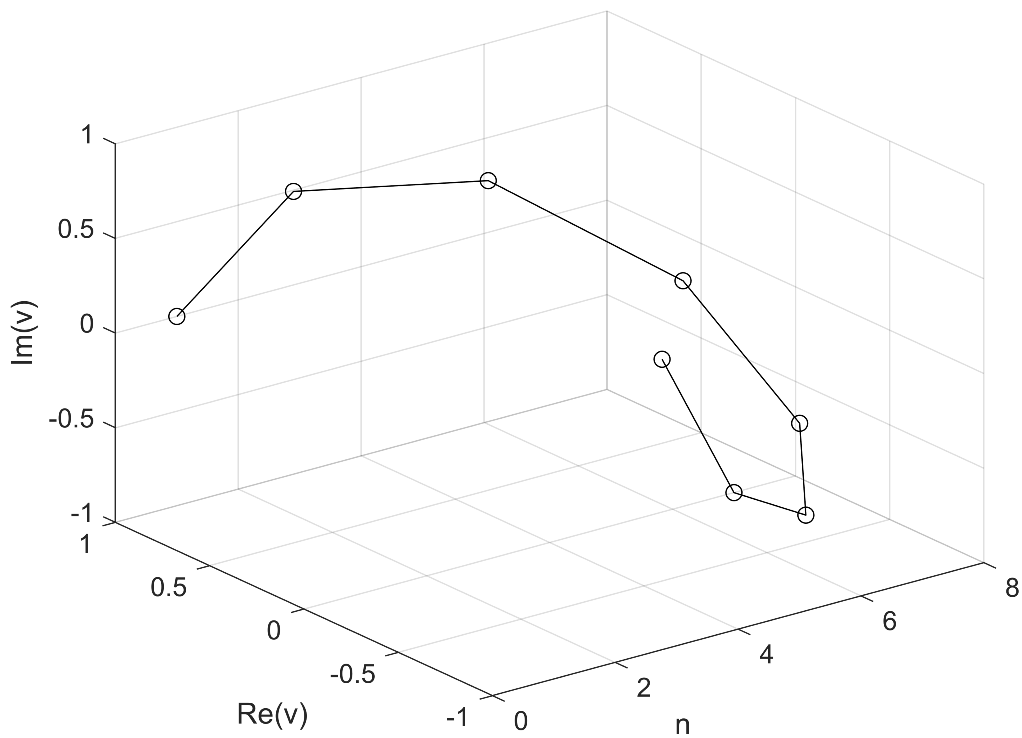
```
ans = -0.7165
```

Task 3. Construct and plot the complex vector v corresponding to 8-th roots of unity. Then plot the elements of the vector in the complex plane.

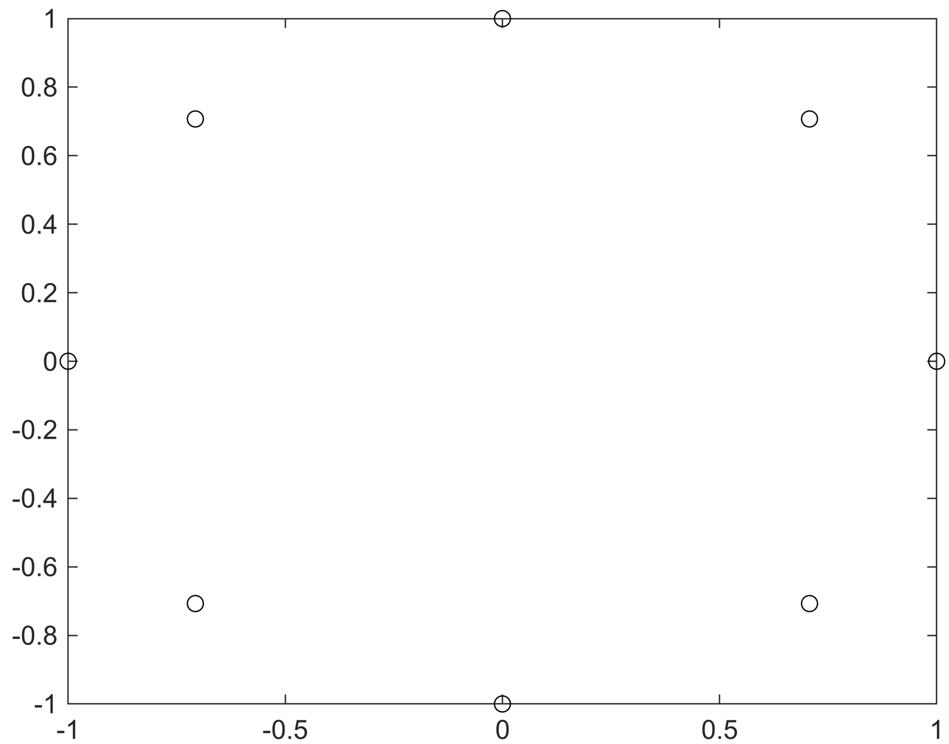
```
figure;
v= [1.0 exp(j*pi/4) exp(j*pi/2) exp(3*j*pi/4) exp(j*pi) exp(5*j*pi/4) exp(3*j*pi/2)
exp(7*j*pi/4) ];
v
```

```
v = 1×8 complex
   1.0000 + 0.0000i   0.7071 + 0.7071i   0.0000 + 1.0000i  -0.7071 + 0.7071i ⋯
```

```
rev=real(v);
imv=imag(v);
plot3(1:8, rev,imv,'ok-')
grid on
xlabel('n')
ylabel('Re(v)')
zlabel('Im(v)')
```




```
plot(v,'ok')
```



Problem 3. Complex functions

Task 1. Set n = 0:199, then multiply n by (2π/200) to get a vector θ containing 200 values from 0 to 2π. Define the complex function z(θ) = r(θ) exp(jθ) where r(θ) is the function sin(5θ).

```
n = 0:199;
theta = n*2*pi/200;
size(theta)
```

```
ans = 1×2
     1   200
```

```
r = sin(5*theta);
z = r .* exp(j*theta);
real(z)
```

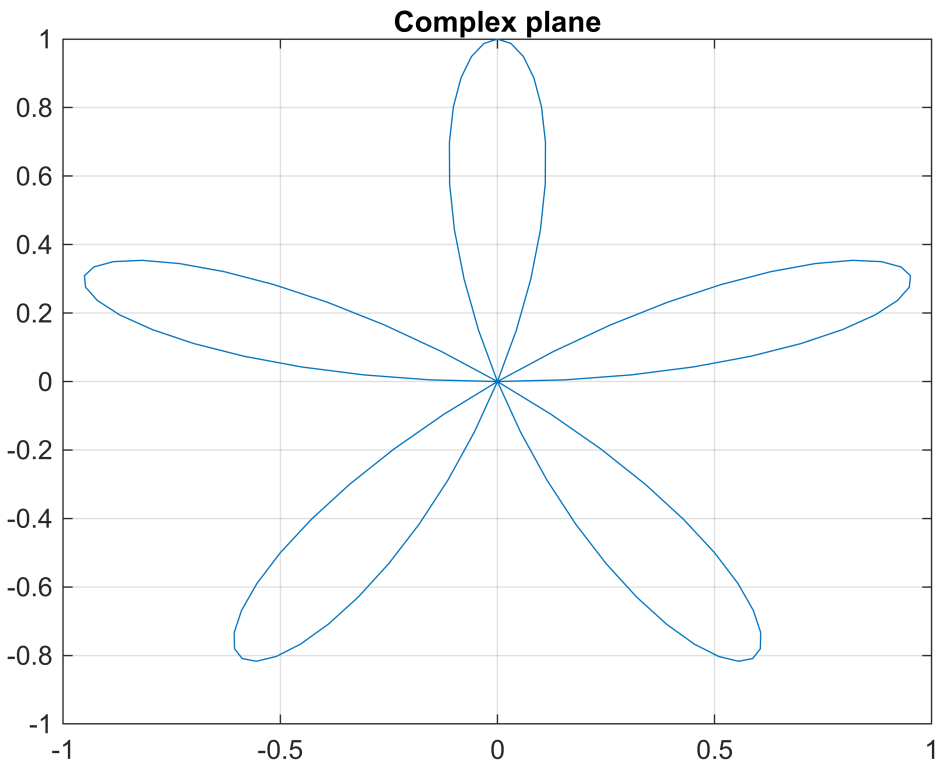
```
ans = 1×200
         0    0.1564    0.3084    0.4520    0.5832    0.6984    0.7947    0.8695 ⋯
```

```
imag(z)
```

