

```
In [1]: import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns

import warnings
warnings.filterwarnings('ignore')

import tensorflow
from tensorflow.keras import Sequential
from tensorflow.keras.layers import Dense
from sklearn.metrics import classification_report
```

```
In [2]: df=pd.read_csv('water_potability.csv')
df.head()
```

Out[2]:

	ph	Hardness	Solids	Chloramines	Sulfate	Conductivity	Organic_carbon	Trihalomethanes	Turbidity	Potability
0	NaN	204.890456	20791.31898	7.300212	368.516441	564.308654	10.379783	86.990970	2.963135	0
1	3.716080	129.422921	18630.05786	6.635246	NaN	592.885359	15.180013	56.329076	4.500656	0
2	8.099124	224.236259	19909.54173	9.275884	NaN	418.606213	16.868637	66.420093	3.055934	0
3	8.316766	214.373394	22018.41744	8.059332	356.886136	363.266516	18.436525	100.341674	4.628771	0
4	9.092223	181.101509	17978.98634	6.546600	310.135738	398.410813	11.558279	31.997993	4.075075	0

```
In [3]: df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 3276 entries, 0 to 3275
Data columns (total 10 columns):
 #   Column           Non-Null Count  Dtype  
--- 
 0   ph               2785 non-null    float64
 1   Hardness          3276 non-null    float64
 2   Solids            3276 non-null    float64
 3   Chloramines       3276 non-null    float64
 4   Sulfate           2495 non-null    float64
 5   Conductivity      3276 non-null    float64
 6   Organic_carbon    3276 non-null    float64
 7   Trihalomethanes  3114 non-null    float64
 8   Turbidity          3276 non-null    float64
 9   Potability         3276 non-null    int64  
dtypes: float64(9), int64(1)
memory usage: 256.1 KB
```

```
In [4]: df.isna().sum()
```

```
Out[4]: ph                491
Hardness          0
Solids            0
Chloramines       0
Sulfate           781
Conductivity      0
Organic_carbon    0
Trihalomethanes  162
Turbidity          0
Potability         0
dtype: int64
```

```
In [5]: col=['ph','Sulfate','Trihalomethanes']
df[col]=df[col].fillna(df[col].mean())
```

```
In [6]: df.isna().sum()
```

```
Out[6]: ph          0  
Hardness      0  
Solids        0  
Chloramines    0  
Sulfate        0  
Conductivity   0  
Organic_carbon 0  
Trihalomethanes 0  
Turbidity       0  
Potability     0  
dtype: int64
```

```
In [7]: df.duplicated().sum()
```

```
Out[7]: 0
```

```
In [8]: df.describe()
```

	ph	Hardness	Solids	Chloramines	Sulfate	Conductivity	Organic_carbon	Trihalomethanes	Turbidity	Pot.
count	3276.000000	3276.000000	3276.000000	3276.000000	3276.000000	3276.000000	3276.000000	3276.000000	3276.000000	3276.000000
mean	7.080795	196.369496	22014.092526	7.122277	333.775777	426.205111	14.284970	66.396293	3.966786	0.3
std	1.469956	32.879761	8768.570828	1.583085	36.142612	80.824064	3.308162	15.769881	0.780382	0.4
min	0.000000	47.432000	320.942611	0.352000	129.000000	181.483754	2.200000	0.738000	1.450000	0.0
25%	6.277673	176.850538	15666.690300	6.127421	317.094638	365.734414	12.065801	56.647656	3.439711	0.0
50%	7.080795	196.967627	20927.833605	7.130299	333.775777	421.884968	14.218338	66.396293	3.955028	0.0
75%	7.870050	216.667456	27332.762125	8.114887	350.385756	481.792305	16.557652	76.666609	4.500320	1.0
max	14.000000	323.124000	61227.196010	13.127000	481.030642	753.342620	28.300000	124.000000	6.739000	1.0

```
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```

```
In [ ]:
```

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In [ ]:
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```
In [9]: df.describe()
```

Out[9]:	ph	Hardness	Solids	Chloramines	Sulfate	Conductivity	Organic_carbon	Trihalomethanes	Turbidity	Pot.
count	3276.000000	3276.000000	3276.000000	3276.000000	3276.000000	3276.000000	3276.000000	3276.000000	3276.000000	3276.000000
mean	7.080795	196.369496	22014.092526	7.122277	333.775777	426.205111	14.284970	66.396293	3.966786	0.3
std	1.469956	32.879761	8768.570828	1.583085	36.142612	80.824064	3.308162	15.769881	0.780382	0.4
min	0.000000	47.432000	320.942611	0.352000	129.000000	181.483754	2.200000	0.738000	1.450000	0.0
25%	6.277673	176.850538	15666.690300	6.127421	317.094638	365.734414	12.065801	56.647656	3.439711	0.0
50%	7.080795	196.967627	20927.833605	7.130299	333.775777	421.884968	14.218338	66.396293	3.955028	0.0
75%	7.870050	216.667456	27332.762125	8.114887	350.385756	481.792305	16.557652	76.666609	4.500320	1.0
max	14.000000	323.124000	61227.196010	13.127000	481.030642	753.342620	28.300000	124.000000	6.739000	1.0

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```
In [10]: df['Solids']=np.log10(df['Solids'])
df['Conductivity']=np.log10(df['Conductivity'])
```

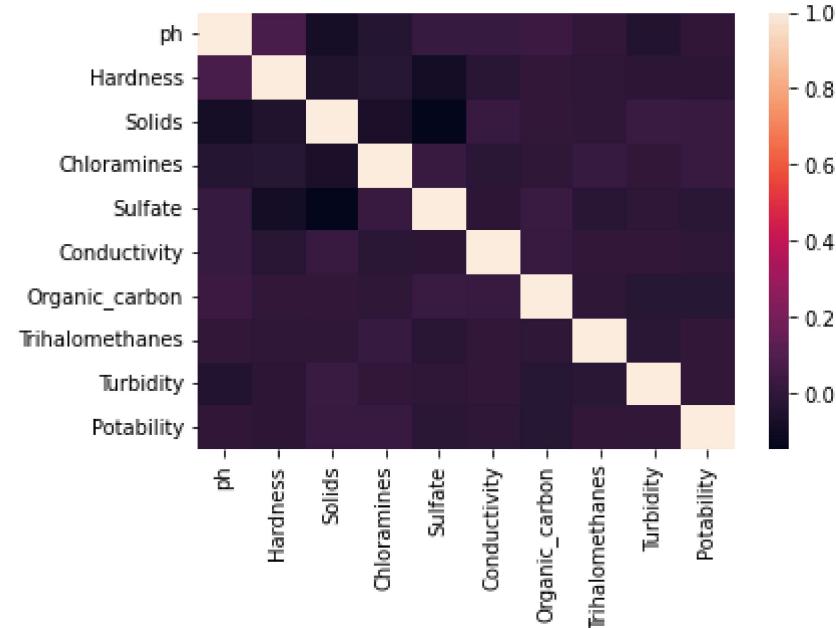
```
In [11]: df.describe()
```

Out[11]:	ph	Hardness	Solids	Chloramines	Sulfate	Conductivity	Organic_carbon	Trihalomethanes	Turbidity	Pota
count	3276.000000	3276.000000	3276.000000	3276.000000	3276.000000	3276.000000	3276.000000	3276.000000	3276.000000	3276.000000
mean	7.080795	196.369496	4.304676	7.122277	333.775777	2.621700	14.284970	66.396293	3.966786	0.39
std	1.469956	32.879761	0.193450	1.583085	36.142612	0.083536	3.308162	15.769881	0.780382	0.48
min	0.000000	47.432000	2.506427	0.352000	129.000000	2.258838	2.200000	0.738000	1.450000	0.00
25%	6.277673	176.850538	4.194977	6.127421	317.094638	2.563166	12.065801	56.647656	3.439711	0.00
50%	7.080795	196.967627	4.320724	7.130299	333.775777	2.625194	14.218338	66.396293	3.955028	0.00
75%	7.870050	216.667456	4.436684	8.114887	350.385756	2.682860	16.557652	76.666609	4.500320	1.00
max	14.000000	323.124000	4.786944	13.127000	481.030642	2.876993	28.300000	124.000000	6.739000	1.00

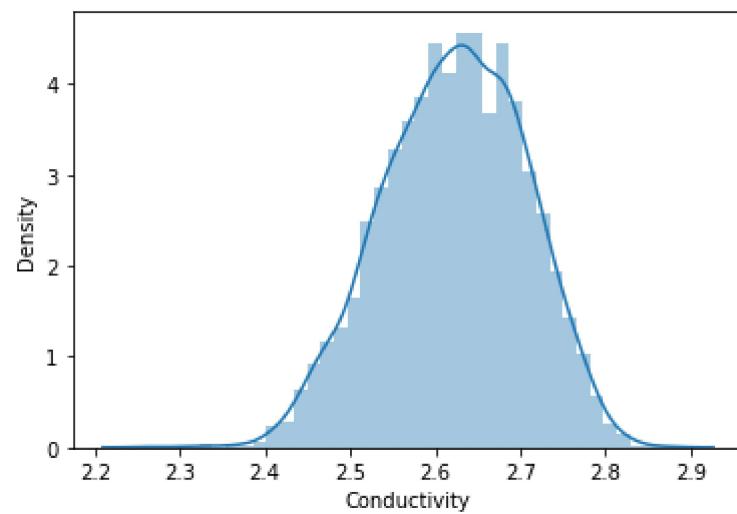
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```
In [12]: sns.heatmap(df.corr())
```

Out[12]: <AxesSubplot:>

In [13]: `sns.distplot(df['Conductivity'])`

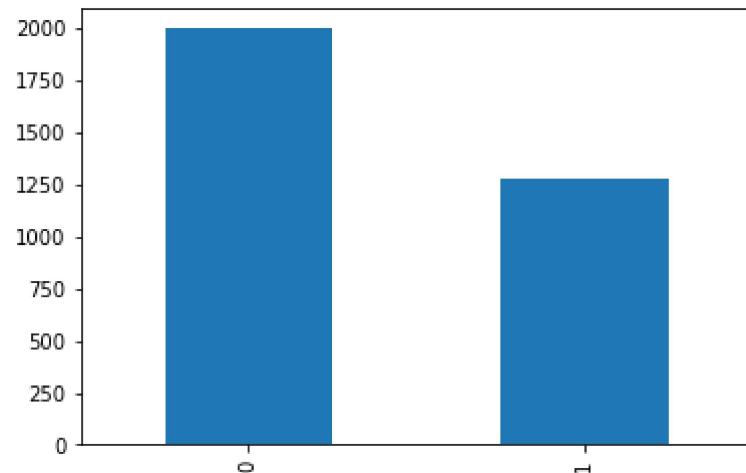
Out[13]: <AxesSubplot:xlabel='Conductivity', ylabel='Density'>

In [14]: `df['Potability'].unique()`

```
Out[14]: array([0, 1], dtype=int64)
```

```
In [15]: df['Potability'].value_counts().plot(kind='bar')
```

```
Out[15]: <AxesSubplot:>
```



```
In [16]: X=df.iloc[:, :-1]  
Y=df.iloc[:, -1]
```

```
In [17]: from sklearn.model_selection import train_test_split  
X_train,X_test,Y_train,Y_test=train_test_split(X,Y,test_size=0.3,random_state=1)
```

```
In [18]: X_train.shape,X_test.shape
```

```
Out[18]: ((2293, 9), (983, 9))
```

```
In [19]: Y_train.shape,Y_test.shape
```

```
Out[19]: ((2293,), (983,))
```

```
In [20]: from sklearn.preprocessing import StandardScaler
```

```
In [21]: ss=StandardScaler()  
X_train=ss.fit_transform(X_train)  
X_test=ss.transform(X_test)
```

```
In [22]: ann=Sequential()
```

```
ann.add(Dense(units=10,activation='relu'))
ann.add(Dense(units=5,activation='relu'))
ann.add(Dense(units=5,activation='relu'))

ann.add(Dense(units=1,activation='sigmoid'))

ann.compile(optimizer='adam',loss='binary_crossentropy')
```

```
In [23]: ann.fit(X_train,Y_train,epochs=300,validation_data=(X_test,Y_test))
```

```
Epoch 1/300
72/72 [=====] - 2s 6ms/step - loss: 0.6924 - val_loss: 0.6888
Epoch 2/300
72/72 [=====] - 0s 4ms/step - loss: 0.6805 - val_loss: 0.6834
Epoch 3/300
72/72 [=====] - 0s 4ms/step - loss: 0.6734 - val_loss: 0.6806
Epoch 4/300
72/72 [=====] - 0s 4ms/step - loss: 0.6688 - val_loss: 0.6791
Epoch 5/300
72/72 [=====] - 0s 3ms/step - loss: 0.6657 - val_loss: 0.6782
Epoch 6/300
72/72 [=====] - 0s 3ms/step - loss: 0.6637 - val_loss: 0.6776
Epoch 7/300
72/72 [=====] - 0s 3ms/step - loss: 0.6620 - val_loss: 0.6774
Epoch 8/300
72/72 [=====] - 0s 4ms/step - loss: 0.6607 - val_loss: 0.6767
Epoch 9/300
72/72 [=====] - 0s 4ms/step - loss: 0.6591 - val_loss: 0.6770
Epoch 10/300
72/72 [=====] - 0s 3ms/step - loss: 0.6579 - val_loss: 0.6768
Epoch 11/300
72/72 [=====] - 0s 4ms/step - loss: 0.6568 - val_loss: 0.6759
Epoch 12/300
72/72 [=====] - 0s 3ms/step - loss: 0.6558 - val_loss: 0.6753
Epoch 13/300
72/72 [=====] - 0s 4ms/step - loss: 0.6547 - val_loss: 0.6743
Epoch 14/300
72/72 [=====] - 0s 3ms/step - loss: 0.6531 - val_loss: 0.6739
Epoch 15/300
72/72 [=====] - 0s 3ms/step - loss: 0.6514 - val_loss: 0.6733
Epoch 16/300
72/72 [=====] - 0s 4ms/step - loss: 0.6499 - val_loss: 0.6732
Epoch 17/300
72/72 [=====] - 0s 3ms/step - loss: 0.6490 - val_loss: 0.6717
Epoch 18/300
72/72 [=====] - 0s 3ms/step - loss: 0.6470 - val_loss: 0.6707
Epoch 19/300
72/72 [=====] - 0s 4ms/step - loss: 0.6455 - val_loss: 0.6693
Epoch 20/300
72/72 [=====] - 0s 3ms/step - loss: 0.6446 - val_loss: 0.6674
Epoch 21/300
72/72 [=====] - 0s 4ms/step - loss: 0.6424 - val_loss: 0.6657
Epoch 22/300
72/72 [=====] - 0s 4ms/step - loss: 0.6408 - val_loss: 0.6640
Epoch 23/300
```

```
72/72 [=====] - 0s 3ms/step - loss: 0.6394 - val_loss: 0.6639
Epoch 24/300
72/72 [=====] - 0s 3ms/step - loss: 0.6381 - val_loss: 0.6628
Epoch 25/300
72/72 [=====] - 0s 3ms/step - loss: 0.6370 - val_loss: 0.6620
Epoch 26/300
72/72 [=====] - 0s 2ms/step - loss: 0.6359 - val_loss: 0.6602
Epoch 27/300
72/72 [=====] - 0s 3ms/step - loss: 0.6347 - val_loss: 0.6607
Epoch 28/300
72/72 [=====] - 0s 4ms/step - loss: 0.6338 - val_loss: 0.6594
Epoch 29/300
72/72 [=====] - 0s 4ms/step - loss: 0.6326 - val_loss: 0.6598
Epoch 30/300
72/72 [=====] - 0s 3ms/step - loss: 0.6320 - val_loss: 0.6599
Epoch 31/300
72/72 [=====] - 0s 3ms/step - loss: 0.6313 - val_loss: 0.6584
Epoch 32/300
72/72 [=====] - 0s 4ms/step - loss: 0.6302 - val_loss: 0.6586
Epoch 33/300
72/72 [=====] - 0s 5ms/step - loss: 0.6298 - val_loss: 0.6597
Epoch 34/300
72/72 [=====] - 0s 4ms/step - loss: 0.6285 - val_loss: 0.6578
Epoch 35/300
72/72 [=====] - 0s 4ms/step - loss: 0.6277 - val_loss: 0.6570
Epoch 36/300
72/72 [=====] - 0s 3ms/step - loss: 0.6267 - val_loss: 0.6572
Epoch 37/300
72/72 [=====] - 0s 3ms/step - loss: 0.6255 - val_loss: 0.6566
Epoch 38/300
72/72 [=====] - 0s 4ms/step - loss: 0.6249 - val_loss: 0.6544
Epoch 39/300
72/72 [=====] - 0s 4ms/step - loss: 0.6234 - val_loss: 0.6546
Epoch 40/300
72/72 [=====] - 0s 3ms/step - loss: 0.6228 - val_loss: 0.6544
Epoch 41/300
72/72 [=====] - 0s 3ms/step - loss: 0.6225 - val_loss: 0.6537
Epoch 42/300
72/72 [=====] - 0s 3ms/step - loss: 0.6205 - val_loss: 0.6531
Epoch 43/300
72/72 [=====] - 0s 3ms/step - loss: 0.6189 - val_loss: 0.6516
Epoch 44/300
72/72 [=====] - 0s 3ms/step - loss: 0.6184 - val_loss: 0.6535
Epoch 45/300
72/72 [=====] - 0s 4ms/step - loss: 0.6174 - val_loss: 0.6546
```

```
Epoch 46/300
72/72 [=====] - 0s 3ms/step - loss: 0.6167 - val_loss: 0.6506
Epoch 47/300
72/72 [=====] - 0s 4ms/step - loss: 0.6151 - val_loss: 0.6510
Epoch 48/300
72/72 [=====] - 0s 4ms/step - loss: 0.6141 - val_loss: 0.6499
Epoch 49/300
72/72 [=====] - 0s 4ms/step - loss: 0.6136 - val_loss: 0.6489
Epoch 50/300
72/72 [=====] - 0s 4ms/step - loss: 0.6130 - val_loss: 0.6496
Epoch 51/300
72/72 [=====] - 0s 4ms/step - loss: 0.6125 - val_loss: 0.6495
Epoch 52/300
72/72 [=====] - 0s 3ms/step - loss: 0.6111 - val_loss: 0.6485
Epoch 53/300
72/72 [=====] - 0s 3ms/step - loss: 0.6098 - val_loss: 0.6486
Epoch 54/300
72/72 [=====] - 0s 3ms/step - loss: 0.6099 - val_loss: 0.6472
Epoch 55/300
72/72 [=====] - 0s 3ms/step - loss: 0.6086 - val_loss: 0.6476
Epoch 56/300
72/72 [=====] - 0s 3ms/step - loss: 0.6077 - val_loss: 0.6475
Epoch 57/300
72/72 [=====] - 0s 3ms/step - loss: 0.6068 - val_loss: 0.6462
Epoch 58/300
72/72 [=====] - 0s 3ms/step - loss: 0.6066 - val_loss: 0.6472
Epoch 59/300
72/72 [=====] - 0s 2ms/step - loss: 0.6056 - val_loss: 0.6484
Epoch 60/300
72/72 [=====] - 0s 3ms/step - loss: 0.6047 - val_loss: 0.6483
Epoch 61/300
72/72 [=====] - 0s 3ms/step - loss: 0.6037 - val_loss: 0.6465
Epoch 62/300
72/72 [=====] - 0s 2ms/step - loss: 0.6034 - val_loss: 0.6484
Epoch 63/300
72/72 [=====] - 0s 2ms/step - loss: 0.6024 - val_loss: 0.6475
Epoch 64/300
72/72 [=====] - 0s 3ms/step - loss: 0.6017 - val_loss: 0.6454
Epoch 65/300
72/72 [=====] - 0s 3ms/step - loss: 0.6008 - val_loss: 0.6464
Epoch 66/300
72/72 [=====] - 0s 3ms/step - loss: 0.6002 - val_loss: 0.6457
Epoch 67/300
72/72 [=====] - 0s 3ms/step - loss: 0.5990 - val_loss: 0.6463
Epoch 68/300
```

```
72/72 [=====] - 0s 3ms/step - loss: 0.5986 - val_loss: 0.6459
Epoch 69/300
72/72 [=====] - 0s 2ms/step - loss: 0.5981 - val_loss: 0.6456
Epoch 70/300
72/72 [=====] - 0s 3ms/step - loss: 0.5970 - val_loss: 0.6462
Epoch 71/300
72/72 [=====] - 0s 4ms/step - loss: 0.5967 - val_loss: 0.6461
Epoch 72/300
72/72 [=====] - 0s 3ms/step - loss: 0.5953 - val_loss: 0.6444
Epoch 73/300
72/72 [=====] - 0s 3ms/step - loss: 0.5951 - val_loss: 0.6467
Epoch 74/300
72/72 [=====] - 0s 3ms/step - loss: 0.5938 - val_loss: 0.6439
Epoch 75/300
72/72 [=====] - 0s 3ms/step - loss: 0.5935 - val_loss: 0.6449
Epoch 76/300
72/72 [=====] - 0s 3ms/step - loss: 0.5927 - val_loss: 0.6464
Epoch 77/300
72/72 [=====] - 0s 2ms/step - loss: 0.5930 - val_loss: 0.6453
Epoch 78/300
72/72 [=====] - 0s 2ms/step - loss: 0.5919 - val_loss: 0.6450
Epoch 79/300
72/72 [=====] - 0s 2ms/step - loss: 0.5909 - val_loss: 0.6456
Epoch 80/300
72/72 [=====] - 0s 3ms/step - loss: 0.5908 - val_loss: 0.6445
Epoch 81/300
72/72 [=====] - 0s 3ms/step - loss: 0.5909 - val_loss: 0.6463
Epoch 82/300
72/72 [=====] - 0s 2ms/step - loss: 0.5898 - val_loss: 0.6440
Epoch 83/300
72/72 [=====] - 0s 3ms/step - loss: 0.5891 - val_loss: 0.6438
Epoch 84/300
72/72 [=====] - 0s 2ms/step - loss: 0.5887 - val_loss: 0.6440
Epoch 85/300
72/72 [=====] - 0s 2ms/step - loss: 0.5888 - val_loss: 0.6456
Epoch 86/300
72/72 [=====] - 0s 2ms/step - loss: 0.5877 - val_loss: 0.6473
Epoch 87/300
72/72 [=====] - 0s 2ms/step - loss: 0.5873 - val_loss: 0.6457
Epoch 88/300
72/72 [=====] - 0s 3ms/step - loss: 0.5868 - val_loss: 0.6453
Epoch 89/300
72/72 [=====] - 0s 4ms/step - loss: 0.5865 - val_loss: 0.6460
Epoch 90/300
72/72 [=====] - 0s 3ms/step - loss: 0.5865 - val_loss: 0.6467
```

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Epoch 91/300
72/72 [=====] - 0s 4ms/step - loss: 0.5857 - val_loss: 0.6463
Epoch 92/300
72/72 [=====] - 0s 5ms/step - loss: 0.5850 - val_loss: 0.6472
Epoch 93/300
72/72 [=====] - 0s 4ms/step - loss: 0.5850 - val_loss: 0.6465
Epoch 94/300
72/72 [=====] - 0s 3ms/step - loss: 0.5845 - val_loss: 0.6479
Epoch 95/300
72/72 [=====] - 0s 4ms/step - loss: 0.5835 - val_loss: 0.6505
Epoch 96/300
72/72 [=====] - 0s 5ms/step - loss: 0.5830 - val_loss: 0.6503
Epoch 97/300
72/72 [=====] - 0s 4ms/step - loss: 0.5832 - val_loss: 0.6494
Epoch 98/300
72/72 [=====] - 0s 4ms/step - loss: 0.5822 - val_loss: 0.6490
Epoch 99/300
72/72 [=====] - 0s 4ms/step - loss: 0.5824 - val_loss: 0.6486
Epoch 100/300
72/72 [=====] - 0s 4ms/step - loss: 0.5818 - val_loss: 0.6522
Epoch 101/300
72/72 [=====] - 0s 4ms/step - loss: 0.5819 - val_loss: 0.6517
Epoch 102/300
72/72 [=====] - 0s 4ms/step - loss: 0.5810 - val_loss: 0.6507
Epoch 103/300
72/72 [=====] - 0s 3ms/step - loss: 0.5807 - val_loss: 0.6533
Epoch 104/300
72/72 [=====] - 0s 3ms/step - loss: 0.5794 - val_loss: 0.6536
Epoch 105/300
72/72 [=====] - 0s 3ms/step - loss: 0.5792 - val_loss: 0.6535
Epoch 106/300
72/72 [=====] - 0s 3ms/step - loss: 0.5792 - val_loss: 0.6515
Epoch 107/300
72/72 [=====] - 0s 3ms/step - loss: 0.5791 - val_loss: 0.6523
Epoch 108/300
72/72 [=====] - 0s 3ms/step - loss: 0.5780 - val_loss: 0.6524
Epoch 109/300
72/72 [=====] - 0s 3ms/step - loss: 0.5770 - val_loss: 0.6548
Epoch 110/300
72/72 [=====] - 0s 4ms/step - loss: 0.5772 - val_loss: 0.6544
Epoch 111/300
72/72 [=====] - 0s 4ms/step - loss: 0.5773 - val_loss: 0.6511
Epoch 112/300
72/72 [=====] - 0s 3ms/step - loss: 0.5760 - val_loss: 0.6529
Epoch 113/300
```

```
72/72 [=====] - 0s 4ms/step - loss: 0.5760 - val_loss: 0.6512
Epoch 114/300
72/72 [=====] - 0s 3ms/step - loss: 0.5756 - val_loss: 0.6514
Epoch 115/300
72/72 [=====] - 0s 3ms/step - loss: 0.5757 - val_loss: 0.6532
Epoch 116/300
72/72 [=====] - 0s 3ms/step - loss: 0.5744 - val_loss: 0.6524
Epoch 117/300
72/72 [=====] - 0s 3ms/step - loss: 0.5738 - val_loss: 0.6534
Epoch 118/300
72/72 [=====] - 0s 3ms/step - loss: 0.5739 - val_loss: 0.6527
Epoch 119/300
72/72 [=====] - 0s 3ms/step - loss: 0.5737 - val_loss: 0.6500
Epoch 120/300
72/72 [=====] - 0s 3ms/step - loss: 0.5733 - val_loss: 0.6540
Epoch 121/300
72/72 [=====] - 0s 3ms/step - loss: 0.5726 - val_loss: 0.6544
Epoch 122/300
72/72 [=====] - 0s 3ms/step - loss: 0.5724 - val_loss: 0.6531
Epoch 123/300
72/72 [=====] - 0s 3ms/step - loss: 0.5720 - val_loss: 0.6535
Epoch 124/300
72/72 [=====] - 0s 3ms/step - loss: 0.5717 - val_loss: 0.6542
Epoch 125/300
72/72 [=====] - 0s 3ms/step - loss: 0.5721 - val_loss: 0.6507
Epoch 126/300
72/72 [=====] - 0s 3ms/step - loss: 0.5708 - val_loss: 0.6530
Epoch 127/300
72/72 [=====] - 0s 3ms/step - loss: 0.5712 - val_loss: 0.6529
Epoch 128/300
72/72 [=====] - 0s 3ms/step - loss: 0.5703 - val_loss: 0.6535
Epoch 129/300
72/72 [=====] - 0s 3ms/step - loss: 0.5697 - val_loss: 0.6533
Epoch 130/300
72/72 [=====] - 0s 3ms/step - loss: 0.5692 - val_loss: 0.6513
Epoch 131/300
72/72 [=====] - 0s 3ms/step - loss: 0.5691 - val_loss: 0.6545
Epoch 132/300
72/72 [=====] - 0s 3ms/step - loss: 0.5693 - val_loss: 0.6535
Epoch 133/300
72/72 [=====] - 0s 3ms/step - loss: 0.5687 - val_loss: 0.6541
Epoch 134/300
72/72 [=====] - 0s 3ms/step - loss: 0.5679 - val_loss: 0.6543
Epoch 135/300
72/72 [=====] - 0s 3ms/step - loss: 0.5678 - val_loss: 0.6545
```

```
Epoch 136/300
72/72 [=====] - 0s 3ms/step - loss: 0.5668 - val_loss: 0.6533
Epoch 137/300
72/72 [=====] - 0s 3ms/step - loss: 0.5676 - val_loss: 0.6545
Epoch 138/300
72/72 [=====] - 0s 3ms/step - loss: 0.5665 - val_loss: 0.6550
Epoch 139/300
72/72 [=====] - 0s 3ms/step - loss: 0.5666 - val_loss: 0.6542
Epoch 140/300
72/72 [=====] - 0s 3ms/step - loss: 0.5668 - val_loss: 0.6569
Epoch 141/300
72/72 [=====] - 0s 3ms/step - loss: 0.5657 - val_loss: 0.6526
Epoch 142/300
72/72 [=====] - 0s 3ms/step - loss: 0.5660 - val_loss: 0.6551
Epoch 143/300
72/72 [=====] - 0s 3ms/step - loss: 0.5658 - val_loss: 0.6553
Epoch 144/300
72/72 [=====] - 0s 3ms/step - loss: 0.5650 - val_loss: 0.6540
Epoch 145/300
72/72 [=====] - 0s 3ms/step - loss: 0.5648 - val_loss: 0.6529
Epoch 146/300
72/72 [=====] - 0s 3ms/step - loss: 0.5644 - val_loss: 0.6536
Epoch 147/300
72/72 [=====] - 0s 3ms/step - loss: 0.5644 - val_loss: 0.6528
Epoch 148/300
72/72 [=====] - 0s 3ms/step - loss: 0.5630 - val_loss: 0.6555
Epoch 149/300
72/72 [=====] - 0s 3ms/step - loss: 0.5641 - val_loss: 0.6559
Epoch 150/300
72/72 [=====] - 0s 3ms/step - loss: 0.5637 - val_loss: 0.6567
Epoch 151/300
72/72 [=====] - 0s 3ms/step - loss: 0.5632 - val_loss: 0.6591
Epoch 152/300
72/72 [=====] - 0s 3ms/step - loss: 0.5625 - val_loss: 0.6558
Epoch 153/300
72/72 [=====] - 0s 3ms/step - loss: 0.5627 - val_loss: 0.6555
Epoch 154/300
72/72 [=====] - 0s 3ms/step - loss: 0.5628 - val_loss: 0.6565
Epoch 155/300
72/72 [=====] - 0s 3ms/step - loss: 0.5618 - val_loss: 0.6580
Epoch 156/300
72/72 [=====] - 0s 3ms/step - loss: 0.5615 - val_loss: 0.6582
Epoch 157/300
72/72 [=====] - 0s 3ms/step - loss: 0.5619 - val_loss: 0.6573
Epoch 158/300
```

```
72/72 [=====] - 0s 3ms/step - loss: 0.5616 - val_loss: 0.6582
Epoch 159/300
72/72 [=====] - 0s 3ms/step - loss: 0.5612 - val_loss: 0.6562
Epoch 160/300
72/72 [=====] - 0s 3ms/step - loss: 0.5610 - val_loss: 0.6562
Epoch 161/300
72/72 [=====] - 0s 3ms/step - loss: 0.5606 - val_loss: 0.6559
Epoch 162/300
72/72 [=====] - 0s 3ms/step - loss: 0.5611 - val_loss: 0.6570
Epoch 163/300
72/72 [=====] - 0s 3ms/step - loss: 0.5608 - val_loss: 0.6578
Epoch 164/300
72/72 [=====] - 0s 3ms/step - loss: 0.5612 - val_loss: 0.6568
Epoch 165/300
72/72 [=====] - 0s 3ms/step - loss: 0.5612 - val_loss: 0.6585
Epoch 166/300
72/72 [=====] - 0s 3ms/step - loss: 0.5609 - val_loss: 0.6581
Epoch 167/300
72/72 [=====] - 0s 3ms/step - loss: 0.5609 - val_loss: 0.6592
Epoch 168/300
72/72 [=====] - 0s 3ms/step - loss: 0.5595 - val_loss: 0.6565
Epoch 169/300
72/72 [=====] - 0s 3ms/step - loss: 0.5599 - val_loss: 0.6562
Epoch 170/300
72/72 [=====] - 0s 3ms/step - loss: 0.5596 - val_loss: 0.6565
Epoch 171/300
72/72 [=====] - 0s 3ms/step - loss: 0.5593 - val_loss: 0.6574
Epoch 172/300
72/72 [=====] - 0s 3ms/step - loss: 0.5595 - val_loss: 0.6578
Epoch 173/300
72/72 [=====] - 0s 3ms/step - loss: 0.5590 - val_loss: 0.6560
Epoch 174/300
72/72 [=====] - 0s 3ms/step - loss: 0.5589 - val_loss: 0.6583
Epoch 175/300
72/72 [=====] - 0s 3ms/step - loss: 0.5587 - val_loss: 0.6559
Epoch 176/300
72/72 [=====] - 0s 3ms/step - loss: 0.5587 - val_loss: 0.6560
Epoch 177/300
72/72 [=====] - 0s 3ms/step - loss: 0.5590 - val_loss: 0.6585
Epoch 178/300
72/72 [=====] - 0s 3ms/step - loss: 0.5592 - val_loss: 0.6588
Epoch 179/300
72/72 [=====] - 0s 3ms/step - loss: 0.5591 - val_loss: 0.6564
Epoch 180/300
72/72 [=====] - 0s 3ms/step - loss: 0.5585 - val_loss: 0.6564
```

```
Epoch 181/300
72/72 [=====] - 0s 3ms/step - loss: 0.5585 - val_loss: 0.6561
Epoch 182/300
72/72 [=====] - 0s 3ms/step - loss: 0.5578 - val_loss: 0.6580
Epoch 183/300
72/72 [=====] - 0s 3ms/step - loss: 0.5574 - val_loss: 0.6566
Epoch 184/300
72/72 [=====] - 0s 3ms/step - loss: 0.5570 - val_loss: 0.6602
Epoch 185/300
72/72 [=====] - 0s 3ms/step - loss: 0.5574 - val_loss: 0.6580
Epoch 186/300
72/72 [=====] - 0s 3ms/step - loss: 0.5576 - val_loss: 0.6566
Epoch 187/300
72/72 [=====] - 0s 3ms/step - loss: 0.5573 - val_loss: 0.6559
Epoch 188/300
72/72 [=====] - 0s 3ms/step - loss: 0.5573 - val_loss: 0.6566
Epoch 189/300
72/72 [=====] - 0s 3ms/step - loss: 0.5567 - val_loss: 0.6587
Epoch 190/300
72/72 [=====] - 0s 3ms/step - loss: 0.5569 - val_loss: 0.6579
Epoch 191/300
72/72 [=====] - 0s 3ms/step - loss: 0.5560 - val_loss: 0.6587
Epoch 192/300
72/72 [=====] - 0s 3ms/step - loss: 0.5563 - val_loss: 0.6603
Epoch 193/300
72/72 [=====] - 0s 3ms/step - loss: 0.5566 - val_loss: 0.6596
Epoch 194/300
72/72 [=====] - 0s 3ms/step - loss: 0.5565 - val_loss: 0.6591
Epoch 195/300
72/72 [=====] - 0s 3ms/step - loss: 0.5550 - val_loss: 0.6575
Epoch 196/300
72/72 [=====] - 0s 3ms/step - loss: 0.5560 - val_loss: 0.6609
Epoch 197/300
72/72 [=====] - 0s 3ms/step - loss: 0.5555 - val_loss: 0.6584
Epoch 198/300
72/72 [=====] - 0s 3ms/step - loss: 0.5555 - val_loss: 0.6586
Epoch 199/300
72/72 [=====] - 0s 3ms/step - loss: 0.5551 - val_loss: 0.6608
Epoch 200/300
72/72 [=====] - 0s 3ms/step - loss: 0.5544 - val_loss: 0.6600
Epoch 201/300
72/72 [=====] - 0s 3ms/step - loss: 0.5544 - val_loss: 0.6589
Epoch 202/300
72/72 [=====] - 0s 3ms/step - loss: 0.5548 - val_loss: 0.6579
Epoch 203/300
```

```
72/72 [=====] - 0s 3ms/step - loss: 0.5540 - val_loss: 0.6636
Epoch 204/300
72/72 [=====] - 0s 3ms/step - loss: 0.5543 - val_loss: 0.6597
Epoch 205/300
72/72 [=====] - 0s 3ms/step - loss: 0.5545 - val_loss: 0.6584
Epoch 206/300
72/72 [=====] - 0s 3ms/step - loss: 0.5547 - val_loss: 0.6589
Epoch 207/300
72/72 [=====] - 0s 3ms/step - loss: 0.5532 - val_loss: 0.6609
Epoch 208/300
72/72 [=====] - 0s 3ms/step - loss: 0.5541 - val_loss: 0.6598
Epoch 209/300
72/72 [=====] - 0s 3ms/step - loss: 0.5534 - val_loss: 0.6610
Epoch 210/300
72/72 [=====] - 0s 3ms/step - loss: 0.5528 - val_loss: 0.6620
Epoch 211/300
72/72 [=====] - 0s 3ms/step - loss: 0.5530 - val_loss: 0.6621
Epoch 212/300
72/72 [=====] - 0s 3ms/step - loss: 0.5521 - val_loss: 0.6603
Epoch 213/300
72/72 [=====] - 0s 3ms/step - loss: 0.5523 - val_loss: 0.6616
Epoch 214/300
72/72 [=====] - 0s 3ms/step - loss: 0.5525 - val_loss: 0.6637
Epoch 215/300
72/72 [=====] - 0s 3ms/step - loss: 0.5519 - val_loss: 0.6620
Epoch 216/300
72/72 [=====] - 0s 3ms/step - loss: 0.5524 - val_loss: 0.6610
Epoch 217/300
72/72 [=====] - 0s 3ms/step - loss: 0.5519 - val_loss: 0.6616
Epoch 218/300
72/72 [=====] - 0s 3ms/step - loss: 0.5518 - val_loss: 0.6614
Epoch 219/300
72/72 [=====] - 0s 3ms/step - loss: 0.5519 - val_loss: 0.6634
Epoch 220/300
72/72 [=====] - 0s 3ms/step - loss: 0.5508 - val_loss: 0.6621
Epoch 221/300
72/72 [=====] - 0s 3ms/step - loss: 0.5509 - val_loss: 0.6632
Epoch 222/300
72/72 [=====] - 0s 3ms/step - loss: 0.5507 - val_loss: 0.6645
Epoch 223/300
72/72 [=====] - 0s 3ms/step - loss: 0.5504 - val_loss: 0.6622
Epoch 224/300
72/72 [=====] - 0s 3ms/step - loss: 0.5512 - val_loss: 0.6620
Epoch 225/300
72/72 [=====] - 0s 3ms/step - loss: 0.5500 - val_loss: 0.6640
```

```
Epoch 226/300
72/72 [=====] - 0s 3ms/step - loss: 0.5503 - val_loss: 0.6636
Epoch 227/300
72/72 [=====] - 0s 3ms/step - loss: 0.5499 - val_loss: 0.6640
Epoch 228/300
72/72 [=====] - 0s 3ms/step - loss: 0.5497 - val_loss: 0.6637
Epoch 229/300
72/72 [=====] - 0s 3ms/step - loss: 0.5497 - val_loss: 0.6646
Epoch 230/300
72/72 [=====] - 0s 3ms/step - loss: 0.5493 - val_loss: 0.6618
Epoch 231/300
72/72 [=====] - 0s 3ms/step - loss: 0.5491 - val_loss: 0.6651
Epoch 232/300
72/72 [=====] - 0s 3ms/step - loss: 0.5493 - val_loss: 0.6645
Epoch 233/300
72/72 [=====] - 0s 3ms/step - loss: 0.5492 - val_loss: 0.6647
Epoch 234/300
72/72 [=====] - 0s 3ms/step - loss: 0.5490 - val_loss: 0.6639
Epoch 235/300
72/72 [=====] - 0s 3ms/step - loss: 0.5488 - val_loss: 0.6637
Epoch 236/300
72/72 [=====] - 0s 3ms/step - loss: 0.5482 - val_loss: 0.6651
Epoch 237/300
72/72 [=====] - 0s 3ms/step - loss: 0.5484 - val_loss: 0.6624
Epoch 238/300
72/72 [=====] - 0s 3ms/step - loss: 0.5489 - val_loss: 0.6624
Epoch 239/300
72/72 [=====] - 0s 3ms/step - loss: 0.5487 - val_loss: 0.6661
Epoch 240/300
72/72 [=====] - 0s 3ms/step - loss: 0.5487 - val_loss: 0.6650
Epoch 241/300
72/72 [=====] - 0s 3ms/step - loss: 0.5480 - val_loss: 0.6642
Epoch 242/300
72/72 [=====] - 0s 3ms/step - loss: 0.5479 - val_loss: 0.6622
Epoch 243/300
72/72 [=====] - 0s 3ms/step - loss: 0.5482 - val_loss: 0.6688
Epoch 244/300
72/72 [=====] - 0s 3ms/step - loss: 0.5479 - val_loss: 0.6638
Epoch 245/300
72/72 [=====] - 0s 3ms/step - loss: 0.5480 - val_loss: 0.6672
Epoch 246/300
72/72 [=====] - 0s 3ms/step - loss: 0.5481 - val_loss: 0.6660
Epoch 247/300
72/72 [=====] - 0s 3ms/step - loss: 0.5480 - val_loss: 0.6637
Epoch 248/300
```

```
72/72 [=====] - 0s 3ms/step - loss: 0.5481 - val_loss: 0.6664
Epoch 249/300
72/72 [=====] - 0s 3ms/step - loss: 0.5477 - val_loss: 0.6682
Epoch 250/300
72/72 [=====] - 0s 3ms/step - loss: 0.5482 - val_loss: 0.6682
Epoch 251/300
72/72 [=====] - 0s 3ms/step - loss: 0.5481 - val_loss: 0.6637
Epoch 252/300
72/72 [=====] - 0s 3ms/step - loss: 0.5464 - val_loss: 0.6768
Epoch 253/300
72/72 [=====] - 0s 3ms/step - loss: 0.5486 - val_loss: 0.6661
Epoch 254/300
72/72 [=====] - 0s 3ms/step - loss: 0.5484 - val_loss: 0.6691
Epoch 255/300
72/72 [=====] - 0s 3ms/step - loss: 0.5475 - val_loss: 0.6653
Epoch 256/300
72/72 [=====] - 0s 3ms/step - loss: 0.5479 - val_loss: 0.6643
Epoch 257/300
72/72 [=====] - 0s 3ms/step - loss: 0.5469 - val_loss: 0.6686
Epoch 258/300
72/72 [=====] - 0s 3ms/step - loss: 0.5470 - val_loss: 0.6649
Epoch 259/300
72/72 [=====] - 0s 3ms/step - loss: 0.5466 - val_loss: 0.6670
Epoch 260/300
72/72 [=====] - 0s 3ms/step - loss: 0.5470 - val_loss: 0.6686
Epoch 261/300
72/72 [=====] - 0s 3ms/step - loss: 0.5470 - val_loss: 0.6706
Epoch 262/300
72/72 [=====] - 0s 3ms/step - loss: 0.5471 - val_loss: 0.6691
Epoch 263/300
72/72 [=====] - 0s 3ms/step - loss: 0.5467 - val_loss: 0.6693
Epoch 264/300
72/72 [=====] - 0s 3ms/step - loss: 0.5466 - val_loss: 0.6707
Epoch 265/300
72/72 [=====] - 0s 3ms/step - loss: 0.5462 - val_loss: 0.6708
Epoch 266/300
72/72 [=====] - 0s 3ms/step - loss: 0.5466 - val_loss: 0.6681
Epoch 267/300
72/72 [=====] - 0s 3ms/step - loss: 0.5460 - val_loss: 0.6703
Epoch 268/300
72/72 [=====] - 0s 3ms/step - loss: 0.5470 - val_loss: 0.6685
Epoch 269/300
72/72 [=====] - 0s 3ms/step - loss: 0.5458 - val_loss: 0.6709
Epoch 270/300
72/72 [=====] - 0s 3ms/step - loss: 0.5470 - val_loss: 0.6697
```

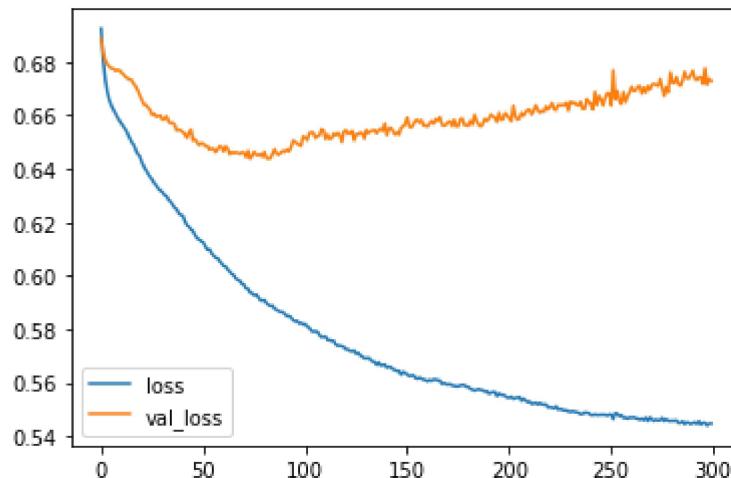
```
Epoch 271/300
72/72 [=====] - 0s 3ms/step - loss: 0.5463 - val_loss: 0.6715
Epoch 272/300
72/72 [=====] - 0s 3ms/step - loss: 0.5458 - val_loss: 0.6718
Epoch 273/300
72/72 [=====] - 0s 3ms/step - loss: 0.5463 - val_loss: 0.6714
Epoch 274/300
72/72 [=====] - 0s 3ms/step - loss: 0.5459 - val_loss: 0.6710
Epoch 275/300
72/72 [=====] - 0s 3ms/step - loss: 0.5460 - val_loss: 0.6736
Epoch 276/300
72/72 [=====] - 0s 3ms/step - loss: 0.5468 - val_loss: 0.6705
Epoch 277/300
72/72 [=====] - 0s 3ms/step - loss: 0.5458 - val_loss: 0.6674
Epoch 278/300
72/72 [=====] - 0s 3ms/step - loss: 0.5464 - val_loss: 0.6705
Epoch 279/300
72/72 [=====] - 0s 3ms/step - loss: 0.5458 - val_loss: 0.6685
Epoch 280/300
72/72 [=====] - 0s 3ms/step - loss: 0.5457 - val_loss: 0.6760
Epoch 281/300
72/72 [=====] - 0s 3ms/step - loss: 0.5458 - val_loss: 0.6722
Epoch 282/300
72/72 [=====] - 0s 3ms/step - loss: 0.5458 - val_loss: 0.6721
Epoch 283/300
72/72 [=====] - 0s 3ms/step - loss: 0.5459 - val_loss: 0.6743
Epoch 284/300
72/72 [=====] - 0s 3ms/step - loss: 0.5450 - val_loss: 0.6717
Epoch 285/300
72/72 [=====] - 0s 3ms/step - loss: 0.5451 - val_loss: 0.6710
Epoch 286/300
72/72 [=====] - 0s 3ms/step - loss: 0.5456 - val_loss: 0.6731
Epoch 287/300
72/72 [=====] - 0s 3ms/step - loss: 0.5445 - val_loss: 0.6763
Epoch 288/300
72/72 [=====] - 0s 3ms/step - loss: 0.5453 - val_loss: 0.6739
Epoch 289/300
72/72 [=====] - 0s 3ms/step - loss: 0.5450 - val_loss: 0.6738
Epoch 290/300
72/72 [=====] - 0s 3ms/step - loss: 0.5445 - val_loss: 0.6751
Epoch 291/300
72/72 [=====] - 0s 3ms/step - loss: 0.5449 - val_loss: 0.6767
Epoch 292/300
72/72 [=====] - 0s 3ms/step - loss: 0.5452 - val_loss: 0.6738
Epoch 293/300
```

