SS414 Practical 1

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In [1]:

```
%matplotlib inline
import pylab as pl
pl.style.use('bmh')
pl.rcParams['figure.figsize'] = (13, 2)
import numpy as np
```

Question 1: ¶

In [2]:

```
def sinewave(A,F,t):
    x = A*np.sin(F*2*np.pi*t)
    return x


A = 2
F = 50
t = np.linspace(0,0.05,100,False)
x = sinewave(A,F,t)
```

Print the x and t array for manual checking:

In [3]:

```
print(x)
```

```
[  0.00000000e+00   3.12868930e-01   6.18033989e-01   9.07980999e-01
   1.17557050e+00   1.41421356e+00   1.61803399e+00   1.78201305e+00
   1.90211303e+00   1.97537668e+00   2.00000000e+00   1.97537668e+00
   1.90211303e+00   1.78201305e+00   1.61803399e+00   1.41421356e+00
   1.17557050e+00   9.07980999e-01   6.18033989e-01   3.12868930e-01
   2.44929360e-16  -3.12868930e-01  -6.18033989e-01  -9.07980999e-01
  -1.17557050e+00  -1.41421356e+00  -1.61803399e+00  -1.78201305e+00
  -1.90211303e+00  -1.97537668e+00  -2.00000000e+00  -1.97537668e+00
  -1.90211303e+00  -1.78201305e+00  -1.61803399e+00  -1.41421356e+00
  -1.17557050e+00  -9.07980999e-01  -6.18033989e-01  -3.12868930e-01
  -4.89858720e-16   3.12868930e-01   6.18033989e-01   9.07980999e-01
   1.17557050e+00   1.41421356e+00   1.61803399e+00   1.78201305e+00
   1.90211303e+00   1.97537668e+00   2.00000000e+00   1.97537668e+00
   1.90211303e+00   1.78201305e+00   1.61803399e+00   1.41421356e+00
   1.17557050e+00   9.07980999e-01   6.18033989e-01   3.12868930e-01
   7.34788079e-16  -3.12868930e-01  -6.18033989e-01  -9.07980999e-01
  -1.17557050e+00  -1.41421356e+00  -1.61803399e+00  -1.78201305e+00
  -1.90211303e+00  -1.97537668e+00  -2.00000000e+00  -1.97537668e+00
  -1.90211303e+00  -1.78201305e+00  -1.61803399e+00  -1.41421356e+00
  -1.17557050e+00  -9.07980999e-01  -6.18033989e-01  -3.12868930e-01
  -9.79717439e-16   3.12868930e-01   6.18033989e-01   9.07980999e-01
   1.17557050e+00   1.41421356e+00   1.61803399e+00   1.78201305e+00
   1.90211303e+00   1.97537668e+00   2.00000000e+00   1.97537668e+00
   1.90211303e+00   1.78201305e+00   1.61803399e+00   1.41421356e+00
   1.17557050e+00   9.07980999e-01   6.18033989e-01   3.12868930e-01]
```

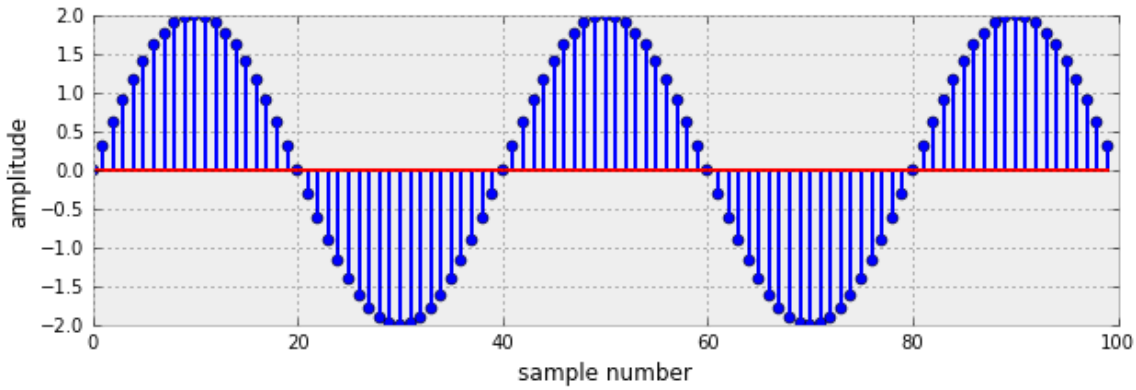
Plot the x-array:

