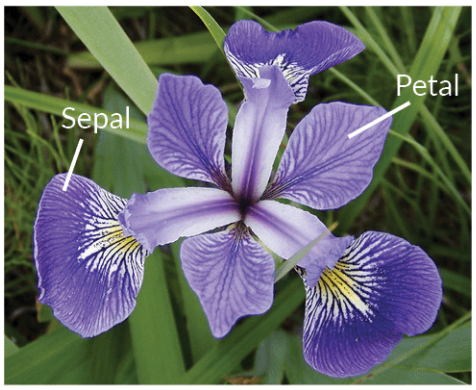
In [1]:
```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
import statsmodels.api as sm
import statsmodels.formula.api as smf
from sklearn.metrics import roc_curve,auc
%matplotlib inline
```

In [2]:
```
iris = pd.read_csv('./data/iris.csv')
iris.head()
```

Out[2]:

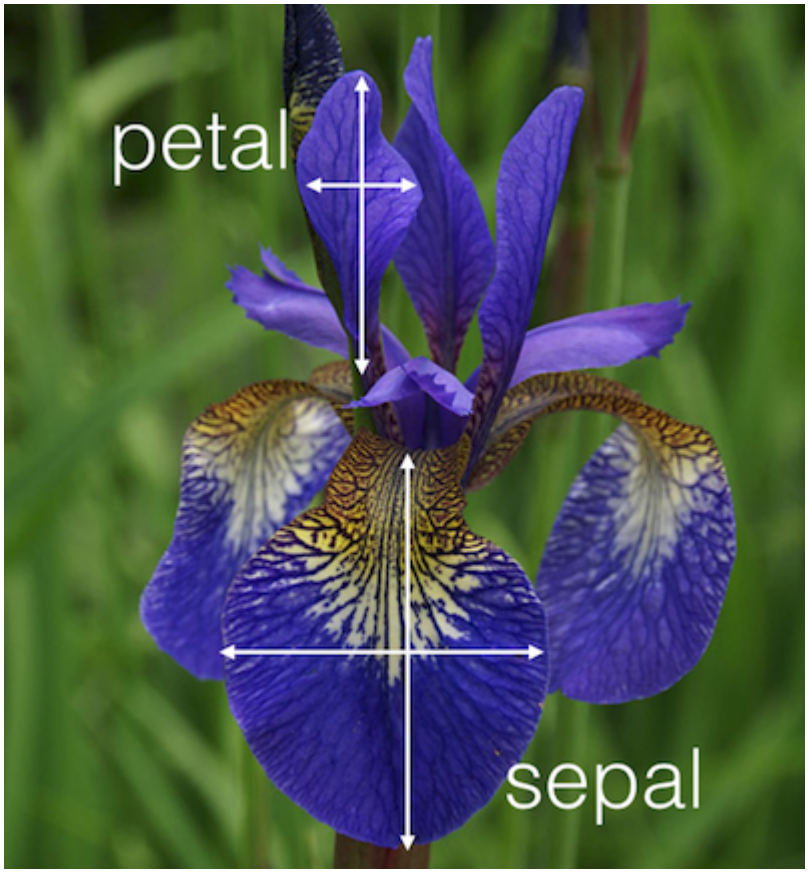
	SepalLength	SepalWidth	PetalLength	PetalWidth	Flower
0	5.1	3.5	1.4	0.2	Iris-setosa
1	4.9	3.0	1.4	0.2	Iris-setosa
2	4.7	3.2	1.3	0.2	Iris-setosa
3	4.6	3.1	1.5	0.2	Iris-setosa
4	5.0	3.6	1.4	0.2	Iris-setosa



Iris Versicolor

Iris Setosa

Iris Virginica



Data Preprocessing

- Categorical Data

In [13]:
```
flower = pd.get_dummies(iris['Flower'])
data = pd.concat((flower,iris),axis=1)
```

In [16]:
```
data.head()
```

Out[16]:

	Iris-setosa	Iris-versicolor	Iris-virginica	SepalLength	SepalWidth	PetalLength	PetalWidth	Flower
0	1	0	0	5.1	3.5	1.4	0.2	Iris-setosa
1	1	0	0	4.9	3.0	1.4	0.2	Iris-setosa
2	1	0	0	4.7	3.2	1.3	0.2	Iris-setosa
3	1	0	0	4.6	3.1	1.5	0.2	Iris-setosa
4	1	0	0	5.0	3.6	1.4	0.2	Iris-setosa

