In [4]:

```
print(1, 16, 1/16, 'text') #note for python 2.7 users: 1/16 -> 0 in python 2.7
```

```
1 16 0.0625 text
```

In [5]:

```
print( '1 divided by 16 is %f' % (1/16) )
print( '1 divided by 16 is %.2f' % (1/16) )
print( '1 divided by 16 is %.2f and 1 divided by 32 is %.2f' % (1/16, 1/32) )
```

```
1 divided by 16 is 0.062500
1 divided by 16 is 0.06
1 divided by 16 is 0.06 and 1 divided by 32 is 0.03
```

2. Numbers and Variables

String, integer, float and bool (logical) variables are ubiquitous data types in Python.

In [6]:

```
var1 = 'Welcome to COMP5318' #alternative: you may use double quotation marks as
 in  "Welcome to COMP5318"
print(var1, ' is ',type(var1))

var2 = 10
print(var2, ' is ',type(var2))

var3 = 10.0 #alternative: 10.
print(var3, ' is ',type(var3))

var4 = True
print(var4, ' is ',type(var4))
```

```
Welcome to COMP5318  is  <class 'str'>
10  is  <class 'int'>
10.0  is  <class 'float'>
True  is  <class 'bool'>
```

2. Lists

A list is a mutable, i.e. values can be changed (add/delete/update), sequence. Since each element has a fixed position, an index which starts from 0 can be used access elements. Although it can contain any type of variable, using heterogeneous variables is not customary. There are immutable data structures such as "tuples" and unordered data structures such as "sets" that we do not discuss in this tutorial.

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In [5]:

```
#For students familiar with MATLAB, indexing and lenght of  arrays can be trick
y.

seq = [2, 10, 20, 30, 50, 80, 130, 210, 340]

print('seq = ', seq)
print('seq[0] = ', seq[0])
print('seq[3] = ', seq[3])
print('seq[3] = ', seq[0:3]) #alternative: seq[:3]
print('seq[3:6] = ', seq[3:6])
print('seq[-1] = ', seq[-1])
print('seq[3:-3] = ', seq[3:-3])
```

```
seq =  [2, 10, 20, 30, 50, 80, 130, 210, 340]
seq[0] =  2
seq[3] =  30
seq[3] =  [2, 10, 20]
seq[3:6] =  [30, 50, 80]
seq[-1] =  340
seq[3:-3] =  [30, 50, 80]
```

Exercise 2.1

Use $len()$ to calculate the length (number of elements) of lists.

Exercise 2.2

Use $.append()$ to add an element to the end of a list.

For more methods of list objects such as $.sort()$, $.count()$, $.reverse()$ refer https://docs.python.org/2/tutorial/datastructures.html (https://docs.python.org/2/tutorial/datastructures.html). Note that lists can be used as queues with some of these methods.

In [2]:

```
fruitSalad = ['Banana', 'Cantaloupe', 'Apple', 'Tomato']
print(fruitSalad)

fruitSalad.remove('Tomato')
fruitSalad.append('Papaya')
fruitSalad.append('Grapes')
print(fruitSalad)

fruitSalad.append('Strawberry')
print(fruitSalad)
```

```
['Banana', 'Cantaloupe', 'Apple', 'Tomato']
['Banana', 'Cantaloupe', 'Apple', 'Papaya', 'Grapes']
['Banana', 'Cantaloupe', 'Apple', 'Papaya', 'Grapes', 'Strawberry']
```

4. Arithmetic Operators

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In [7]:

```
x = 10
y = 20
z = x + y
print('x=%d, y=%d, z=%d' % (x, y, z)) #alternative for printing: print('x=',x,
  'y=',y, 'z=',z)
```

```
x=10, y=20, z=30
```

Exercise 4.1 Identify the use of following arithmetic operators. $+, -, *, /, \%, **, //$

In [8]:

```
#string operations
firstName = 'Alan'
lastName = 'Turing'
fullName = firstName + ' ' + lastName
print(fullName)
```

```
Alan Turing
```

5. Relational and Logical Operators

Relational operators are used to identify the relationship between two entities (e.g. variables) and the output is either True or False.

In [9]:

```
print(20>10)
```

```
True
```

Exercise 5.1 Identify the use of following relational operators. $==, !=, >, <, >=, <=$

In [10]:

```
x = 2
y= 1.1*(x**2) - 15*x - 20
if y>0:
    print('y is positive')
else:
    print('y is non-positive')
```

```
y is non-positive
```

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In [11]:

```
x = 2
y= 1.1*(x**2) - 15*x - 20
if y==0:
    print('y is zero')
elif y>0:
    print('y is positive')
else:
    print('y is negative')
```

```
y is negative
```

In [12]:

```
x = 10
a, b = -15, 15
if x>a and x<b: #alternative: a<x<b
    print('In range!')
else:
    print('Out of range!')
```

```
In range!
```

Exercise 5.2

Identify the use of following logical operators: and, or and not

6. Math Library

This can be considered as the generic library for mathematics in python.

In [13]:

```
import math

theta = 2*math.pi
y = math.cos(theta)**2 + math.sin(theta)**2
print(y)
```

```
1.0
```

7. Iterations

In [18]:

```
sum_var = 0
for i in range(10): #alternative: range(0,10,1)
    sum_var = sum_var + i #: alternative sum_var += i
print(sum_var)
```

```
45
```

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In [16]:

```
x = [10, 20, 30, -35, 5.5]
sum_var = 0
for i in x:
    sum_var = sum_var + i
print(sum_var)
```

```
30.5
```

Exercise 7.1 Append the above program to add all positive numbers in list x.

