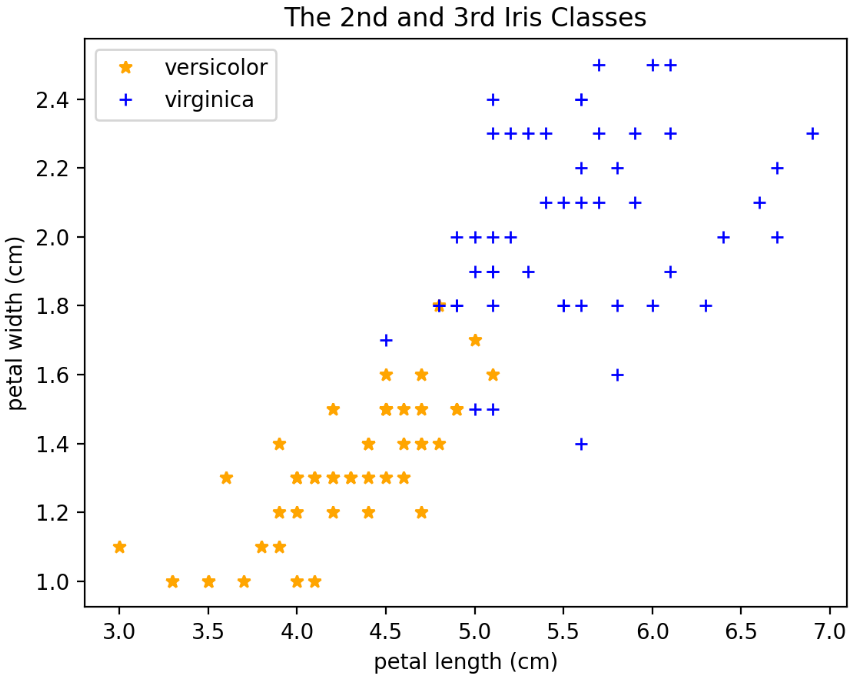
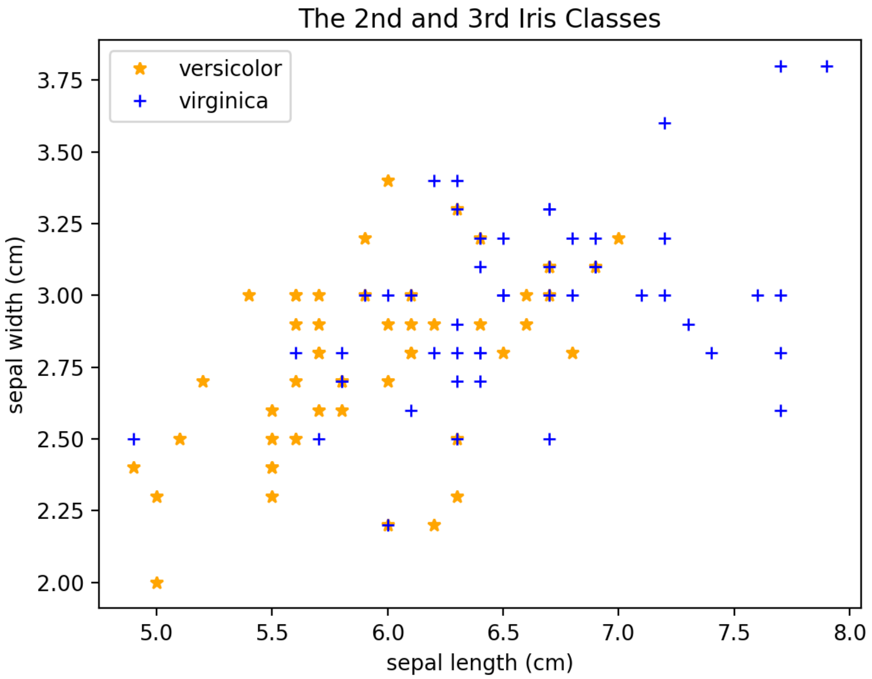
Exercise 1

(a)

The plot of 2nd and 3rd classes of the dataset with petal width vs. petal length:



The plot of 2nd and 3rd classes of the dataset with sepal width vs. sepal length:



We can see that petal width vs. petal length can better seperate the 2nd and 3rd classes.

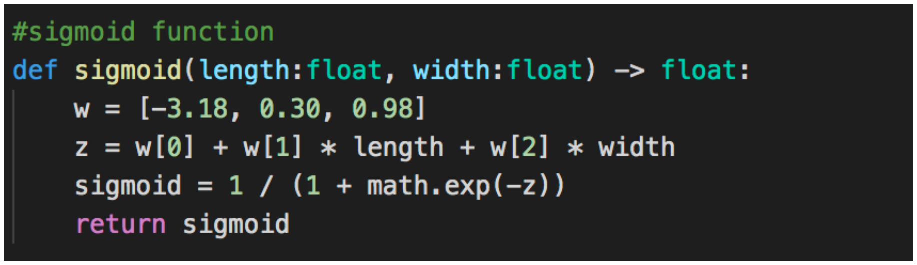
(b)

We define the output unit: y = $w_1\cdot$ petal_length + $w_2\cdot$ petal_width + w_0

w_1 and w_2 are weigths, w_0 is bias.