Considering two attributes

- PetalLength
- Petal Width

In [172]:
```
df = data[['PetalLength','PetalWidth','Flower']]
df.head()
```

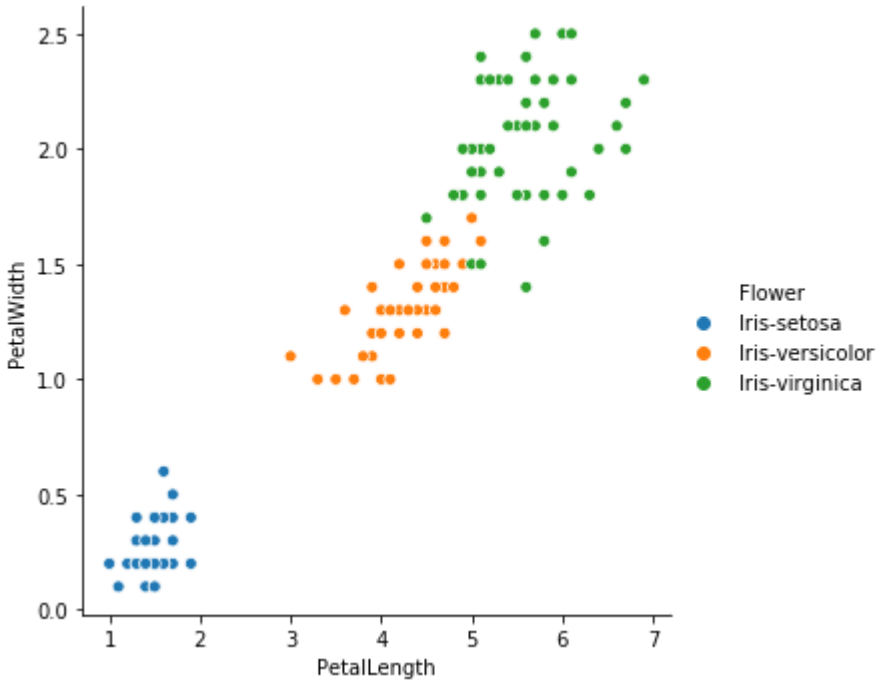
Out[172]:

	PetalLength	PetalWidth	Flower
0	1.4	0.2	Iris-setosa
1	1.4	0.2	Iris-setosa
2	1.3	0.2	Iris-setosa
3	1.5	0.2	Iris-setosa
4	1.4	0.2	Iris-setosa

visualizing data

In [174]:
```
sns.relplot(x='PetalLength',y='PetalWidth',data=df,hue='Flower')
```

Out[174]:
```
<seaborn.axisgrid.FacetGrid at 0x1da3a6ad518>
```



Split data

- independent
- dependent

In [175]:
```
X= df.iloc[:,:-1] # independent
y = df.iloc[:,-1] # dependent
```

Logistic Regression for multiclass

- Number of lines the seperate n classes = n - 1

Method-1

In [176]:
```
model = sm.MNLogit(y,X).fit()
print(model.summary())
```

```
Optimization terminated successfully.
         Current function value: 0.502085
         Iterations 10
                          MNLogit Regression Results
==============================================================================
Dep. Variable:                 Flower   No. Observations:                  150
Model:                        MNLogit   Df Residuals:                      146
Method:                           MLE   Df Model:                            2
Date:                Sat, 06 Apr 2019   Pseudo R-squ.:                  0.5430
Time:                        23:19:54   Log-Likelihood:                -75.313
converged:                       True   LL-Null:                       -164.79
                                        LLR p-value:                 1.380e-39
==============================================================================
==========
Flower=Iris-versicolor       coef    std err          z      P>|z|      [0.025
0.975]
------------------------------------------------------------------------------
----------
PetalLength               -5.5132      1.207     -4.568      0.000      -7.879
-3.148
PetalWidth                21.7362      4.703      4.621      0.000      12.518
30.955
------------------------------------------------------------------------------
----------
Flower=Iris-virginica       coef    std err          z      P>|z|      [0.025
0.975]
------------------------------------------------------------------------------
----------
PetalLength               -7.6121      1.269     -6.000      0.000     -10.099
-5.126
PetalWidth                28.1132      4.848      5.799      0.000      18.611
37.615
==============================================================================
==========
```

