```
answersOn = true;
```

Communications Electronics -- Homework 1

Frequency Wavelengths and Bandwidth

Problem 1

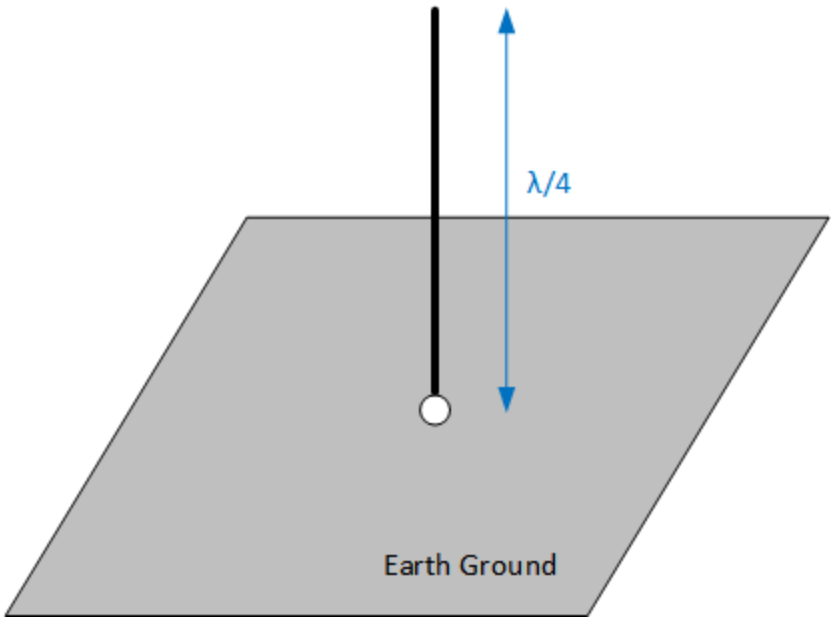
Compute the wavelength (in meters) of a signal in free space with a frequency of 350 MHz.

```
clearvars -except answersOn
speedOfLight = 3e8;  %  meters per second
frequency = 350e6;   %  Hertz

%  Calculate the wavelength in freespace which is c/f -- c is the speed of
light and f
%  is the frequency

lambda = speedOfLight / frequency;

if answersOn
    fprintf('The wavelength of a signal with a frequency of %3.0f MHz is %1.4f
meters\n', frequency/1e6, lambda )
end
```

```
The wavelength of a signal with a frequency of 350 MHz is 0.8571 meters
```

Problem 2

A quarter wavelength antenna is often used as a vertical antenna mounted on the ground. The antenna is one-quarter wavelength long and the signal is reflected from the earth ground. Compute the length (in meters) of a quarter wavelength antenna for a frequency of 146 MHz.

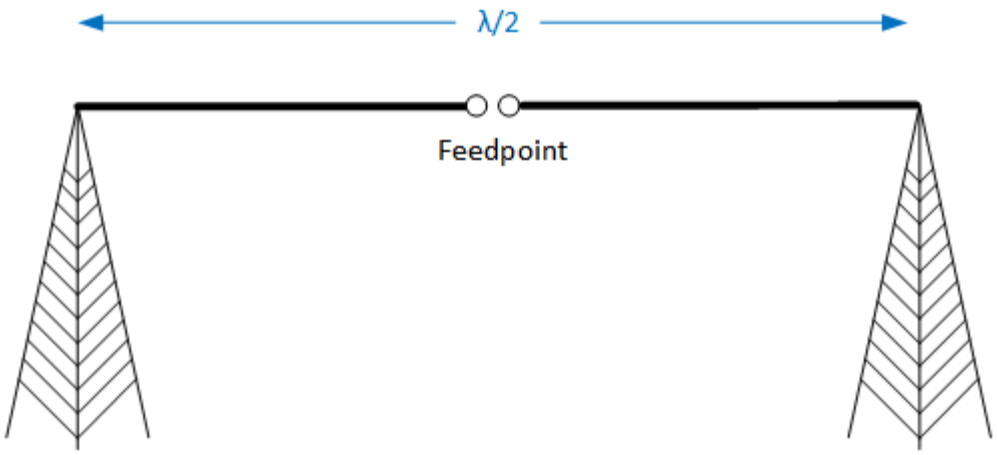



```
clearvars -except answersOn
speedOfLight = 3e8;  %  meters per second
frequency = 146e6;   %  Hertz

%  First calculate the wavelength in freespace which is c/f -- c is the speed
of light and f
%  is the frequency

lambda = speedOfLight / frequency;


%  Since the antenna is 1/4 of this wavelength simply divide by 4
antennaLength = lambda / 4;

if answersOn
    fprintf('The lenth of the quarter wavelength antenna at a freqeuncy of
%3.2f MHz is %1.4f meters\n', frequency/1e6, lambda )
end
```

```
The lenth of the quarter wavelength antenna at a freqeuncy of 146.00 MHz is 2.0548 meters
```