In [4]:

```
%matplotlib inline
pl.figure(figsize=(10,3))
pl.xlabel('sample number')
pl.ylabel('amplitude')
pl.stem(x)
```

Out[4]:

```
<Container object of 3 artists>
```



Question 2:

In [5]:

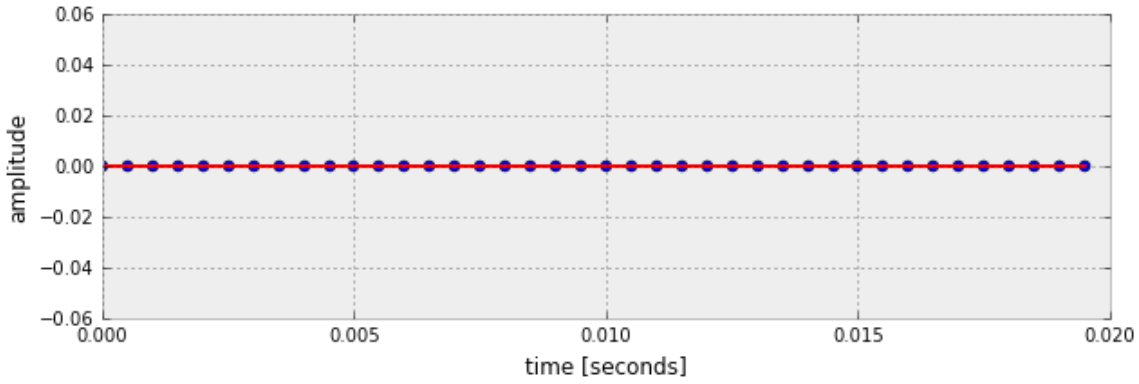
```
A = 10
fs = 2000
T = 1 / fs
n = np.arange(40)
```

In [6]:

```
%matplotlib inline
F = 0
t = n*T
x = sinewave(A,F,t)
pl.figure(figsize=(10,3))
pl.xlabel('time [seconds]')
pl.ylabel('amplitude')
pl.stem(n/fs,x)
```

Out[6]:

```
<Container object of 3 artists>
```

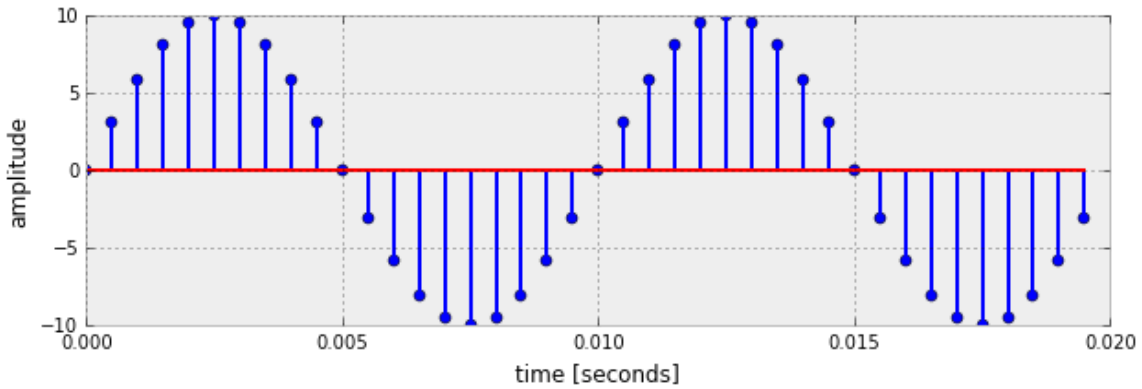


In [7]:

```
%matplotlib inline
F = 100
x = sinewave(A,F,t)
pl.figure(figsize=(10,3))
pl.xlabel('time [seconds]')
pl.ylabel('amplitude')
pl.stem(n/fs,x)
```