Method-2

In [177]:
```
model_formula = sm.MNLogit.from_formula('Flower~PetalLength+PetalWidth-1',data=i
print(model_formula.summary())
```

```
Optimization terminated successfully.
         Current function value: 0.502085
         Iterations 10
                          MNLogit Regression Results
==============================================================================
Dep. Variable:                      y   No. Observations:                  150
Model:                        MNLogit   Df Residuals:                      146
Method:                           MLE   Df Model:                            2
Date:                Sat, 06 Apr 2019   Pseudo R-squ.:                  0.5430
Time:                        23:19:56   Log-Likelihood:                -75.313
converged:                       True   LL-Null:                       -164.79
                                        LLR p-value:                 1.380e-39
==============================================================================
=============
y=Flower[Iris-versicolor]       coef    std err          z      P>|z|      [0.0
25      0.975]
------------------------------------------------------------------------------
-------------
PetalLength                 -5.5132      1.207     -4.568      0.000      -7.8
79      -3.148
PetalWidth                  21.7362      4.703      4.621      0.000      12.5
18      30.955
------------------------------------------------------------------------------
-------------
y=Flower[Iris-virginica]       coef    std err          z      P>|z|      [0.02
5      0.975]
------------------------------------------------------------------------------
------------
PetalLength                 -7.6121      1.269     -6.000      0.000     -10.09
9      -5.126
PetalWidth                  28.1132      4.848      5.799      0.000      18.61
1      37.615
==============================================================================
=============
```

Two models

1. Iris versicolor

Eq: $ln(s) = -5.5132 * PetalLength + 21.7362 * PetalWidth$

2. Iris Vignica

Eq: $ln(s) = -7.6121 * PetalLength + 28.1132 * PetalWidth$

model.predict(data[['PetalLength','PetalWidth']])

In [180]:
```
def drawline(i,p=0.5,colour = 'b'):
    inte = 0#model.params[i].Intercept
    pL =model.params[i].PetalLength
    pW = model.params[i].PetalWidth
    #np.log(p/(1-p)) = inte + pL*data['PetalLength'] + pW*data['PetalWidth']
    petallength = (-inte - pW*data['PetalWidth'] + np.log(p/(1-p)))/pL
    plt.plot(petallength,data['PetalWidth'])
```

In [181]:
```
def modelpredict(i,x1,x2):
    a = 0#model.params[i].Intercept
    b1 =model.params[i].PetalLength
    b2 = model.params[i].PetalWidth
    log_or = a + b1*x1 + b2*x2
    _or = np.exp(log_or)
    probability = _or/(1+_or)
    return probability
```

In [182]:
```
def threshold(probability,thresh=0.5):
    if probability <= thresh:
        return 1
    else:
        return 0
```

In [183]:
```
data['Flower'].unique()
```

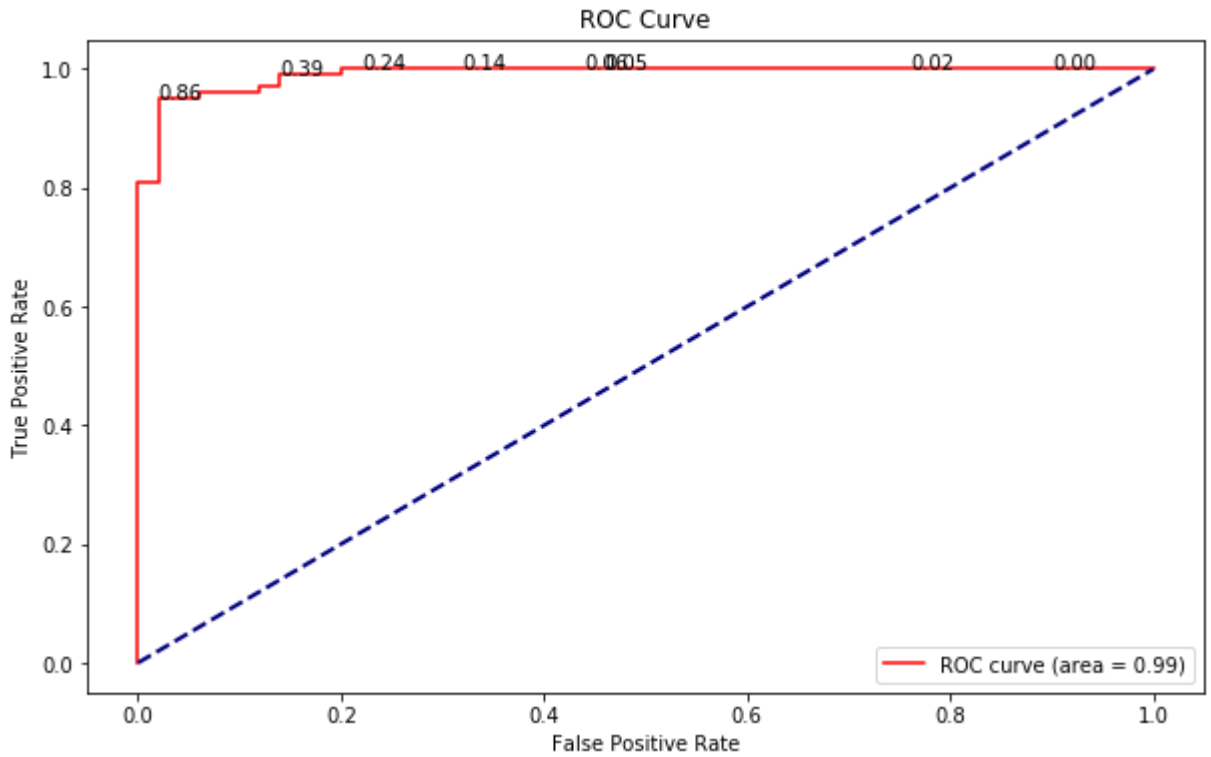
Out[183]:
```
array(['Iris-setosa', 'Iris-versicolor', 'Iris-virginica'], dtype=object)
```

