Ans 11) In the perceptron learning algorithm, we have the variables as weights and the perceptron should learn to improve the accuracy by updating the weights in each iteration (epochs).

This updating of the weights will mean that the perceptron is learning with each passing input set in each iteration.

Now, in order to achieve good accuracy, we have in this experiment, used three learning rates as 0.1,0.01,0.001.

Experiment-1: -

In this experiment, I have used learning rate as 0.1. Here, as the initial weights are used with the input data sets, the perceptron starts learning. With each passing epoch, the accuracy starts increasing indicating that the perceptron is making decisions as per the target more accurately.

The more correctly the perceptron is predicting the outcomes, the more the accuracy increases.

In this particular experiment, the accuracy percentage plateaus at 90% for 70 epochs which can be seen as per the graph below.
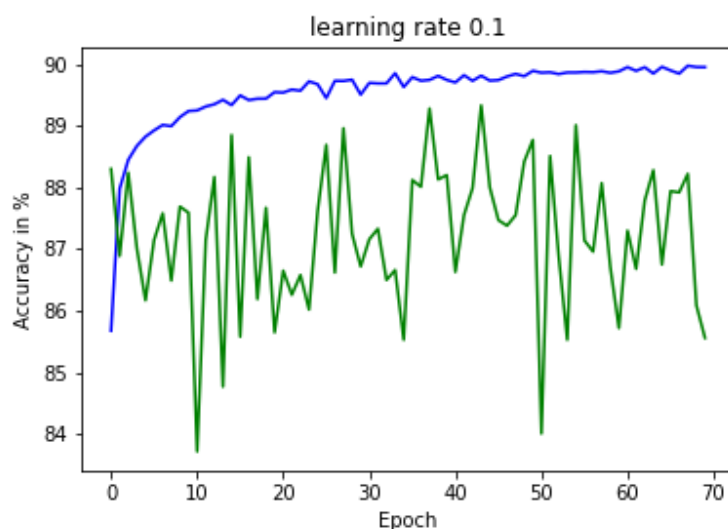
This Experiment also gives us a confusion matrix which is plotted below

```
CONFUSION MATRIX OF TRAIN SET : learning rate 0.1

[[5689    3   31   24   11   60   41   10   32   22]
 [   1 6458   55   23   23   23   14   19  100   26]
 [  36   59 5304  168   35   52   88   67  134   11]
 [  16   36  148 5321    9  242   11   57  216   85]
 [  12    5   57   10 5311   50   50   59   38  253]
 [  71   36   41  261   20 4588   77   11  247   64]
 [  34    7   76   22   55   92 5580    3   44    3]
 [   9   26   62   63   48   18    3 5714   26  298]
 [  43  105  161  177   60  236   51   22 4905   87]
 [  12    7   23   62  270   60    3  303  109 5100]]
CONFUSION MATRIX OF TEST SET : learning rate 0.1

[[ 961    0   15    4    4   12   18    3   14   10]
 [   0 1122   38    1    3    3    4   11   26    3]
 [   1    2  736    8    3    0    7   19    7    1]
 [   2    3  162  933    7   56    2   29  194   18]
 [   0    0    6    2  778    5    4   10   11    4]
 [   8    3   19   36    2  777   53    2  105    7]
 [   2    3   12    1   16    8  864    0    8    1]
 [   3    0    6   10    1    3    0  859    4    8]
 [   1    1   27    5   12   17    5    4  570    1]
 [   2    1   11   10  156   11    1   91   35  956]]
```
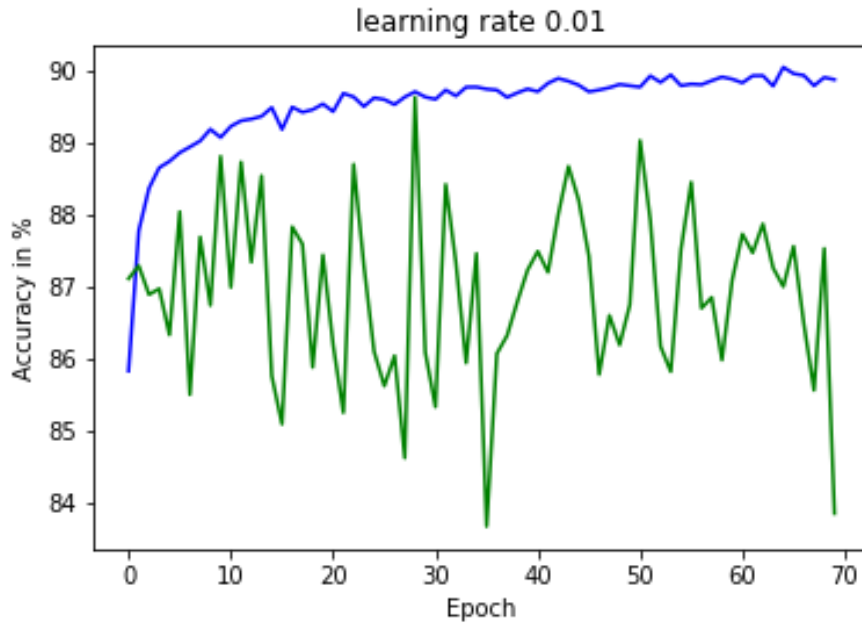
As we know that the accuracy is above 90% but is not near to 100%, the confusion matrix is diagonally dominant but not completely diagonally dependent.

2) Experiment-2

In this experiment, I have used learning rate as 0.01. Here, as the initial weights are used with the input data sets, the perceptron starts learning. With each passing epoch, the accuracy starts increasing indicating that the perceptron is making decisions as per the target more accurately.

The more correctly the perceptron is predicting the outcomes, the more the accuracy increases.

In this particular experiment, the accuracy percentage plateaus at 90% for 70 epochs which can be seen as per the graph below.

learning rate 0.01

The confusion matrix for this experiment is given below: -

```
CONFUSION MATRIX OF TRAIN SET : learning rate 0.01

[[5689    1   34   26   15   56   35   11   35   22]
 [   1 6446   64   22   20   21   16   20  108   25]
 [  38   74 5284  177   40   53   90   62  133   12]
 [  16   39  132 5315   10  231    6   58  235   86]
 [  12    6   57    9 5332   55   47   53   32  241]
 [  62   28   39  251   16 4585   94   17  258   69]
 [  38    5   82   17   49   96 5579    6   43    2]
 [   8   25   63   58   38   18    3 5723   23  302]
 [  42  110  178  184   57  240   45   21 4882   94]
 [  17    8   25   72  265   66    3  294  102 5096]]
CONFUSION MATRIX OF TEST SET : learning rate 0.01

[[ 963    0   11    3    3   15   24    3    8    9]
 [   0 1116   23    1    1    6    4   12   20    6]
 [   3    1  734    8    5    0   19   18    4    1]
 [   5    9  214  975   11  173    7   65  273   30]
 [   0    1    9    2  789   12    5   10   10    5]
 [   4    2    3    5    0  623   41    2   19    3]
 [   1    3   10    0    8    6  854    0    6    1]
 [   2    1    5    7    2    4    0  780    2    3]
 [   2    2   16    4   15   35    4    6  603    2]
 [   0    0    7    5  148   18    0  132   29  949]]
```
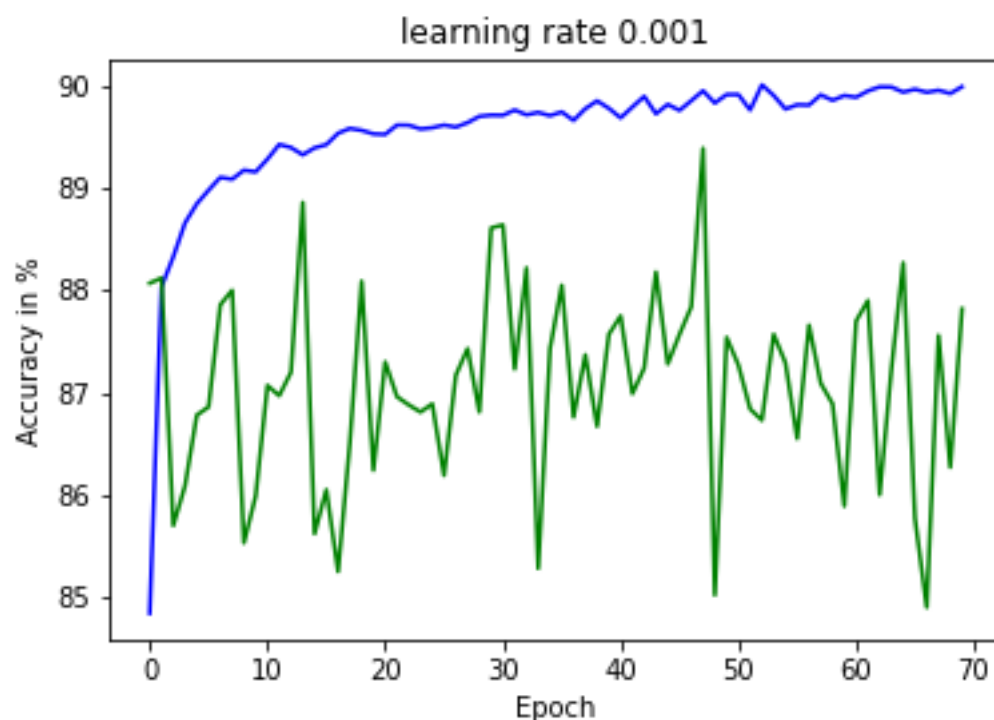
2) Experiment-2

In this experiment, I have used learning rate as 0.001. Here, as the initial weights are used with the input data sets, the perceptron starts learning. With each passing epoch, the accuracy starts increasing indicating that the perceptron is making decisions as per the target more accurately.

The more correctly the perceptron is predicting the outcomes, the more the accuracy increases.

In this particular experiment, the accuracy percentage plateaus at 90% for 70 epochs which can be seen as per the graph below.

The confusion matrix for this experiment is given below:-

CONFUSION MATRIX OF TRAIN SET : learning rate 0.001

```
[[5678     1    34    25    18    53    40     9    35    26]
 [    2  6444    68    25    27    21    12    19   105    22]
 [   33    64  5305   169    35    56    82    60   136    19]
 [   15    36   134  5334    13   234     4    52   220    86]
 [   13     7    59    10  5303    53    54    47    40   257]
 [   75    35    34   264    17  4589    96    14   237    61]
 [   37     5    76    21    54    95  5584     4    44     2]
 [   10    25    64    49    41    16     3  5736    21   299]
 [   43   114   157   163    58   241    39    31  4910    90]
 [   17    11    27    71   276    63     4   293   103  5087]]
```
CONFUSION MATRIX OF TEST SET : learning rate 0.001

```
[[ 967     0    23    15     4    28    20     3    20    10]
 [   0  1123    39     1     3     7     5    16    42     8]
 [   2     3   850    27     3     4     8    25    21     1]
 [   1     1    60   889     4    32     1    15    95    10]
 [   1     0    10     4   883    14     6    16    15    18]
 [   2     1     5    36     0   730     9     2    26     5]
 [   2     4    19     5    21    30   907     0    22     1]
 [   3     1     5    11     1     5     1   871     8     9]
 [   2     2    14     9     5    25     1     4   690     5]
 [   0     0     7    13    58    17     0    76    35   942]]
```