```
72/72 [=====] - 0s 3ms/step - loss: 0.5446 - val_loss: 0.6732
Epoch 294/300
72/72 [=====] - 0s 3ms/step - loss: 0.5457 - val_loss: 0.6742
Epoch 295/300
72/72 [=====] - 0s 3ms/step - loss: 0.5443 - val_loss: 0.6742
Epoch 296/300
72/72 [=====] - 0s 3ms/step - loss: 0.5451 - val_loss: 0.6717
Epoch 297/300
72/72 [=====] - 0s 3ms/step - loss: 0.5450 - val_loss: 0.6775
Epoch 298/300
72/72 [=====] - 0s 3ms/step - loss: 0.5440 - val_loss: 0.6715
Epoch 299/300
72/72 [=====] - 0s 3ms/step - loss: 0.5448 - val_loss: 0.6736
Epoch 300/300
72/72 [=====] - 0s 3ms/step - loss: 0.5447 - val_loss: 0.6729
<keras.callbacks.History at 0x146f7248bb0>
```

Out[23]:

```
In [24]: lossdf=pd.DataFrame(ann.history.history)
lossdf.plot()
```

Out[24]: <AxesSubplot:>



```
In [25]: from tensorflow.keras.callbacks import EarlyStopping
es=EarlyStopping(monitor='val_loss', mode='min', verbose=1, patience=25)
```

```
In [26]: ann=Sequential()
ann.add(Dense(units=10, activation='relu'))
ann.add(Dense(units=5, activation='tanh'))
```

```
ann.add(Dense(units=5,activation='tanh'))  
  
ann.add(Dense(units=1,activation='sigmoid'))  
  
ann.compile(optimizer='adam',loss='binary_crossentropy')  
ann.fit(X_train,Y_train,epochs=300,validation_data=(X_test,Y_test),callbacks=[es])
```

```
Epoch 1/300
72/72 [=====] - 2s 5ms/step - loss: 0.6941 - val_loss: 0.6744
Epoch 2/300
72/72 [=====] - 0s 3ms/step - loss: 0.6640 - val_loss: 0.6714
Epoch 3/300
72/72 [=====] - 0s 3ms/step - loss: 0.6589 - val_loss: 0.6702
Epoch 4/300
72/72 [=====] - 0s 3ms/step - loss: 0.6559 - val_loss: 0.6685
Epoch 5/300
72/72 [=====] - 0s 3ms/step - loss: 0.6531 - val_loss: 0.6662
Epoch 6/300
72/72 [=====] - 0s 3ms/step - loss: 0.6505 - val_loss: 0.6637
Epoch 7/300
72/72 [=====] - 0s 3ms/step - loss: 0.6471 - val_loss: 0.6610
Epoch 8/300
72/72 [=====] - 0s 3ms/step - loss: 0.6433 - val_loss: 0.6575
Epoch 9/300
72/72 [=====] - 0s 3ms/step - loss: 0.6392 - val_loss: 0.6543
Epoch 10/300
72/72 [=====] - 0s 3ms/step - loss: 0.6349 - val_loss: 0.6499
Epoch 11/300
72/72 [=====] - 0s 3ms/step - loss: 0.6288 - val_loss: 0.6476
Epoch 12/300
72/72 [=====] - 0s 3ms/step - loss: 0.6239 - val_loss: 0.6428
Epoch 13/300
72/72 [=====] - 0s 3ms/step - loss: 0.6189 - val_loss: 0.6408
Epoch 14/300
72/72 [=====] - 0s 3ms/step - loss: 0.6148 - val_loss: 0.6371
Epoch 15/300
72/72 [=====] - 0s 3ms/step - loss: 0.6109 - val_loss: 0.6356
Epoch 16/300
72/72 [=====] - 0s 3ms/step - loss: 0.6071 - val_loss: 0.6306
Epoch 17/300
72/72 [=====] - 0s 3ms/step - loss: 0.6041 - val_loss: 0.6284
Epoch 18/300
72/72 [=====] - 0s 3ms/step - loss: 0.6008 - val_loss: 0.6256
Epoch 19/300
72/72 [=====] - 0s 3ms/step - loss: 0.5988 - val_loss: 0.6233
Epoch 20/300
72/72 [=====] - 0s 3ms/step - loss: 0.5970 - val_loss: 0.6235
Epoch 21/300
72/72 [=====] - 0s 3ms/step - loss: 0.5949 - val_loss: 0.6226
Epoch 22/300
72/72 [=====] - 0s 3ms/step - loss: 0.5946 - val_loss: 0.6209
Epoch 23/300
```

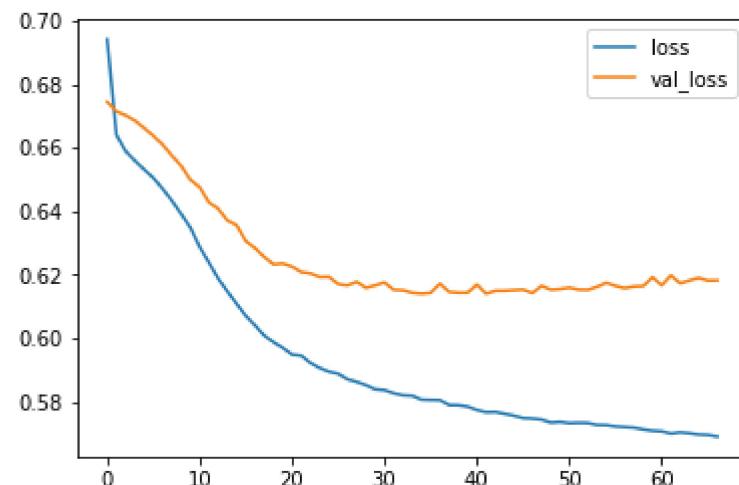
```
72/72 [=====] - 0s 3ms/step - loss: 0.5923 - val_loss: 0.6204
Epoch 24/300
72/72 [=====] - 0s 3ms/step - loss: 0.5907 - val_loss: 0.6193
Epoch 25/300
72/72 [=====] - 0s 3ms/step - loss: 0.5895 - val_loss: 0.6194
Epoch 26/300
72/72 [=====] - 0s 3ms/step - loss: 0.5888 - val_loss: 0.6171
Epoch 27/300
72/72 [=====] - 0s 3ms/step - loss: 0.5871 - val_loss: 0.6167
Epoch 28/300
72/72 [=====] - 0s 3ms/step - loss: 0.5863 - val_loss: 0.6178
Epoch 29/300
72/72 [=====] - 0s 3ms/step - loss: 0.5853 - val_loss: 0.6159
Epoch 30/300
72/72 [=====] - 0s 3ms/step - loss: 0.5840 - val_loss: 0.6167
Epoch 31/300
72/72 [=====] - 0s 3ms/step - loss: 0.5837 - val_loss: 0.6176
Epoch 32/300
72/72 [=====] - 0s 3ms/step - loss: 0.5827 - val_loss: 0.6153
Epoch 33/300
72/72 [=====] - 0s 3ms/step - loss: 0.5821 - val_loss: 0.6151
Epoch 34/300
72/72 [=====] - 0s 3ms/step - loss: 0.5819 - val_loss: 0.6143
Epoch 35/300
72/72 [=====] - 0s 3ms/step - loss: 0.5807 - val_loss: 0.6141
Epoch 36/300
72/72 [=====] - 0s 3ms/step - loss: 0.5806 - val_loss: 0.6143
Epoch 37/300
72/72 [=====] - 0s 3ms/step - loss: 0.5806 - val_loss: 0.6172
Epoch 38/300
72/72 [=====] - 0s 3ms/step - loss: 0.5790 - val_loss: 0.6146
Epoch 39/300
72/72 [=====] - 0s 3ms/step - loss: 0.5790 - val_loss: 0.6143
Epoch 40/300
72/72 [=====] - 0s 3ms/step - loss: 0.5785 - val_loss: 0.6144
Epoch 41/300
72/72 [=====] - 0s 3ms/step - loss: 0.5775 - val_loss: 0.6169
Epoch 42/300
72/72 [=====] - 0s 3ms/step - loss: 0.5768 - val_loss: 0.6141
Epoch 43/300
72/72 [=====] - 0s 3ms/step - loss: 0.5768 - val_loss: 0.6150
Epoch 44/300
72/72 [=====] - 0s 3ms/step - loss: 0.5763 - val_loss: 0.6150
Epoch 45/300
72/72 [=====] - 0s 3ms/step - loss: 0.5757 - val_loss: 0.6152
```

```
Epoch 46/300
72/72 [=====] - 0s 3ms/step - loss: 0.5749 - val_loss: 0.6153
Epoch 47/300
72/72 [=====] - 0s 3ms/step - loss: 0.5747 - val_loss: 0.6142
Epoch 48/300
72/72 [=====] - 0s 3ms/step - loss: 0.5744 - val_loss: 0.6165
Epoch 49/300
72/72 [=====] - 0s 3ms/step - loss: 0.5735 - val_loss: 0.6153
Epoch 50/300
72/72 [=====] - 0s 3ms/step - loss: 0.5737 - val_loss: 0.6155
Epoch 51/300
72/72 [=====] - 0s 3ms/step - loss: 0.5733 - val_loss: 0.6159
Epoch 52/300
72/72 [=====] - 0s 4ms/step - loss: 0.5734 - val_loss: 0.6153
Epoch 53/300
72/72 [=====] - 0s 4ms/step - loss: 0.5734 - val_loss: 0.6153
Epoch 54/300
72/72 [=====] - 0s 4ms/step - loss: 0.5727 - val_loss: 0.6162
Epoch 55/300
72/72 [=====] - 0s 4ms/step - loss: 0.5727 - val_loss: 0.6175
Epoch 56/300
72/72 [=====] - 0s 3ms/step - loss: 0.5723 - val_loss: 0.6165
Epoch 57/300
72/72 [=====] - 0s 3ms/step - loss: 0.5721 - val_loss: 0.6158
Epoch 58/300
72/72 [=====] - 0s 3ms/step - loss: 0.5719 - val_loss: 0.6163
Epoch 59/300
72/72 [=====] - 0s 3ms/step - loss: 0.5713 - val_loss: 0.6164
Epoch 60/300
72/72 [=====] - 0s 4ms/step - loss: 0.5709 - val_loss: 0.6192
Epoch 61/300
72/72 [=====] - 0s 3ms/step - loss: 0.5707 - val_loss: 0.6167
Epoch 62/300
72/72 [=====] - 0s 3ms/step - loss: 0.5700 - val_loss: 0.6198
Epoch 63/300
72/72 [=====] - 0s 3ms/step - loss: 0.5704 - val_loss: 0.6173
Epoch 64/300
72/72 [=====] - 0s 3ms/step - loss: 0.5701 - val_loss: 0.6182
Epoch 65/300
72/72 [=====] - 0s 3ms/step - loss: 0.5697 - val_loss: 0.6190
Epoch 66/300
72/72 [=====] - 0s 3ms/step - loss: 0.5696 - val_loss: 0.6182
Epoch 67/300
72/72 [=====] - 0s 3ms/step - loss: 0.5691 - val_loss: 0.6183
Epoch 67: early stopping
```

```
Out[26]: <keras.callbacks.History at 0x146faac2130>
```

```
In [27]: lossdf=pd.DataFrame(ann.history.history)
lossdf.plot()
```

```
Out[27]: <AxesSubplot:>
```



```
In [28]: from tensorflow.keras.layers import Dropout
```

```
In [29]: ann=Sequential()
ann.add(Dense(units=10,activation='relu'))
ann.add(Dropout(rate=0.3))
ann.add(Dense(units=8,activation='tanh'))
ann.add(Dropout(rate=0.2))
ann.add(Dense(units=8,activation='tanh'))

ann.add(Dense(units=1,activation='sigmoid'))

ann.compile(optimizer='adam',loss='binary_crossentropy')
ann.fit(X_train,Y_train,epochs=300,validation_data=(X_test,Y_test),callbacks=[es])
```

```
Epoch 1/300
72/72 [=====] - 3s 8ms/step - loss: 0.6717 - val_loss: 0.6812
Epoch 2/300
72/72 [=====] - 0s 3ms/step - loss: 0.6690 - val_loss: 0.6805
Epoch 3/300
72/72 [=====] - 0s 3ms/step - loss: 0.6677 - val_loss: 0.6788
Epoch 4/300
72/72 [=====] - 0s 3ms/step - loss: 0.6659 - val_loss: 0.6778
Epoch 5/300
72/72 [=====] - 0s 3ms/step - loss: 0.6643 - val_loss: 0.6757
Epoch 6/300
72/72 [=====] - 0s 3ms/step - loss: 0.6616 - val_loss: 0.6725
Epoch 7/300
72/72 [=====] - 0s 3ms/step - loss: 0.6619 - val_loss: 0.6707
Epoch 8/300
72/72 [=====] - 0s 3ms/step - loss: 0.6583 - val_loss: 0.6681
Epoch 9/300
72/72 [=====] - 0s 3ms/step - loss: 0.6574 - val_loss: 0.6667
Epoch 10/300
72/72 [=====] - 0s 3ms/step - loss: 0.6558 - val_loss: 0.6623
Epoch 11/300
72/72 [=====] - 0s 3ms/step - loss: 0.6514 - val_loss: 0.6596
Epoch 12/300
72/72 [=====] - 0s 3ms/step - loss: 0.6505 - val_loss: 0.6592
Epoch 13/300
72/72 [=====] - 0s 3ms/step - loss: 0.6487 - val_loss: 0.6562
Epoch 14/300
72/72 [=====] - 0s 3ms/step - loss: 0.6460 - val_loss: 0.6535
Epoch 15/300
72/72 [=====] - 0s 3ms/step - loss: 0.6437 - val_loss: 0.6497
Epoch 16/300
72/72 [=====] - 0s 4ms/step - loss: 0.6405 - val_loss: 0.6466
Epoch 17/300
72/72 [=====] - 0s 4ms/step - loss: 0.6438 - val_loss: 0.6463
Epoch 18/300
72/72 [=====] - 0s 4ms/step - loss: 0.6393 - val_loss: 0.6431
Epoch 19/300
72/72 [=====] - 0s 3ms/step - loss: 0.6385 - val_loss: 0.6403
Epoch 20/300
72/72 [=====] - 0s 3ms/step - loss: 0.6353 - val_loss: 0.6394
Epoch 21/300
72/72 [=====] - 0s 3ms/step - loss: 0.6338 - val_loss: 0.6367
Epoch 22/300
72/72 [=====] - 0s 3ms/step - loss: 0.6370 - val_loss: 0.6353
Epoch 23/300
```

```
72/72 [=====] - 0s 3ms/step - loss: 0.6407 - val_loss: 0.6350
Epoch 24/300
72/72 [=====] - 0s 4ms/step - loss: 0.6355 - val_loss: 0.6352
Epoch 25/300
72/72 [=====] - 0s 4ms/step - loss: 0.6350 - val_loss: 0.6330
Epoch 26/300
72/72 [=====] - 0s 4ms/step - loss: 0.6349 - val_loss: 0.6319
Epoch 27/300
72/72 [=====] - 0s 3ms/step - loss: 0.6271 - val_loss: 0.6283
Epoch 28/300
72/72 [=====] - 0s 3ms/step - loss: 0.6350 - val_loss: 0.6275
Epoch 29/300
72/72 [=====] - 0s 3ms/step - loss: 0.6314 - val_loss: 0.6238
Epoch 30/300
72/72 [=====] - 0s 3ms/step - loss: 0.6313 - val_loss: 0.6252
Epoch 31/300
72/72 [=====] - 0s 3ms/step - loss: 0.6376 - val_loss: 0.6245
Epoch 32/300
72/72 [=====] - 0s 3ms/step - loss: 0.6264 - val_loss: 0.6231
Epoch 33/300
72/72 [=====] - 0s 3ms/step - loss: 0.6249 - val_loss: 0.6206
Epoch 34/300
72/72 [=====] - 0s 3ms/step - loss: 0.6202 - val_loss: 0.6183
Epoch 35/300
72/72 [=====] - 0s 3ms/step - loss: 0.6280 - val_loss: 0.6178
Epoch 36/300
72/72 [=====] - 0s 3ms/step - loss: 0.6227 - val_loss: 0.6154
Epoch 37/300
72/72 [=====] - 0s 3ms/step - loss: 0.6246 - val_loss: 0.6174
Epoch 38/300
72/72 [=====] - 0s 3ms/step - loss: 0.6268 - val_loss: 0.6174
Epoch 39/300
72/72 [=====] - 0s 3ms/step - loss: 0.6219 - val_loss: 0.6168
Epoch 40/300
72/72 [=====] - 0s 3ms/step - loss: 0.6174 - val_loss: 0.6169
Epoch 41/300
72/72 [=====] - 0s 3ms/step - loss: 0.6230 - val_loss: 0.6154
Epoch 42/300
72/72 [=====] - 0s 3ms/step - loss: 0.6188 - val_loss: 0.6154
Epoch 43/300
72/72 [=====] - 0s 3ms/step - loss: 0.6233 - val_loss: 0.6164
Epoch 44/300
72/72 [=====] - 0s 3ms/step - loss: 0.6260 - val_loss: 0.6169
Epoch 45/300
72/72 [=====] - 0s 3ms/step - loss: 0.6176 - val_loss: 0.6166
```

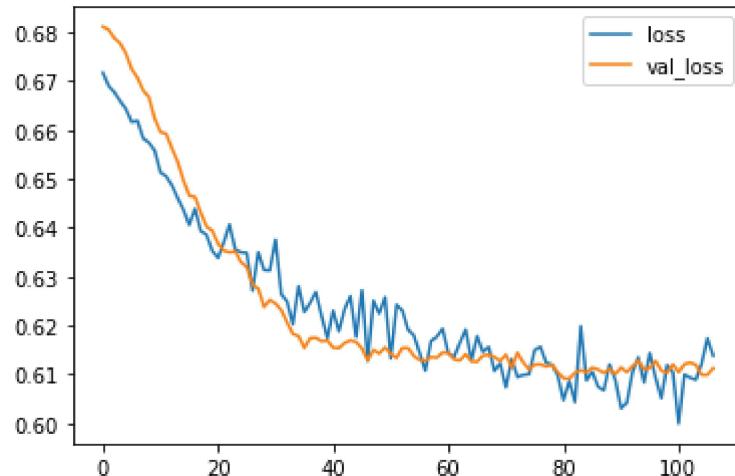
```
Epoch 46/300
72/72 [=====] - 0s 3ms/step - loss: 0.6272 - val_loss: 0.6153
Epoch 47/300
72/72 [=====] - 0s 3ms/step - loss: 0.6127 - val_loss: 0.6128
Epoch 48/300
72/72 [=====] - 0s 3ms/step - loss: 0.6251 - val_loss: 0.6150
Epoch 49/300
72/72 [=====] - 0s 3ms/step - loss: 0.6225 - val_loss: 0.6143
Epoch 50/300
72/72 [=====] - 0s 3ms/step - loss: 0.6257 - val_loss: 0.6155
Epoch 51/300
72/72 [=====] - 0s 3ms/step - loss: 0.6133 - val_loss: 0.6141
Epoch 52/300
72/72 [=====] - 0s 3ms/step - loss: 0.6242 - val_loss: 0.6134
Epoch 53/300
72/72 [=====] - 0s 3ms/step - loss: 0.6231 - val_loss: 0.6154
Epoch 54/300
72/72 [=====] - 0s 3ms/step - loss: 0.6191 - val_loss: 0.6154
Epoch 55/300
72/72 [=====] - 0s 3ms/step - loss: 0.6180 - val_loss: 0.6138
Epoch 56/300
72/72 [=====] - 0s 3ms/step - loss: 0.6144 - val_loss: 0.6129
Epoch 57/300
72/72 [=====] - 0s 3ms/step - loss: 0.6108 - val_loss: 0.6128
Epoch 58/300
72/72 [=====] - 0s 3ms/step - loss: 0.6168 - val_loss: 0.6135
Epoch 59/300
72/72 [=====] - 0s 3ms/step - loss: 0.6177 - val_loss: 0.6134
Epoch 60/300
72/72 [=====] - 0s 3ms/step - loss: 0.6193 - val_loss: 0.6144
Epoch 61/300
72/72 [=====] - 0s 3ms/step - loss: 0.6143 - val_loss: 0.6144
Epoch 62/300
72/72 [=====] - 0s 3ms/step - loss: 0.6135 - val_loss: 0.6130
Epoch 63/300
72/72 [=====] - 0s 3ms/step - loss: 0.6165 - val_loss: 0.6128
Epoch 64/300
72/72 [=====] - 0s 4ms/step - loss: 0.6191 - val_loss: 0.6141
Epoch 65/300
72/72 [=====] - 0s 3ms/step - loss: 0.6128 - val_loss: 0.6127
Epoch 66/300
72/72 [=====] - 0s 3ms/step - loss: 0.6178 - val_loss: 0.6126
Epoch 67/300
72/72 [=====] - 0s 3ms/step - loss: 0.6146 - val_loss: 0.6138
Epoch 68/300
```

```
72/72 [=====] - 0s 4ms/step - loss: 0.6156 - val_loss: 0.6140
Epoch 69/300
72/72 [=====] - 0s 3ms/step - loss: 0.6107 - val_loss: 0.6136
Epoch 70/300
72/72 [=====] - 0s 3ms/step - loss: 0.6123 - val_loss: 0.6127
Epoch 71/300
72/72 [=====] - 0s 3ms/step - loss: 0.6074 - val_loss: 0.6140
Epoch 72/300
72/72 [=====] - 0s 3ms/step - loss: 0.6131 - val_loss: 0.6114
Epoch 73/300
72/72 [=====] - 0s 3ms/step - loss: 0.6095 - val_loss: 0.6144
Epoch 74/300
72/72 [=====] - 0s 3ms/step - loss: 0.6099 - val_loss: 0.6124
Epoch 75/300
72/72 [=====] - 0s 3ms/step - loss: 0.6100 - val_loss: 0.6110
Epoch 76/300
72/72 [=====] - 0s 3ms/step - loss: 0.6150 - val_loss: 0.6120
Epoch 77/300
72/72 [=====] - 0s 3ms/step - loss: 0.6156 - val_loss: 0.6120
Epoch 78/300
72/72 [=====] - 0s 3ms/step - loss: 0.6123 - val_loss: 0.6116
Epoch 79/300
72/72 [=====] - 0s 3ms/step - loss: 0.6120 - val_loss: 0.6120
Epoch 80/300
72/72 [=====] - 0s 3ms/step - loss: 0.6097 - val_loss: 0.6105
Epoch 81/300
72/72 [=====] - 0s 3ms/step - loss: 0.6047 - val_loss: 0.6092
Epoch 82/300
72/72 [=====] - 0s 3ms/step - loss: 0.6086 - val_loss: 0.6091
Epoch 83/300
72/72 [=====] - 0s 3ms/step - loss: 0.6043 - val_loss: 0.6103
Epoch 84/300
72/72 [=====] - 0s 3ms/step - loss: 0.6199 - val_loss: 0.6109
Epoch 85/300
72/72 [=====] - 0s 3ms/step - loss: 0.6088 - val_loss: 0.6104
Epoch 86/300
72/72 [=====] - 0s 3ms/step - loss: 0.6105 - val_loss: 0.6113
Epoch 87/300
72/72 [=====] - 0s 3ms/step - loss: 0.6075 - val_loss: 0.6110
Epoch 88/300
72/72 [=====] - 0s 3ms/step - loss: 0.6067 - val_loss: 0.6103
Epoch 89/300
72/72 [=====] - 0s 3ms/step - loss: 0.6120 - val_loss: 0.6111
Epoch 90/300
72/72 [=====] - 0s 3ms/step - loss: 0.6089 - val_loss: 0.6100
```

```
Epoch 91/300
72/72 [=====] - 0s 3ms/step - loss: 0.6030 - val_loss: 0.6114
Epoch 92/300
72/72 [=====] - 0s 3ms/step - loss: 0.6042 - val_loss: 0.6105
Epoch 93/300
72/72 [=====] - 0s 3ms/step - loss: 0.6105 - val_loss: 0.6116
Epoch 94/300
72/72 [=====] - 0s 3ms/step - loss: 0.6135 - val_loss: 0.6128
Epoch 95/300
72/72 [=====] - 0s 3ms/step - loss: 0.6083 - val_loss: 0.6110
Epoch 96/300
72/72 [=====] - 0s 3ms/step - loss: 0.6143 - val_loss: 0.6114
Epoch 97/300
72/72 [=====] - 0s 3ms/step - loss: 0.6093 - val_loss: 0.6127
Epoch 98/300
72/72 [=====] - 0s 3ms/step - loss: 0.6051 - val_loss: 0.6107
Epoch 99/300
72/72 [=====] - 0s 3ms/step - loss: 0.6119 - val_loss: 0.6103
Epoch 100/300
72/72 [=====] - 0s 3ms/step - loss: 0.6105 - val_loss: 0.6120
Epoch 101/300
72/72 [=====] - 0s 3ms/step - loss: 0.5999 - val_loss: 0.6104
Epoch 102/300
72/72 [=====] - 0s 3ms/step - loss: 0.6100 - val_loss: 0.6121
Epoch 103/300
72/72 [=====] - 0s 3ms/step - loss: 0.6093 - val_loss: 0.6124
Epoch 104/300
72/72 [=====] - 0s 3ms/step - loss: 0.6089 - val_loss: 0.6119
Epoch 105/300
72/72 [=====] - 0s 3ms/step - loss: 0.6121 - val_loss: 0.6099
Epoch 106/300
72/72 [=====] - 0s 3ms/step - loss: 0.6173 - val_loss: 0.6099
Epoch 107/300
72/72 [=====] - 0s 3ms/step - loss: 0.6138 - val_loss: 0.6112
Epoch 107: early stopping
<keras.callbacks.History at 0x146fc145280>
```

In [30]: `lossdf=pd.DataFrame(ann.history.history)
lossdf.plot()`

Out[30]: <AxesSubplot:>



```
In [31]: Y_pred=ann.predict(X_test)
```

```
31/31 [=====] - 0s 1ms/step
```

```
In [32]: Y_pred=Y_pred>0.5
```

```
In [33]: print(classification_report(Y_test,Y_pred))
```

	precision	recall	f1-score	support
0	0.66	0.91	0.76	585
1	0.69	0.30	0.41	398
accuracy			0.66	983
macro avg	0.67	0.60	0.59	983
weighted avg	0.67	0.66	0.62	983

```
In [ ]:
```

```
In [ ]:
```

```
In [ ]:
```