For Iris-Versicolor

In [167]:
```
y_set_versi = data['Flower'].replace(
    to_replace=['Iris-setosa','Iris-versicolor'
                ,'Iris-virginica'],value=[0,1,1])
```

In [184]:
```
y_prob = modelpredict(0,data['PetalLength'],data['PetalWidth'])
y_pred = y_prob.apply(threshold)
y_true = y_set_versi
```

In [185]:
```
fpr,tpr,threshold = roc_curve(y_set_versi,y_prob)

plt.figure(figsize=(10,6))
plt.plot(fpr,tpr,color='red',lw=1.5)
plt.plot([0, 1], [0, 1], color='navy',lw = 2, linestyle='--')

for i,value in enumerate(fpr*10):
    try:
        if (round(fpr[i+1]*10) - round(fpr[i]*10)) == 1:
            plt.text(fpr[i],tpr[i],'%0.2f'%(threshold[i]))
    except IndexError:
        print(' ')

plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('ROC Curve')
plt.legend(['ROC curve (area = %0.2f)' % auc(fpr,tpr)])
plt.show()
```



From ROC:

- threshold *p-value* = 0.78

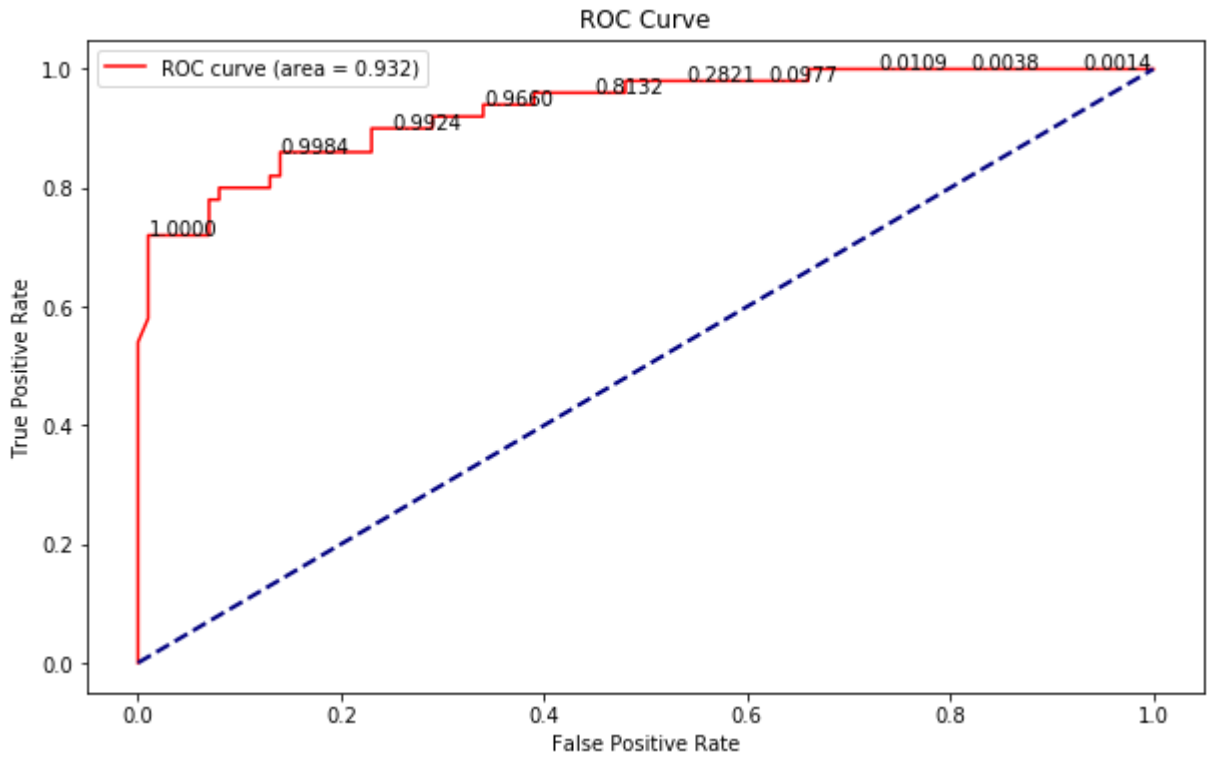
For Versicolor

In [186]:
```
def threshold_versicolor(probability,thresh=0.5):
    if probability <= thresh:
        return 1
    else:
        return 0