Out[7]:

```
<Container object of 3 artists>
```

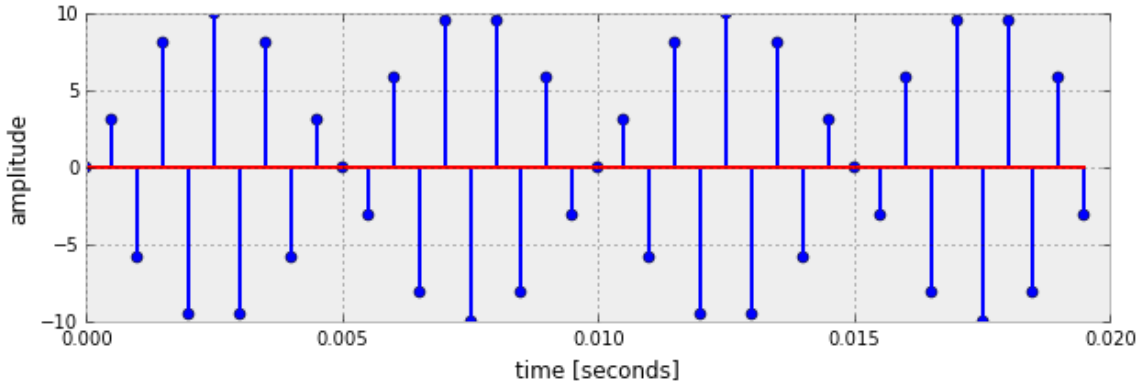


In [8]:

```
%matplotlib inline
F = 900
x = sinewave(A,F,t)
pl.figure(figsize=(10,3))
pl.xlabel('time [seconds]')
pl.ylabel('amplitude')
pl.stem(n/fs,x)
```

Out[8]:

<Container object of 3 artists>

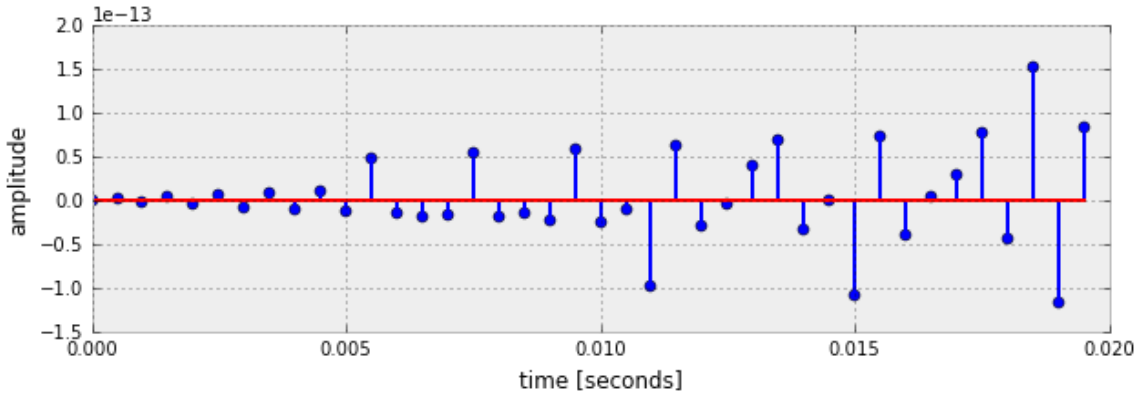


In [9]:

```
%matplotlib inline
F = 1000
x = sinewave(A,F,t)
pl.figure(figsize=(10,3))
pl.xlabel('time [seconds]')
pl.ylabel('amplitude')
pl.stem(n/fs,x)
```

Out[9]:

<Container object of 3 artists>

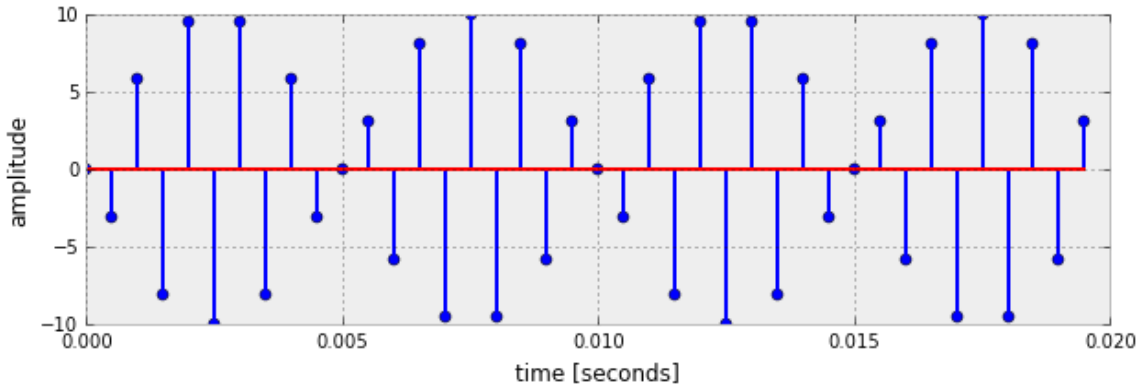


In [10]:

```
%matplotlib inline
F = 1100
x = sinewave(A,F,t)
pl.figure(figsize=(10,3))
pl.xlabel('time [seconds]')
pl.ylabel('amplitude')
pl.stem(n/fs,x)
```