Problem 3

A half-wave dipole is an antenna that is mounted between two objects (towers, trees, etc..) and is fed with a signal in the center. The length of the antenna is one-half of the wavelength of the signal frequency. What is the length of a half wavelength dipole antenna (in meters) for a frequency of 7.1 MHz which is in the Ham radio band.



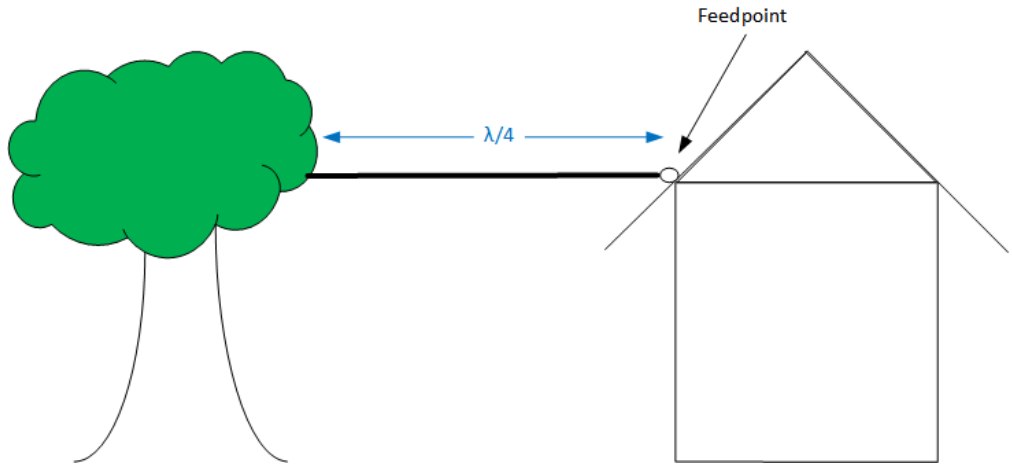

```
clearvars -except answersOn
speedOfLight = 3e8;  %  meters per second
frequency = 7.1e6;   %  Hertz

%  First calculate the wavelength in freespace which is c/f -- c is the speed
of light and f
%  is the frequency

lambda = speedOfLight / frequency;


%  Since the antenna is 1/2 of this wavelength simply divide by 2
antennaLength = lambda / 2;

if answersOn
    fprintf('The lenth of the halfwave dipole antenna at a freqeuncy of %3.2f
MHz is %1.4f meters\n', frequency/1e6, lambda )
end
```

```
The lenth of the halfwave dipole antenna at a freqeuncy of 7.10 MHz is 42.2535 meters
```