```

In [187]:
```
y_set_veri = data['Flower'].replace(
    to_replace=['Iris-setosa','Iris-versicolor'
                ,'Iris-virginica'],value=[0,0,1])
```

In [188]:
```
y_prob = modelpredict(1,data['PetalLength'],data['PetalWidth'])
y_pred = y_prob.apply(threshold_versicolor)
y_true = y_set_veri
```

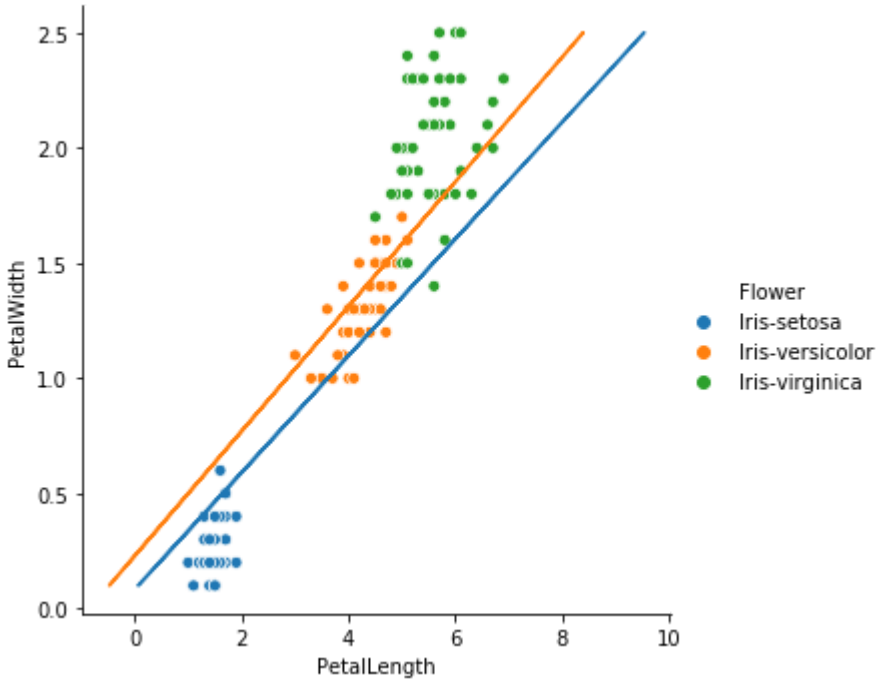
In [189]:
```
fpr,tpr,threshold = roc_curve(y_set_veri,y_prob)

plt.figure(figsize=(10,6))
plt.plot(fpr,tpr,color='red',lw=1.5)
plt.plot([0, 1], [0, 1], color='navy',lw = 2, linestyle='--')

for i,value in enumerate(fpr*10):
    try:
        if (round(fpr[i+1]*10) - round(fpr[i]*10)) == 1:
            plt.text(fpr[i],tpr[i],'%0.4f'%(threshold[i]))
    except IndexError:
        print(' ')

plt.xlabel('False Positive Rate')
plt.ylabel('True Positive Rate')
plt.title('ROC Curve')
plt.legend(['ROC curve (area = %0.3f)' % auc(fpr,tpr)])
plt.show()
```



From ROC:

- threshold *p-value* = 0.9984

In [190]:
```
sns.relplot(x='PetalLength',y='PetalWidth',data=iris,hue='Flower')
drawline(0,0.86)
drawline(1,0.9984)
```



In [ ]:
```

```