Out[10]:

<Container object of 3 artists>

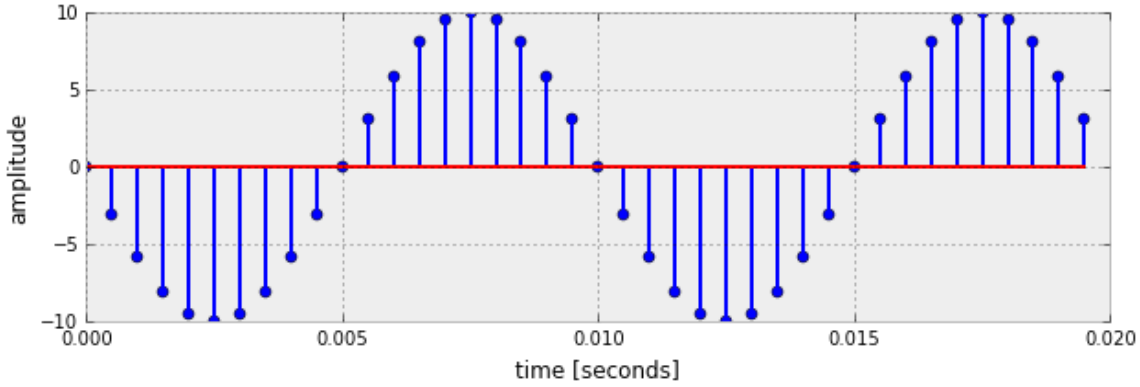


In [11]:

```
%matplotlib inline
F = 1900
x = sinewave(A,F,t)
pl.figure(figsize=(10,3))
pl.xlabel('time [seconds]')
pl.ylabel('amplitude')
pl.stem(n/fs,x)
```

Out[11]:

<Container object of 3 artists>

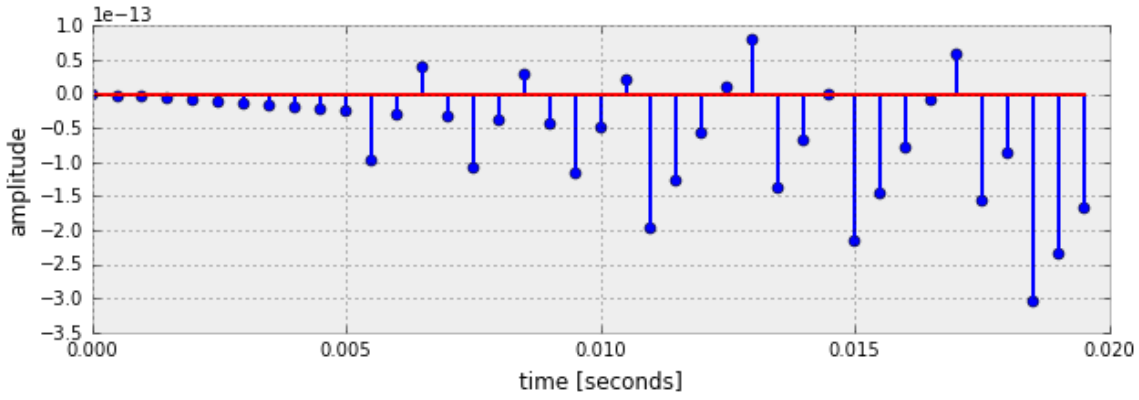


In [12]:

```
%matplotlib inline
F = 2000
x = sinewave(A,F,t)
pl.figure(figsize=(10,3))
pl.xlabel('time [seconds]')
pl.ylabel('amplitude')
pl.stem(n/fs,x)
```