Problem 4

My neighbor has installed an end-fed wire antenna from his attic to a nearby tree. The length of the wire looks to be about 70 feet long. I know that an end-fed antenna is typically about one-quarter

wavelength long. Estimate the frequency at which my neighbor is transmitting or receiving. Recall that the speed of light in freespace is 186,282 miles/sec




```
clearvars -except answersOn
speedOfLight = 186282;  %  miles per second
lambdaOver4 =  70;  %  feet

%  First calculate the wavelength by multiplying by 4

lambda = lambdaOver4 * 4;  % feet
lambdaMiles = lambda / 5280;  % Miles

%
% Calcuate the frequency based on the freespace velocity   f = c/lambda
%

frequency = speedOfLight / lambdaMiles;


if answersOn
    fprintf('The frequency my neighbor is using is approximately %3.2f MHz\n',
frequency/1e6 )
end
```

```
The frequency my neighbor is using is approximately 3.51 MHz
```

Problem 5

Near Field Communications (NFC) is a technology that is used in cellphone and other devices to communicate over very short ranges (~ 4 cm). It can be used to make credit card and banking transactions at Wegmans or other retail stores and many other applications. If the wavelength in freespace of the signal that is used in NFC is 22.12 meters, what is the frequency that is used for NFC?

```
clearvars -except answersOn
speedOfLight = 3e8;  %  meters per second
lambda = 22.12;   %  Meters

%  Calculate the frequency in freespace which is c/lambda -- c is the speed
%  of light and lambda is the wavelength

frequency = speedOfLight / lambda;


if answersOn
    fprintf('The frequency of NFC communications is %3.2f MHz\n', frequency/1e6
)
end
```

```
The frequency of NFC communications is 13.56 MHz
```

Problem 6

I want to transmit a signal from my radio station in Rochester NY to my father who lives in Western Massachusetts, a distance of 230 miles. How long will it take my transmission to get to my father after I transmit the signal? Recall that the propagation time is

```
clearvars -except answersOn
speedOfLight = 186282;  %  miles per second
distance = 230;   %  Miles

%  Calculate the propagation time

propTime = distance / speedOfLight;


if answersOn
```

```
    fprintf('It will take %3.3f microseconds to reach my father''s house.\n',
propTime/1e-6 )
 end
```

```
It will take 1234.687 microseconds to reach my father's house.
```

Problem 7

NASA can send control signals to the MARs rover using radio waves and the MARs rover transmits telemetry signals from Mars back to earth. What is the delay (in minutes) from the time that the MARs rover transmits and the signal is received on earth? Assume freespace transmission and the average distance from Mars to the Earth is 140 million miles.

```
 clearvars -except answersOn
 speedOfLight = 186282;  %  miles per second  Speed of light
 distance = 140e6;   %  Miles  Distance to Mars

 %  Calculate the propagation time

 propTimeSeconds = distance / speedOfLight;
 propTimeMinutes = propTimeSeconds/60;


 if answersOn
    fprintf('It will take %3.3f minutes for the signal from Mars Rover to reach
the earty\n', propTimeMinutes )
 end
```

```
It will take 12.526 minutes for the signal from Mars Rover to reach the earty
```

Problem 8

In an RG213 coaxial cable, the velocity or propagation of a signal is slower than that in free space. In RG213 coaxial cable it is 66% of the speed of light. How long does it take for a signal to travel from one end to the other in a RG213 coaxial cable that is 12 miles long?

```
 clearvars -except answersOn
 speedOfLight = 186282;  %  miles per second  Speed of light
```

```
distance = 12;   %  Miles  Length of cable
velocityConstant = 0.66;

%  Calcuate the speed of the signal in the coaxial cable
speedInRG213 = speedOfLight * velocityConstant;

%  Calculate the propagation time

propTimeSeconds = distance / speedInRG213;


if answersOn
    fprintf('It will take %3.3f microseconds for the signal to travel the
length of the RG213 coaxial cable\n', propTimeSeconds/1e-6 )
end
```

```
It will take 97.604 microseconds for the signal to travel the length of the RG213 coaxial
cable
```

Problem 9

A narrowband communications signal used for public safety communications to communicate audio has a spectrum that looks like the figure below. The following is a list of the frequencies shown in the diagram. The regions indicate the 50% total power, 90% total power and the 99% total power bandwidths.