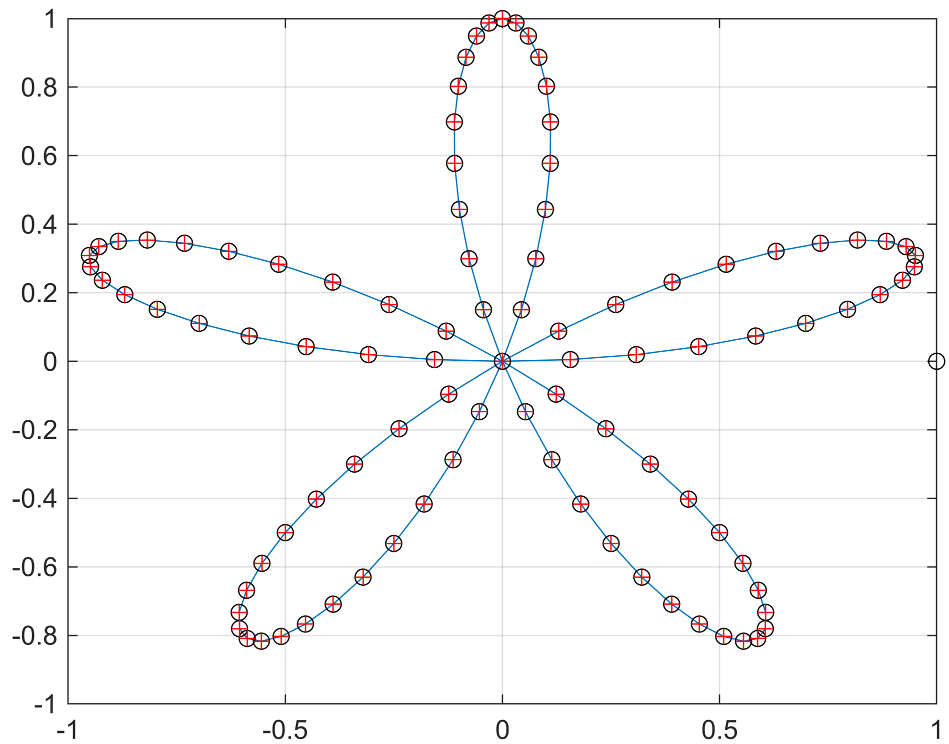
```
ans = 1×200
         0    0.0049    0.0194    0.0427    0.0737    0.1106    0.1516    0.1944 ⋯
```

Task 2. Plot the complex function z in the complex plane. Then plot an animation plotting the points successively, to see how the curve is parametrized by θ.

```
figure;
plot(z);
title('Complex plane');
grid on;
```

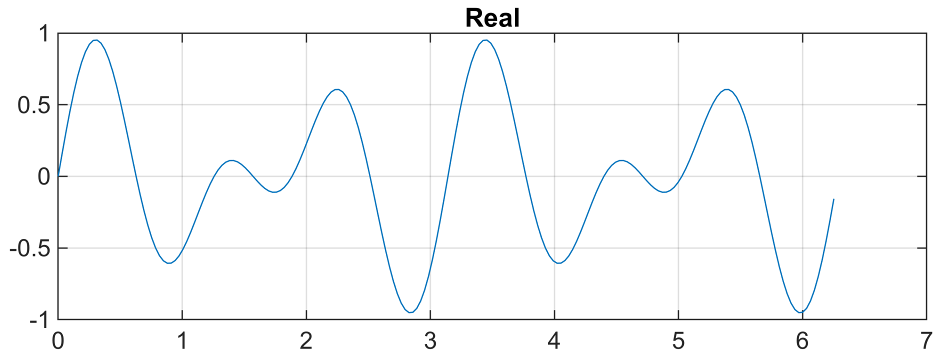


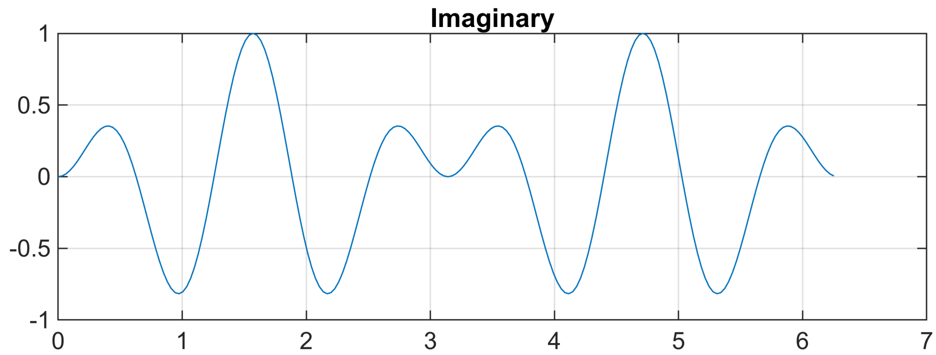

```
figure;
plot(z)
hold on
for n=1:100
    plot(z(n),'ok')
    pause(0.02);
end
for n=101:200
    plot(z(n),'+r')
    pause(0.02);
end
hold off
grid on;
```