The sigmoid function is $sigmoid = \dfrac{1}{1+e^{-y}}$

sigmoind function code:



```
#sigmoid function
def sigmoid(length:float, width:float) -> float:
    w = [-3.18, 0.30, 0.98]
    z = w[0] + w[1] * length + w[2] * width
    sigmoid = 1 / (1 + math.exp(-z))
    return sigmoid
```

The sigmoid function classifies the data. If the value of sigmoid is less than 0.5, the data is flower is classified as versicolor. Otherwise, the flower is classified as virginica.

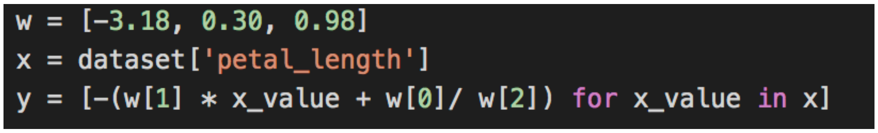
(c)

Because the output unit is y = $w_1\cdot$ petal_length + $w_2\cdot$ petal_width + w_0 and the decision boundary is when y = 0,

we use x_1 to represent petal length and x_2 to represent petal width:
$0 = w_1 \cdot x_1 + w_2 \cdot x_2 + w_0$

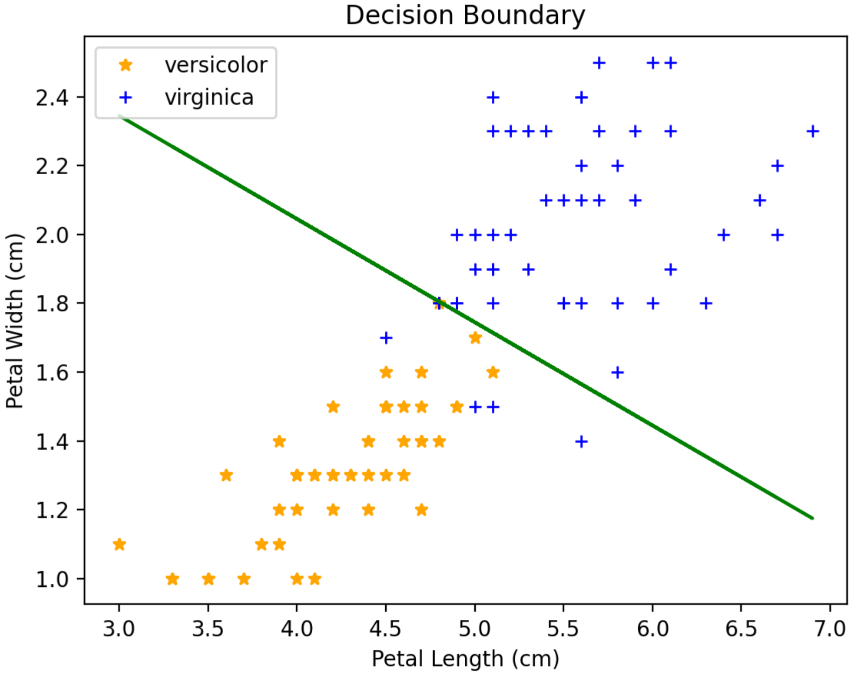
$$x_2 = -\frac{w_1 \cdot x_1 + w_0}{w_2}$$

decision line code:



```
w = [-3.18, 0.30, 0.98]
x = dataset['petal_length']
y = [-(w[1] * x_value + w[0]/ w[2]) for x_value in x]
```

We draw the decision line on the graph using python: $plt.plot(x_1, x_2)$

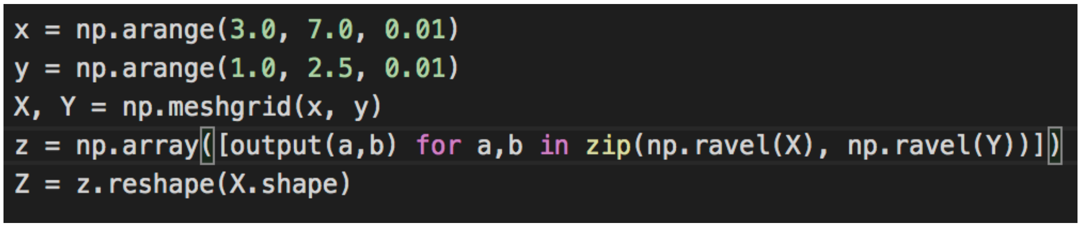


(d)

From the graph generated in (a), we can see that the range of petal length is from about 3.0 to 7.0 cm and the range of petal width is from about 1.0 to 2.5 cm, so we set the range of petal length from 3.0 to 7.0 cm and the range of petal width from 1.0 to 2.5 cm for the surface that we are going to draw.