F1 = 459.975 MHz

F2 = 459.990 MHz

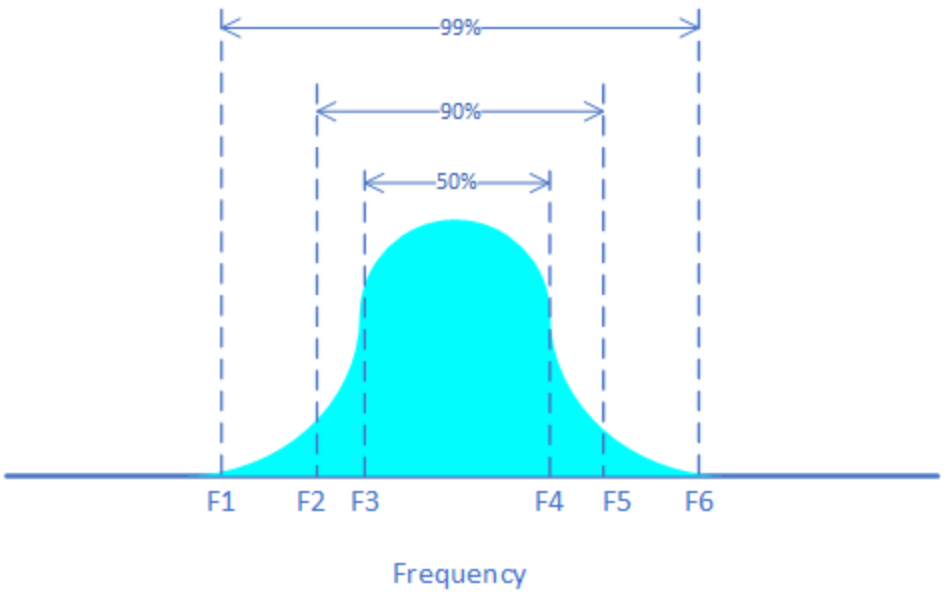
F3 = 459.995 MHz

F4 = 460.005MHz

F5 = 460.010 MHz

F6 = 460.025 MHz

What are the 50%, 90% and 99% bandwidths of the signal?




```
clearvars -except answersOn
f1 = 459.975e6;  %  Hz  -99%
f2 = 459.990e6;  %  Hz  -90%
f3 = 459.995e6;  %  Hz  -50%
f4 = 460.005e6;  %  Hz  +50%
f5 = 460.010e6;  %  Hz  +90%
f6 = 460.025e6;  %  Hz  +99%

pct50BW = f4 - f3;
pct90BW = f5 - f2;
pct99BW = f6 - f1;

if answersOn
    fprintf('The 50 percent BW is %3.3f kHz.\nThe 90 percent BW is %3.3f
kHz\nThe 99 percent BW is %3.3f kHz\n', pct50BW/1e3, pct90BW/1e3, pct99BW/1e3)
end
```

```
The 50 percent BW is 10.000 kHz.
The 90 percent BW is 20.000 kHz
The 99 percent BW is 50.000 kHz
```

Problem 10

A 5 GHz WiFi communications signal has a spectrum that looks like the figure below and is centered at 5280 MHz. The following is a list of the approximate frequencies shown in the diagram. The regions indicate the 50% total power, 90% total power and the 99% total power bandwidths.