Task 3. Plot the real and imaginary parts of z versus θ. Use `subplot to stack them in a single figure.`

```
figure;
subplot(2,1,1)
plot(theta,real(z));
title('Real');
grid on;
subplot(2,1,2)
plot(theta,imag(z));
title('Imaginary');
grid on;
hold off;
```






```
real(z)
```

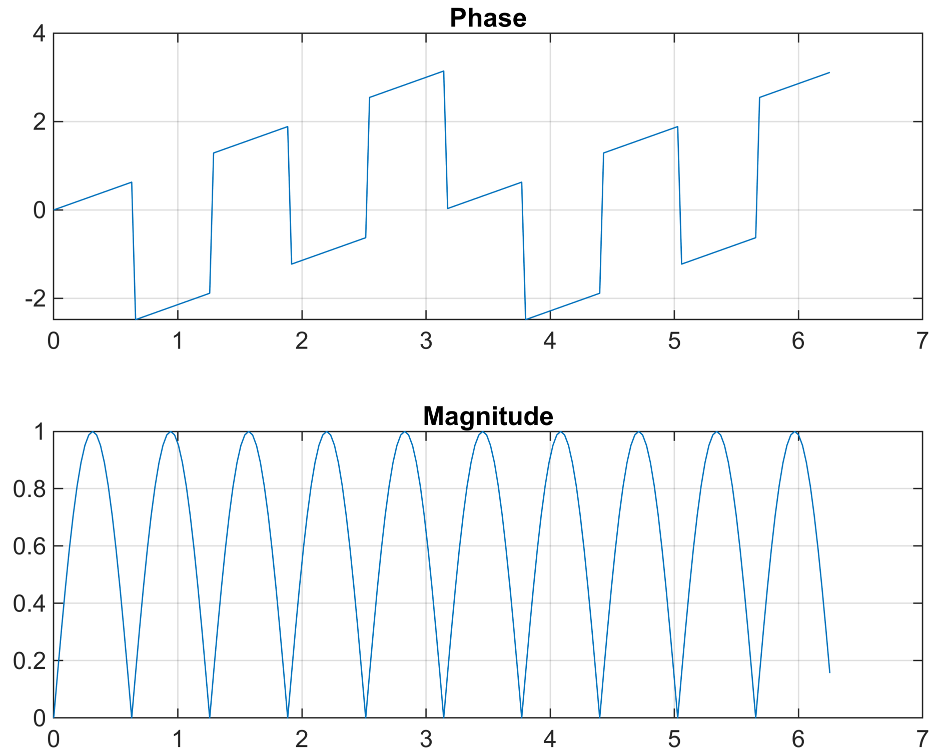
```
ans = 1×200
         0    0.1564    0.3084    0.4520    0.5832    0.6984    0.7947    0.8695 ⋯
```

```
imag(z)
```

```
ans = 1×200
         0    0.0049    0.0194    0.0427    0.0737    0.1106    0.1516    0.1944 ⋯
```

Plot the phase and magnitude of z versus θ. Use `subplot to stack them in a single figure.`

```
figure;
subplot(2,1,1)
plot(theta,angle(z));
title('Phase');
grid on;
subplot(2,1,2)
plot(theta,abs(z));
title('Magnitude');
grid on;
hold off;
```



Note: Note: The resolution of your plots depends on how many values of θ you pick between zero and 2π. With 15,000 values, the curves look continuous.

Task 4. Determine mathematically the formulas for the real and imaginary parts, expressing them as sums of sines and cosines, and convince yourself that these plots are correct.

$$\mathrm{Re}(z) = r(\theta)\cos(\theta) = \sin(5\theta)\cos(\theta) = \frac{1}{2}(\sin(6\theta) + \sin(4\theta))$$

$$\mathrm{Im}(z) = r(\theta)\sin(\theta) = \sin(5\theta)\sin(\theta) = \frac{1}{2}(-\cos(6\theta) + \cos(4\theta))$$