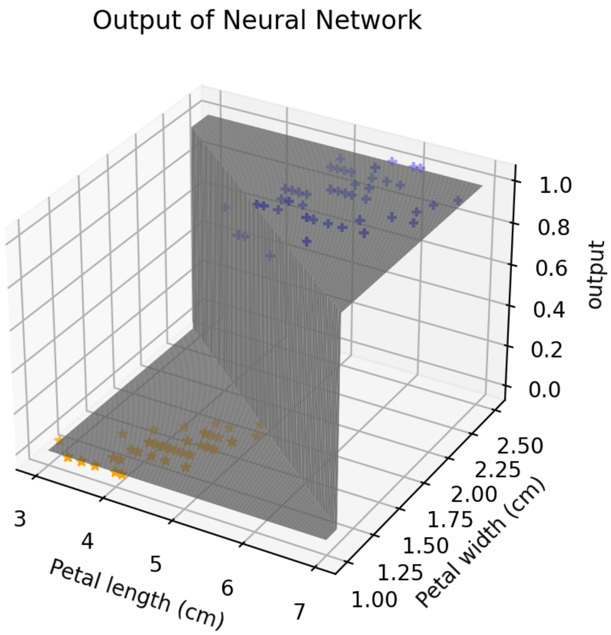
Then we use the output function we defined in (b) to calculate the output of each pair of petal length and petal width.

Code to prepare petal length, petal wieth, and the output:



```
x = np.arange(3.0, 7.0, 0.01)
y = np.arange(1.0, 2.5, 0.01)
X, Y = np.meshgrid(x, y)
z = np.array([output(a,b) for a,b in zip(np.ravel(X), np.ravel(Y))])
Z = z.reshape(X.shape)
```

We use the petal length, petal wieth, and the output to draw a 3D neural network

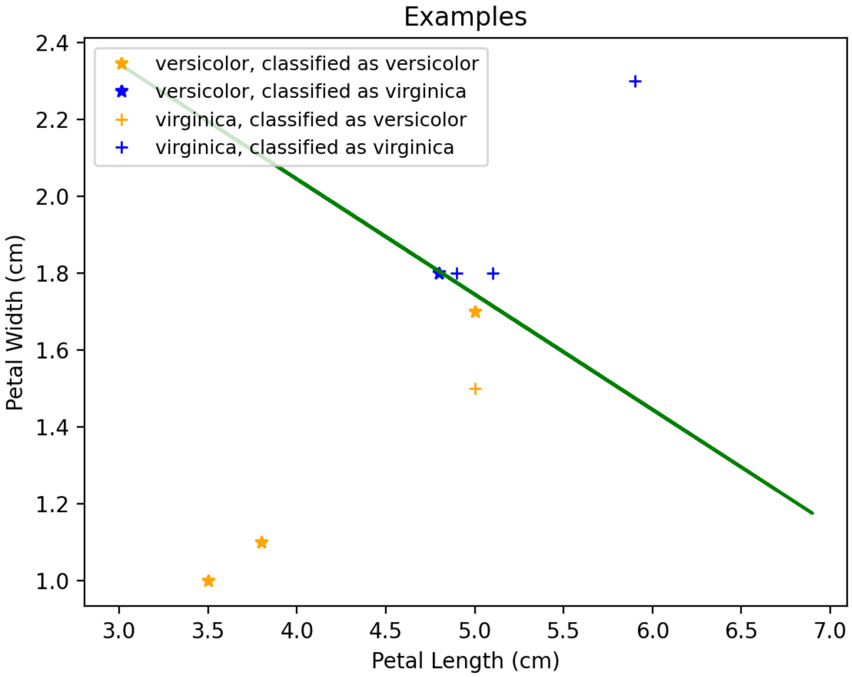


Output of Neural Network

(e)

We selected 8 examples.

petal length (cm)	petal width (cm)	species
4.8	1.8	versicolor
5.0	1.7	versicolor
3.5	1.0	versicolor
3.8	1.1	versicolor
5.1	1.8	virginica
5.0	1.5	virginica
4.9	1.8	virginica
5.9	2.3	virginica


Examples
versicolor, classified as versicolor
versicolor, classified as virginica
virginica, classified as versicolor
virginica, classified as virginica
Petal Width (cm)
2.4
2.2
2.0
1.8
1.6
1.4
1.2
1.0
Petal Length (cm)
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0