F1 = 5264 MHz

F2 = 5269 MHz

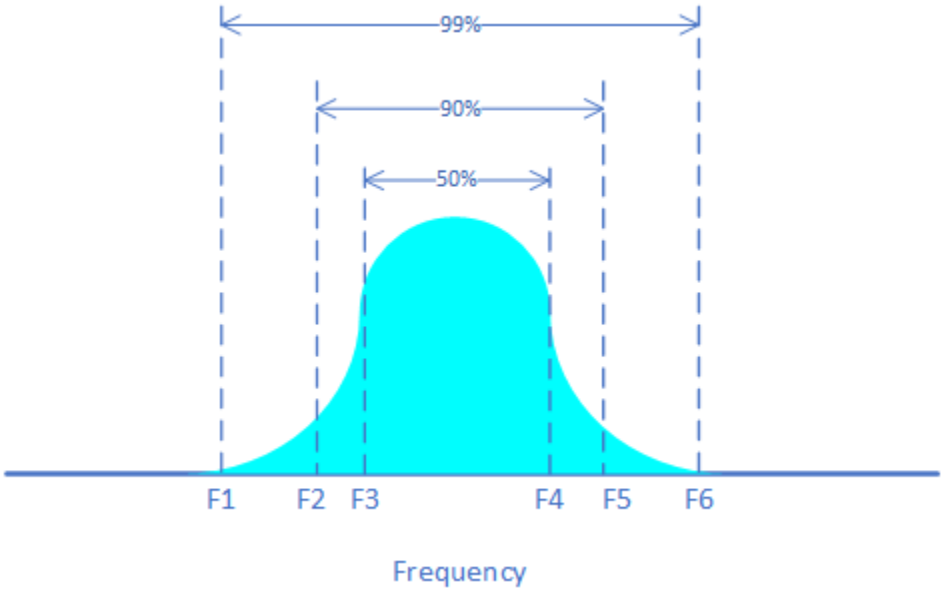
F3 = 5271 MHz

F4 = 5289 MHz

F5 = 5291 MHz

F6 = 5296 MHz

What are the 50%, 90% and 99% bandwidths of the signal?

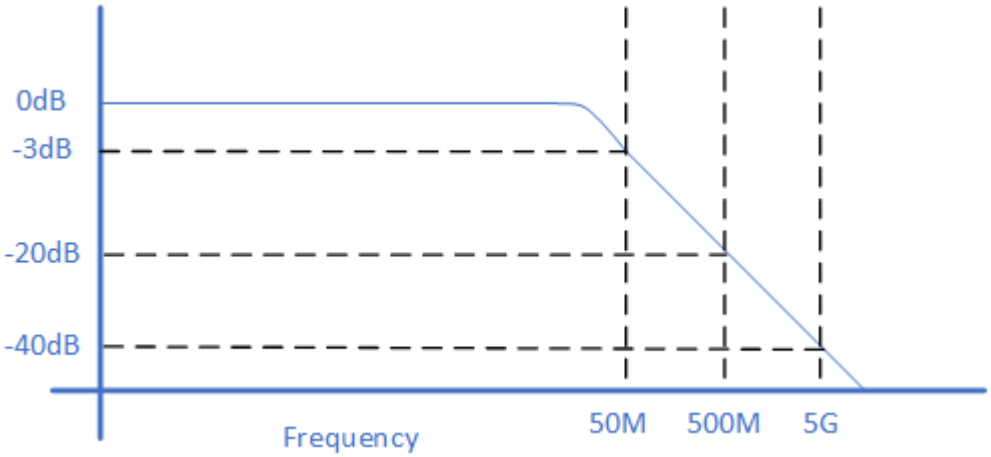



```
clearvars -except answersOn
f1 = 5264e6;  %  Hz  -99%
f2 = 5269e6;  %  Hz  -90%
f3 = 5271e6;  %  Hz  -50%
f4 = 5289e6;  %  Hz  +50%
f5 = 5291e6;  %  Hz  +90%
f6 = 5296e6;  %  Hz  +99%

pct50BW = f4 - f3;
pct90BW = f5 - f2;
pct99BW = f6 - f1;
if answersOn
    fprintf('The 50 percent BW is %3.3f MHz.\nThe 90 percent BW is %3.3f
MHz\nThe 99 percent BW is %3.3f MHz\n', pct50BW/1e6, pct90BW/1e6, pct99BW/1e6)
end
```

```
The 50 percent BW is 18.000 MHz.
The 90 percent BW is 22.000 MHz
The 99 percent BW is 32.000 MHz
```

Problem 11

A low pass filter has the shape shown below. What are the 3dB, 20dB and 40 dB bandwidths?

