```
import tensorflow as tf
import tensorflow_hub as hub


import tensorflow_text as text


import pandas as pd

df=pd.read_csv('spam.csv',encoding = "ISO-8859-1")
df.head(5)
```

	v1	v2	Unnamed: 2	Unnamed: 3	Unnamed: 4
0	ham	Go until jurong point, crazy.. Available only ...	NaN	NaN	NaN
1	ham	Ok lar... Joking wif u oni...	NaN	NaN	NaN
2	spam	Free entry in 2 a wkly comp to win FA Cup fina...	NaN	NaN	NaN
3	ham	U dun say so early hor... U c already then say...	NaN	NaN	NaN

```
df=df.drop(['Unnamed: 2','Unnamed: 3','Unnamed: 4'],axis=1)


df.head()
```

	v1	v2
0	ham	Go until jurong point, crazy.. Available only ...
1	ham	Ok lar... Joking wif u oni...
2	spam	Free entry in 2 a wkly comp to win FA Cup fina...
3	ham	U dun say so early hor... U c already then say...
4	ham	Nah I don't think he goes to usf, he lives aro...

```
df.rename(columns={'v1':'Category','v2':'Message'},inplace=True)


df.groupby('Category').describe()
```

	Message			
	count	unique	top	freq
Category				
ham	4825	4516	Sorry, I'll call later	30
spam	747	653	Please call our customer service representativ...	4

```
df['Category'].value_counts()
```

```
ham     4825
spam     747
Name: Category, dtype: int64
```

```
747/4825
```

```
0.15481865284974095
```

```
df_spam=df[df['Category']=='spam']
df_spam.shape
```

```
(747, 2)
```

```
df_ham=df[df['Category']=='ham']
df_ham.shape
```

```
(4825, 2)
```

```
#Down Sampling
df_ham_downsampled=df_ham.sample(df_spam.shape[0])
df_ham_downsampled.shape
```

```
(747, 2)
```

```
df_balanced=pd.concat([df_spam,df_ham_downsampled])
df_balanced.shape
```

```
(1494, 2)
```

```
df_balanced['Category'].value_counts()
```

```
spam    747
ham     747
Name: Category, dtype: int64
```

```
df_balanced.sample(5)
```

	Category	Message
1001	spam	Please call our customer service representativ...
4146	ham	Pls help me tell sura that i'm expecting a bat...
1163	ham	New Theory: Argument wins d SITUATION, but los...
4022	ham	Well. Balls. Time to make calls
1140	ham	Oh:)as usual vijay film or its different?

```
df_balanced['spam']=df_balanced['Category'].apply(lambda x:1 if x=='spam' else 0)
df_balanced.sample(10)
```