In [16]:

```
x = [i for i in range(10)]
print(x)

y = [i**2 for i in x] # or [i**2 for i in range(10)]
print(y)
```

```
[0, 1, 2, 3, 4, 5, 6, 7, 8, 9]
[0, 1, 4, 9, 16, 25, 36, 49, 64, 81]
```

Exercise 7.2 Let $\mathbf{x} = [3, 1, 2, 4]$ and $\mathbf{y} = [1, 2, 1, 2]$. Calculate the similarity between $\mathbf{x}$ and $\mathbf{y}$ using,

1) Cosine distance defined as $\text{sim}_{dot}(\mathbf{x}, \mathbf{y}) = \mathbf{x} \cdot \mathbf{y}/\|\mathbf{x}\|\|\mathbf{y}\|$

2) Eucledian distance (a.k.a L^2 distance) defined as $\text{sim}_{Euc}(\mathbf{x}, \mathbf{y}) = \|\mathbf{x} - \mathbf{y}\|_2 = \sqrt{\sum_{i=1}^{N}(x_i - y_i)^2}$

(Refer lecture 1).

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In [12]:

```
import numpy as np
x=[3,1,2,1]
y=[1,2,1,2]
def dot(x,y):
    #return sum(map(operator.mul, x, y))
    return sum([ xi*yi for xi, yi in zip(x,y)])

sim_cos = dot(x,y) / np.sqrt(dot(x,x) * dot(y,y))
sim_euc = np.sqrt(sum([(xi - yi) ** 2 for xi, yi in zip(x,y)]))

print('sim_cos = {:.3f}'.format(sim_cos)) #alternative to print('sim_cos = %.3f'
 % sim_cos)
print('sim_euc = {:.3f}'.format(sim_euc))

#My coding-------------------------------------------------------------------
---------------
s=np.array([3,1,2,1])
b=np.array([1,2,1,2])
Ls=np.sqrt(s.dot(s))
Lb=np.sqrt(b.dot(b))
cos_angle =s.dot(b) / (Ls*Lb)
def dot(s,b):
    #return sum(map(operator.mul, x, y))
    return sum([ si*bi for si, bi in zip(s,b)])
sim_euc=np.sqrt(sum([(xi-yi)**2  for xi,yi in zip(x,y)]))
print ('cos_angle=%.3f'% cos_angle)
print('sim_euc = %.3f'%sim_euc)
```

```
sim_cos = 0.735
sim_euc = 2.646
cos_angle=0.735
sim_euc = 2.646
```

8. Plotting with Matplotlib Library

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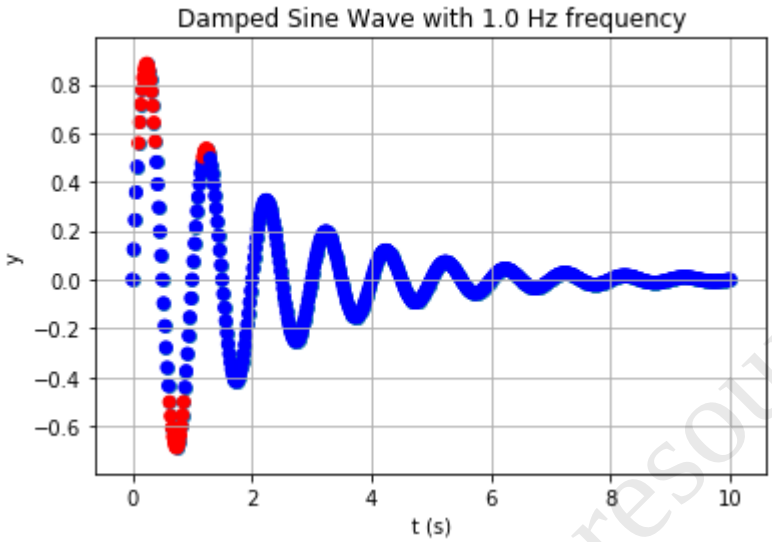
In [21]:

```
import math
import matplotlib.pyplot as pl
%matplotlib inline

t = [i/50 for i in range(501)] #generate values from 0 to 10
f = 1
y = [math.sin(2*math.pi*f*i)*math.exp(-0.5*i) for i in t] # y = sin(2Pi*f*t)*exp
(-t/2)
pl.scatter(t,y)
pl.scatter(t,y, c=['b' if -0.5<i<0.5 else 'r' for i in y]) #answer for 8.2
pl.title('Damped Sine Wave with %.1f Hz frequency' % f)
pl.xlabel('t (s)')
pl.ylabel('y')
pl.grid()
pl.show()
```



Exercise 8.1 Change *pl.scatter* to *pl.plot*.

Exercise 8.2 Highligh data points, s.t. $|y| > 0.5$ in a different marker colour.

9. Data Structures

Exercise 9.1 (Demanding question) Given a list of words, group all of them based on the following similarity metric.

$$\text{sim}(\text{word}_1, \text{word}_2) = \begin{cases} 1, & \text{if letters in only } \text{word}_1 \text{ are used to form } \text{word}_2 \text{ and vice versa } \textit{(iff)} \\ 0, & \text{otherwise} \end{cases}$$

E.g. 'arts', 'rats', 'star', 'tars' and 'start' are similar words.

Choose an appropriate data structure and analyze computational complexity of your algorithm.

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