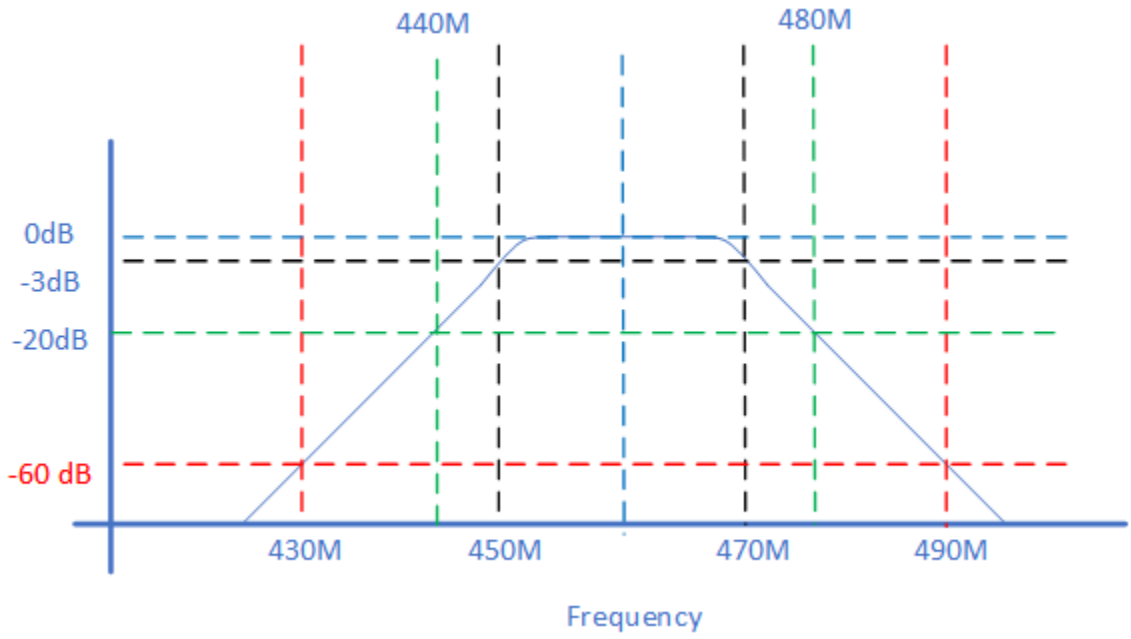



```
clearvars -except answersOn
% Observing the filter frequency response chart
%
bw3 = 50;
bw20 = 500;
bw40 = 5000;

if answersOn
    fprintf('The 3dB bandwidth is %3.2f MHz\nThe 20 dB bandwidth is %3.2f
MHz\nThe 40 dB bandwidth is %3.2f MHz', bw3, bw20, bw40)
end
```

```
The 3dB bandwidth is 50.00 MHz
The 20 dB bandwidth is 500.00 MHz
The 40 dB bandwidth is 5000.00 MHz
```

Problem 12

A front end filter for a public safety band radio operating in the UHF band has a frequency response that looks like the figure below. What is the 3dB BW of the filter? What are the 20 dB and 60 dB bandwidths?




```
clearvars -except answersOn
% Observing the filter frequency response chart
%
bw3 = 470 - 450;  % MHz
bw20 = 480 - 440;  %  MHz
bw60 = 490 - 430;  % MHz

if answersOn
    fprintf('The 3dB bandwidth is %3.2f MHz\nThe 20 dB bandwidth is %3.2f
MHz\nThe 60 dB bandwidth is %3.2f MHz', bw3, bw20, bw60)
end
```

```
The 3dB bandwidth is 20.00 MHz
The 20 dB bandwidth is 40.00 MHz
The 60 dB bandwidth is 60.00 MHz
```