	Category	Message	spam
1369	ham	Did you try making another butt.	0
931	ham	Congratulations ore mo owo re wa. Enjoy it and...	0
2093	spam	Final Chance! Claim ur â£150 worth of discount...	1
2263	spam	Not heard from U4 a while. Call 4 rude chat pr...	1
1804	ham	The bus leaves at <#>	0
2334	ham	Do you like Italian food?	0
2648	ham	Hi, can i please get a <#> dollar loan...	0
5492	spam	Marvel Mobile Play the official Ultimate Spide...	1
483	ham	Thank you baby! I cant wait to taste the real ...	0
1268	spam	Can U get 2 phone NOW? I wanna chat 2 set up m...	1

```
from sklearn.model_selection import train_test_split

X_train,X_test,y_train,y_test=train_test_split(df_balanced['Message'],df_balanced['spam'],stratify=df_balanced['spam'])
X_train.head(4)
```

```
4164    Dear Voucher Holder, To claim this weeks offer...
958     My sort code is  and acc no is . The bank is n...
1429    For sale - arsenal dartboard. Good condition b...
2271    Life spend with someone for a lifetime may be ...
Name: Message, dtype: object
```

```
bert_preprocess=hub.KerasLayer("https://tfhub.dev/tensorflow/bert_en_uncased_preprocess/3")
bert_encoder=hub.KerasLayer("https://tfhub.dev/tensorflow/bert_en_uncased_L-12_H-768_A-12/4")
```

```
def get_sentence_embeding(sentences):
  preprocessed_text=bert_preprocess(sentences)
  return bert_encoder(preprocessed_text)['pooled_output']
```

```
get_sentence_embeding(["500$ discount.hurry up",
                       "Bhavin, are you up for a volleyball game tomorrow" ])
```

```
<tf.Tensor: shape=(2, 768), dtype=float32, numpy=
array([[-0.843517  , -0.51327276, -0.88845724, ..., -0.7474888 ,
        -0.75314736,  0.91964495],
       [-0.86342734, -0.5988451 , -0.9751756 , ..., -0.91110355,
        -0.72617364,  0.8519889 ]], dtype=float32)>
```

```
e=get_sentence_embeding([
    'banana',
```

```
    'grapes',
    'mango',
    'jeff bezos',
    'elon musk',
    'bill gates'
])
```

```
e
```

```
<tf.Tensor: shape=(6, 768), dtype=float32, numpy=
array([[-0.76069194, -0.14219394,  0.49604553, ...,  0.42165306,
        -0.5322141 ,  0.8031219 ],
       [-0.86023223, -0.21242952,  0.49156865, ...,  0.39797997,
        -0.6050631 ,  0.84471667],
       [-0.7128861 , -0.15463905,  0.38401675, ...,  0.3527874 ,
        -0.5099133 ,  0.734741  ],
       [-0.8253345 , -0.3555056 , -0.5906967 , ..., -0.01613647,
        -0.6141757 ,  0.87230283],
       [-0.7504135 , -0.2681261 , -0.26689693, ...,  0.02839418,
        -0.59381   ,  0.797499  ],
       [-0.78544354, -0.29949677,  0.4102741 , ...,  0.5222538 ,
        -0.49573544,  0.8150749 ]], dtype=float32)>
```

```
from sklearn.metrics.pairwise import cosine_similarity
cosine_similarity([e[0]],[e[3]])
```

```
array([[0.84703875]], dtype=float32)
```

```
cosine_similarity([e[0]],[e[4]])
```

```
array([[0.8933632]], dtype=float32)
```

```
#Bert Layers
text_input=tf.keras.layers.Input(shape=(),dtype=tf.string,name='text')
preprocessed_text=bert_preprocess(text_input)
outputs=bert_encoder(preprocessed_text)

#Neural network layers

l=tf.keras.layers.Dropout(0.1,name='dropout')(outputs['pooled_output'])
l=tf.keras.layers.Dense(1,activation='sigmoid',name='output')(l)

#Construct final model
model=tf.keras.Model(inputs=[text_input],outputs=[l])
```

```
model.summary()
```

```
Model: "model"
__________________________________________________________________________________________________
 Layer (type)                   Output Shape         Param #     Connected to
==================================================================================================
 text (InputLayer)              [(None,)]            0           []

 keras_layer_1 (KerasLayer)     {'input_type_ids':   0           ['text[0][0]']
                                (None, 128),
                                 'input_mask': (Non
                                e, 128),
                                 'input_word_ids':
                                (None, 128)}

 keras_layer_2 (KerasLayer)     {'pooled_output': (  109482241   ['keras_layer_1[1][0]',
                                None, 768),                      'keras_layer_1[1][1]',
                                 'sequence_output':              'keras_layer_1[1][2]']
                                 (None, 128, 768),
                                 'default': (None,
                                768),
                                 'encoder_outputs':
                                 [(None, 128, 768),
                                 (None, 128, 768),
                                 (None, 128, 768),
                                 (None, 128, 768),
                                 (None, 128, 768),
                                 (None, 128, 768),
                                 (None, 128, 768),
                                 (None, 128, 768),
                                 (None, 128, 768),
                                 (None, 128, 768),
                                 (None, 128, 768),
                                 (None, 128, 768)]}

 dropout (Dropout)              (None, 768)          0           ['keras_layer_2[1][13]']
```

```
 output (Dense)                (None, 1)           769         ['dropout[0][0]']

==================================================================================================
Total params: 109,483,010
Trainable params: 769
Non-trainable params: 109,482,241
__________________________________________________________________________________________________
```

```
METRICS=[
    tf.keras.metrics.BinaryAccuracy(name='accuracy'),
    tf.keras.metrics.Precision(name='precesion'),
    tf.keras.metrics.Recall(name='recall')
]
model.compile(optimizer='adam',
              loss='binary_crossentropy',
              metrics=METRICS)
```

```
model.fit(X_train,y_train,epochs=10)
```

```
Epoch 1/10
35/35 [==============================] - 371s 10s/step - loss: 0.6439 - accuracy: 0.6321 - precesion: 0.6498 - recall: 0.5732
Epoch 2/10
35/35 [==============================] - 362s 10s/step - loss: 0.5083 - accuracy: 0.8330 - precesion: 0.8188 - recall: 0.8554
Epoch 3/10
35/35 [==============================] - 361s 10s/step - loss: 0.4362 - accuracy: 0.8536 - precesion: 0.8486 - recall: 0.8607
Epoch 4/10
35/35 [==============================] - 362s 10s/step - loss: 0.3883 - accuracy: 0.8741 - precesion: 0.8682 - recall: 0.8821
Epoch 5/10
35/35 [==============================] - 361s 10s/step - loss: 0.3596 - accuracy: 0.8786 - precesion: 0.8681 - recall: 0.8929
Epoch 6/10
35/35 [==============================] - 362s 10s/step - loss: 0.3405 - accuracy: 0.8875 - precesion: 0.8834 - recall: 0.8929
Epoch 7/10
35/35 [==============================] - 365s 10s/step - loss: 0.3159 - accuracy: 0.9018 - precesion: 0.8906 - recall: 0.9161
Epoch 8/10
35/35 [==============================] - 358s 10s/step - loss: 0.2995 - accuracy: 0.9062 - precesion: 0.8943 - recall: 0.9214
Epoch 9/10
35/35 [==============================] - 364s 10s/step - loss: 0.2884 - accuracy: 0.9054 - precesion: 0.8982 - recall: 0.9143
Epoch 10/10
35/35 [==============================] - 359s 10s/step - loss: 0.2809 - accuracy: 0.9027 - precesion: 0.8868 - recall: 0.9232
<keras.callbacks.History at 0x7f853172a4d0>
```

```
model.evaluate(X_test,y_test)
```

```
12/12 [==============================] - 124s 10s/step - loss: 0.3121 - accuracy: 0.8930 - precesion: 0.8517 - recall: 0.9519
[0.3121029734611511, 0.893048107624054, 0.8516746163368225, 0.9518716335296631]
```

```
y_predicted=model.predict(X_test)
y_predicted=y_predicted.flatten()
```

```
12/12 [==============================] - 130s 11s/step
```

```
import numpy as np
y_predicted=np.where(y_predicted>0.5,1,0)
y_predicted
```

```
array([1, 1, 1, 1, 0, 1, 1, 1, 0, 1, 1, 0, 1, 1, 0, 0, 0, 0, 1, 0, 0, 1,
       0, 0, 1, 0, 1, 1, 1, 1, 0, 0, 0, 0, 0, 0, 1, 0, 0, 1, 1, 1, 1, 0, 0,
       0, 0, 1, 1, 1, 1, 1, 1, 1, 1, 0, 1, 1, 0, 0, 1, 1, 1, 0, 0, 1, 0, 1,
       0, 1, 1, 0, 0, 1, 0, 0, 1, 0, 1, 0, 0, 1, 1, 0, 1, 1, 1, 1, 1, 0,
       1, 1, 1, 1, 1, 0, 1, 0, 1, 1, 0, 0, 1, 0, 1, 1, 1, 1, 0, 1, 0, 1,
       0, 0, 1, 0, 0, 1, 1, 0, 0, 0, 0, 1, 0, 1, 0, 0, 1, 0, 1, 0, 0, 0,
       0, 1, 0, 1, 0, 0, 0, 1, 0, 1, 0, 0, 0, 0, 0, 0, 0, 1, 1, 0, 0,
       0, 0, 0, 1, 0, 1, 1, 0, 0, 0, 0, 0, 1, 1, 0, 1, 1, 1, 1, 1, 0, 1, 1,
       0, 0, 1, 0, 0, 1, 0, 0, 1, 1, 0, 0, 1, 1, 0, 1, 0, 0, 0, 0, 0, 1,
       1, 1, 1, 1, 1, 1, 1, 1, 0, 1, 0, 0, 1, 0, 1, 1, 1, 0, 1, 1, 1, 1,
       1, 1, 1, 0, 0, 0, 0, 0, 0, 1, 0, 1, 0, 1, 1, 1, 1, 0, 1, 1, 0, 0,
       1, 1, 1, 0, 1, 0, 1, 0, 0, 0, 0, 0, 1, 1, 1, 0, 1, 0, 0, 1, 1, 1,
       1, 1, 1, 1, 1, 1, 0, 0, 0, 1, 0, 1, 1, 0, 0, 0, 1, 0, 1, 1, 1, 0,
       1, 0, 0, 1, 0, 1, 1, 1, 1, 0, 1, 1, 1, 1, 1, 0, 1, 1, 0, 1, 1, 0,
       0, 1, 1, 1, 1, 0, 1, 1, 0, 1, 1, 1, 1, 1, 1, 1, 1, 1, 1, 0, 0, 1,
       0, 1, 1, 0, 1, 1, 1, 1, 1, 1, 1, 1, 0, 1, 0, 1, 1, 1, 1, 1, 1, 1, 1,
       0, 0, 1, 1, 1, 1, 0, 0, 1, 1, 0, 0, 0, 0, 0, 1, 1, 0, 0, 1, 1, 1])
```

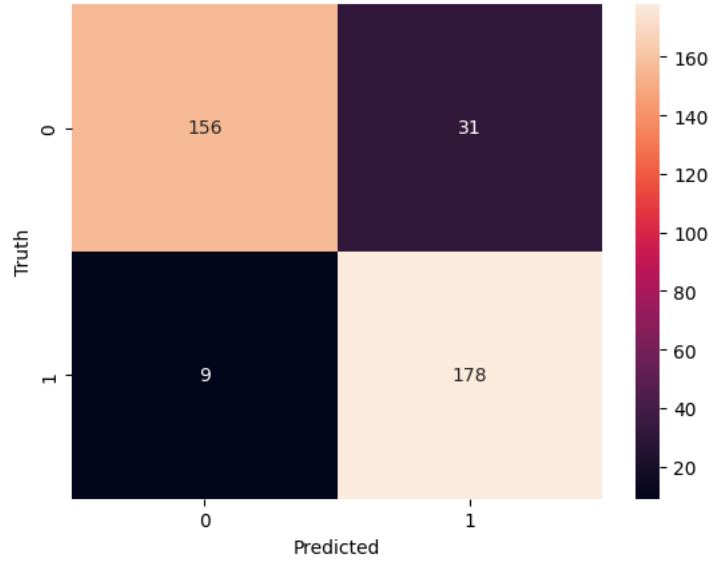
```
from sklearn.metrics import confusion_matrix, classification_report

cm=confusion_matrix(y_test,y_predicted)
cm
```

```
array([[156,  31],
       [  9, 178]])
```

```
from matplotlib import pyplot as plt
import seaborn as sns
sns.heatmap(cm,annot=True,fmt='d')
plt.xlabel('Predicted')
plt.ylabel('Truth')
```

```
Text(50.722222222222214, 0.5, 'Truth')
```




```
print(classification_report(y_test,y_predicted))
```

```
                   precision    recall  f1-score   support

               0       0.95      0.83      0.89       187
               1       0.85      0.95      0.90       187

        accuracy                           0.89       374
       macro avg       0.90      0.89      0.89       374
    weighted avg       0.90      0.89      0.89       374
```

```
df.head(15)
```

	Category	Message
0	ham	Go until jurong point, crazy.. Available only ...
1	ham	Ok lar... Joking wif u oni...
2	spam	Free entry in 2 a wkly comp to win FA Cup fina...
3	ham	U dun say so early hor... U c already then say...
4	ham	Nah I don't think he goes to usf, he lives aro...
5	spam	FreeMsg Hey there darling it's been 3 week's n...
6	ham	Even my brother is not like to speak with me. ...
7	ham	As per your request 'Melle Melle (Oru Minnamin...
8	spam	WINNER!! As a valued network customer you have...
9	spam	Had your mobile 11 months or more? U R entitle...
10	ham	I'm gonna be home soon and i don't want to tal...
11	spam	SIX chances to win CASH! From 100 to 20,000 po...
12	spam	URGENT! You have won a 1 week FREE membership ...
13	ham	I've been searching for the right words to tha...
14	ham	I HAVE A DATE ON SUNDAY WITH WILL!!

```
reviews=[
  'Go until jurong point, crazy.. Available only ...',
  'Free entry in 2 a wkly comp to win FA Cup fina...',
  'WINNER!! As a valued network customer you have...',
  "I've been searching for the right words to tha...",
  'SIX chances to win CASH! From 100 to 20,000 po...',
]
```

```
model.predict(reviews)
```

```
1/1 [==============================] - 2s 2s/step
array([[0.3520816 ],
       [0.2312882 ],
       [0.2804671 ],
       [0.10399497],
       [0.5811036 ]], dtype=float32)
```