Out[12]:

```
<Container object of 3 artists>
```

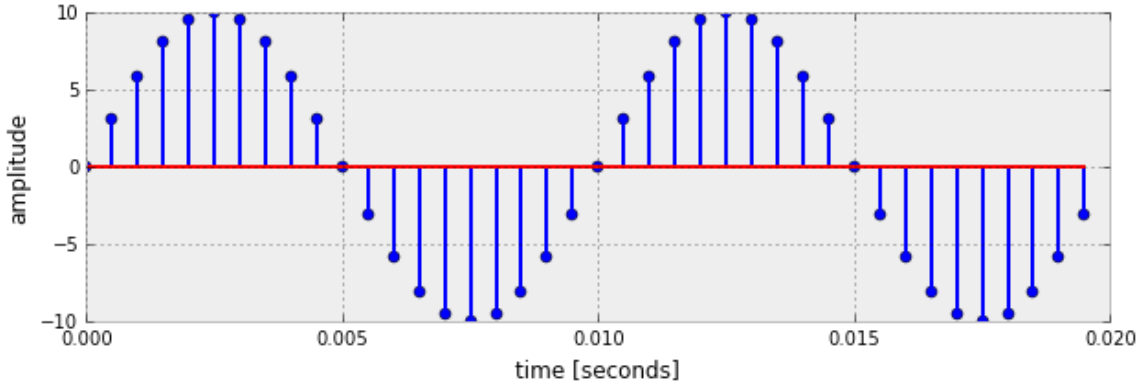


In [13]:

```
%matplotlib inline
F = 2100
x = sinewave(A,F,t)
pl.figure(figsize=(10,3))
pl.xlabel('time [seconds]')
pl.ylabel('amplitude')
pl.stem(n/fs,x)
```

Out[13]:

```
<Container object of 3 artists>
```



In [ ]:

interpretation: when the sampling frequency is an exact multiple of the sines frequency, no information is gained because the same point on each cycle. If the sampling frequency is a little more or less than the sine's frequency, a sine (of the same frequency as the sampling rate) is detected by the sampling because the each sample moves a bit forward or back on the sine's cycle. If the sampling frequency is a little more or less than twice the sine's frequency, the sample will alternate signs because it detects on both the positive and negative parts of each sine's cycle. However, a sine is still detected, but the frequency is not.

The digital frequency is the sine's period divided by the sampling period. For example, if F=100:

In [14]:

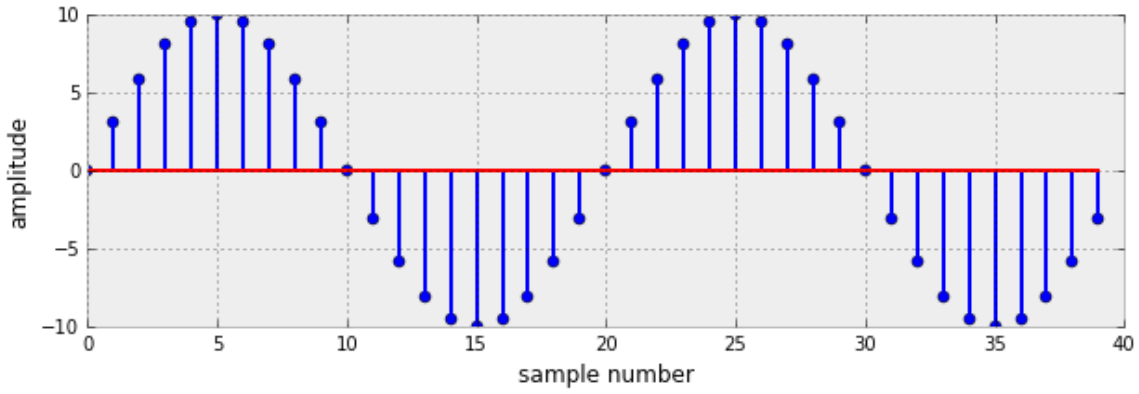
```
F = 100
fw = (1/F)/(T)
x = sinewave(A,F,n*T)
```

In [15]:

```
%matplotlib inline
pl.figure(figsize=(10,3))
pl.xlabel('sample number')
pl.ylabel('amplitude')
pl.stem(x)
```

Out[15]:

```
<Container object of 3 artists>
```



Question 3:

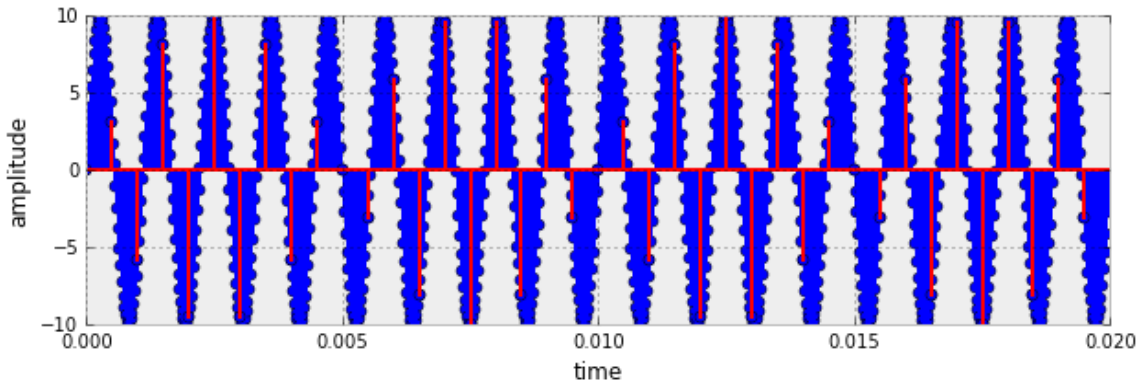
In [16]:

```
%matplotlib inline
n = np.arange(800)
fs = 40000
T = 1/fs
F = 900
x = sinewave(A,F,n*T)
pl.figure(figsize=(10,3))
pl.xlabel('time')
pl.ylabel('amplitude')
pl.stem(n/fs,x)


fs = 2000
n = np.arange(40)
T = 1/fs
y = sinewave(A,F,n*T)
pl.stem(n/fs,y,'r')
```

Out[16]:

```
<Container object of 3 artists>
```



This confirms my interpretation.

Question 4

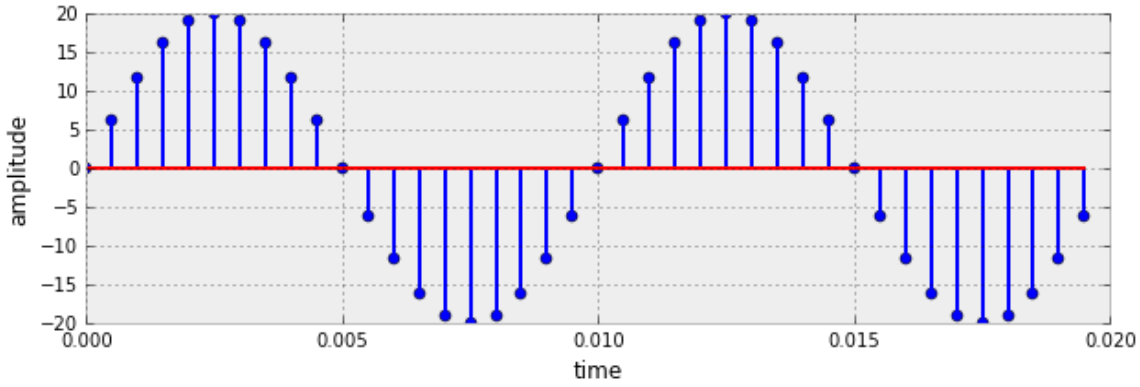
In [17]:

```
A = 10
fs = 2000
T = 1/fs
n = np.arange(40)

pl.figure(figsize=(10,3))
pl.xlabel('time')
pl.ylabel('amplitude')
x = sinewave(A,100,n*T) + sinewave(A,2100,n*T)
pl.stem(n/fs,x)
```

Out[17]:

```
<Container object of 3 artists>
```



Since an 100Hz sine and a 2100Hz sine has the same frequency offset of an integer multiple of the sampling frequency, their sampled signals are the same.

Question 5

The period of a 100Hz sine is 10 ms and its sampled signal has a period of 20 samples.

The period of a 900Hz sine is 1.11 ms. Its sampled sampled signal has 20 samples and not 22 because of the effects explained in question 2.

To get the sampled signal's period in seconds, divide the number of samples by the sampling frequency: 20/2000 = 0.01 seconds

$w = 2\pi f$

$900 rad/s = 900 * 2\pi Hz$

$f = 900 Hz$

Thus, a 900rad/s sine wave is the same as a 900Hz sine wave and has all the same attributes.

In [ ]: