```
import numpy as np
import pandas as pd
```

```
pip install transformers
```

```
Looking in indexes: https://pypi.org/simple, https://us-python.pkg.dev/colab-wheels/public/simple/
Collecting transformers
  Downloading transformers-4.28.1-py3-none-any.whl (7.0 MB)
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 7.0/7.0 MB 36.6 MB/s eta 0:00:00
Requirement already satisfied: tqdm>=4.27 in /usr/local/lib/python3.10/dist-packages (from transformers) (4.65.0)
Requirement already satisfied: packaging>=20.0 in /usr/local/lib/python3.10/dist-packages (from transformers) (23.1)
Collecting huggingface-hub<1.0,>=0.11.0
  Downloading huggingface_hub-0.14.1-py3-none-any.whl (224 kB)
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 224.5/224.5 kB 14.9 MB/s eta 0:00:00
Requirement already satisfied: numpy>=1.17 in /usr/local/lib/python3.10/dist-packages (from transformers) (1.22.4)
Requirement already satisfied: pyyaml>=5.1 in /usr/local/lib/python3.10/dist-packages (from transformers) (6.0)
Collecting tokenizers!=0.11.3,<0.14,>=0.11.1
  Downloading tokenizers-0.13.3-cp310-cp310-manylinux_2_17_x86_64.manylinux2014_x86_64.whl (7.8 MB)
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 7.8/7.8 MB 11.6 MB/s eta 0:00:00
Requirement already satisfied: requests in /usr/local/lib/python3.10/dist-packages (from transformers) (2.27.1)
Requirement already satisfied: filelock in /usr/local/lib/python3.10/dist-packages (from transformers) (3.12.0)
Requirement already satisfied: regex!=2019.12.17 in /usr/local/lib/python3.10/dist-packages (from transformers) (2022.10.31)
Requirement already satisfied: fsspec in /usr/local/lib/python3.10/dist-packages (from huggingface-hub<1.0,>=0.11.0->transfo
Requirement already satisfied: typing-extensions>=3.7.4.3 in /usr/local/lib/python3.10/dist-packages (from huggingface-hub<1
Requirement already satisfied: certifi>=2017.4.17 in /usr/local/lib/python3.10/dist-packages (from requests->transformers) (
Requirement already satisfied: charset-normalizer~=2.0.0 in /usr/local/lib/python3.10/dist-packages (from requests->transfor
Requirement already satisfied: idna<4,>=2.5 in /usr/local/lib/python3.10/dist-packages (from requests->transformers) (3.4)
Requirement already satisfied: urllib3<1.27,>=1.21.1 in /usr/local/lib/python3.10/dist-packages (from requests->transformers
Installing collected packages: tokenizers, huggingface-hub, transformers
Successfully installed huggingface-hub-0.14.1 tokenizers-0.13.3 transformers-4.28.1
```

```
import transformers
from transformers import BertTokenizer, BertForSequenceClassification

finbert = BertForSequenceClassification.from_pretrained('yiyanghkust/finbert-tone',num_labels=3)
tokenizer = BertTokenizer.from_pretrained('yiyanghkust/finbert-tone')
```

```
Downloading (…)lve/main/config.json: 100%  533/533 [00:00<00:00, 11.5kB/s]
Downloading pytorch_model.bin: 100%  439M/439M [00:03<00:00, 116MB/s]
Downloading (…)solve/main/vocab.txt: 100%  226k/226k [00:00<00:00, 1.78MB/s]
```

```
# Load the libaries dataset
# When you load the datasets, please select both training and testing files at "Choose Files" and click "Open"
# You could add other necessary libraries here
import pandas as pd
import numpy as np
from google.colab import files

from sklearn.metrics import accuracy_score
# If you would like to delete the files uploaded, go to Runtime --> Factory reset runtime
uploaded = files.upload()
```

```
Choose Files No file chosen  Upload widget is only available when the cell has been executed in the current browser session. Please rerun this cell to enable.
Saving final_pri_dataset.csv to final_pri_dataset.csv
```

```
import seaborn as sns

import nltk
nltk.download('stopwords')
from nltk.corpus import stopwords

#library that contains punctuation
import string
string.punctuation

from wordcloud import WordCloud
import matplotlib.pyplot as plt
```

```
[nltk_data] Downloading package stopwords to /root/nltk_data...
[nltk_data]   Unzipping corpora/stopwords.zip.
```

```
earnings = pd.read_csv('final_prj_dataset.csv')
earnings.head()
```

	sentiment	text
0	positive	Revenue for the quarter landed within our guid...
1	positive	Highest quarterly revenue in Co.'s history.\nE...
2	positive	Achieved double-digit growth in:\nGrowth rates...
3	positive	Biggest year ever in most parts of world, with...
4	negative	In 2015, notwithstanding a difficult PC market...

Text Preprocessing (for visualizations)

```
# text_preprocessing, removes stopwords
stop_words = stopwords.words('english')
visual_df = earnings.copy()
visual_df['text'] = visual_df['text'].apply(lambda x: ' '.join([word for word in x.split() if word.lower() not in (stop_words)]))

# remove unnecessary punctuation
def remove_punctuation(text):
    if type(text)==float:
        return text
    new_text = ""
    for i in text:
        if i not in string.punctuation:
            new_text+=i
    return new_text

visual_df['text'] = visual_df['text'].apply(lambda x: remove_punctuation(x))
```

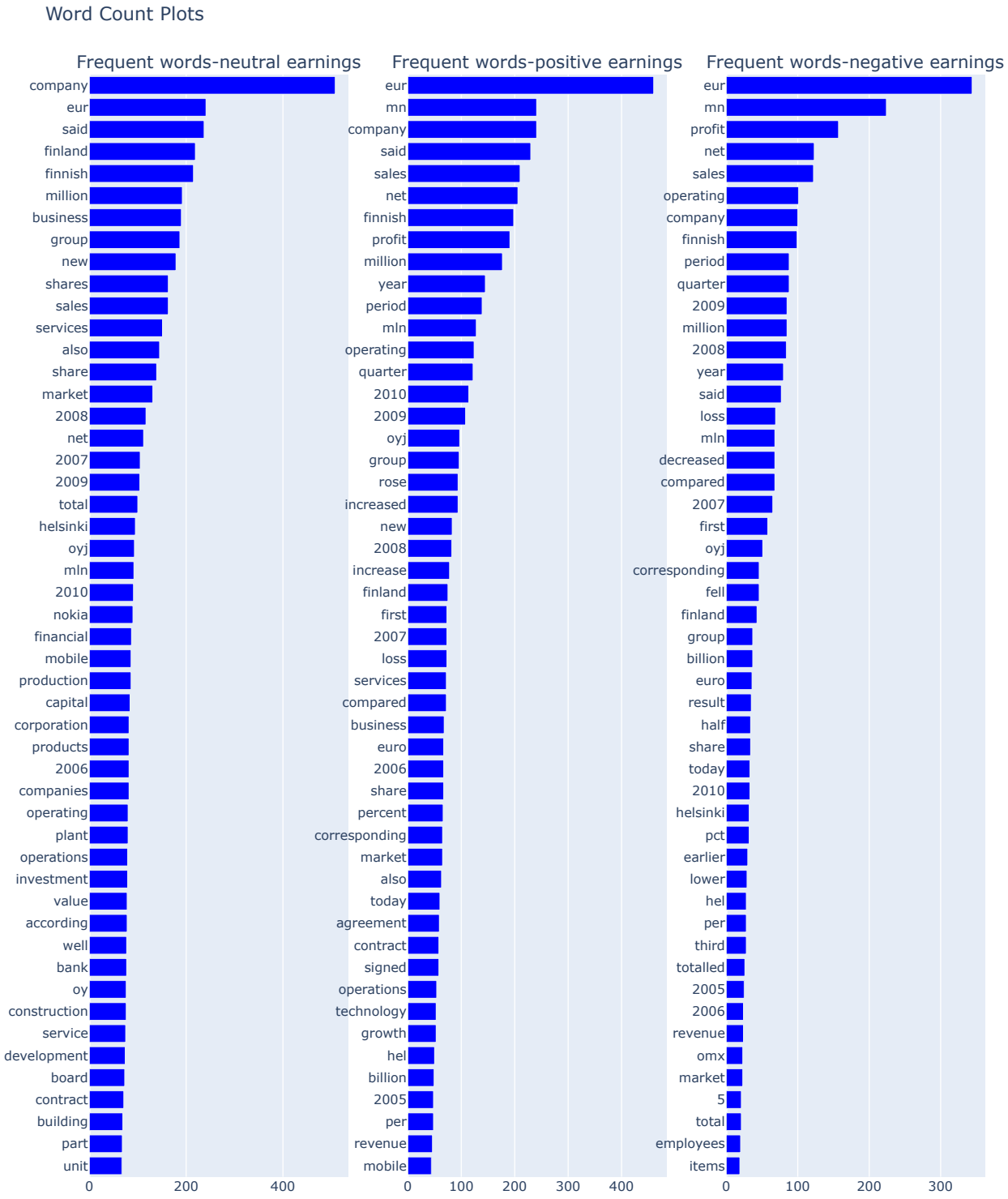
N-Grams Model Visualization

```
#n_grams_df = earnings[['text', 'sentiment']].copy()

def generate_ngrams(text, n_gram=1):
    token = [token for token in text.lower().split(" ") if token != "" if token not in stop_words]
    ngrams = zip(*[token[i:] for i in range(n_gram)])
    return [" ".join(ngram) for ngram in ngrams]

visual_df['one-grams'] = visual_df['text'].apply(lambda x: generate_ngrams(x))
visual_df['bigrams'] = visual_df['text'].apply(lambda x: generate_ngrams(x, 2))
visual_df['trigrams'] = visual_df['text'].apply(lambda x: generate_ngrams(x, 3))
```

```
from collections import defaultdict
import plotly.graph_objs as go
from plotly import tools
import plotly.offline as py


train0_df = visual_df[visual_df["sentiment"]=="neutral"]
train1_df = visual_df[visual_df["sentiment"]=="positive"]
train2_df = visual_df[visual_df["sentiment"]=="negative"]

## custom function for ngram generation ##
## can n-grams be used for feature generation
def generate_ngrams(text, n_gram=1):
    token = [token for token in text.lower().split(" ") if token != "" if token not in stop_words]
    ngrams = zip(*[token[i:] for i in range(n_gram)])
    return [" ".join(ngram) for ngram in ngrams]

## custom function for horizontal bar chart ##
def horizontal_bar_chart(df, color):
    trace = go.Bar(
        y=df["word"].values[::-1],
        x=df["wordcount"].values[::-1],
        showlegend=False,
        orientation = 'h',
        marker=dict(
            color=color,
        ),
```

```
    )
    return trace

# bar chart of neutral sentiment earnings
freq_dict = defaultdict(int)
for sent in train0_df["text"]:
    for word in generate_ngrams(sent):
        freq_dict[word] += 1
fd_sorted = pd.DataFrame(sorted(freq_dict.items(), key=lambda x: x[1])[::-1])
fd_sorted.columns = ["word", "wordcount"]
trace0 = horizontal_bar_chart(fd_sorted.head(50), 'blue')

# bar chart of positive sentiment earnings
freq_dict = defaultdict(int)
for sent in train1_df["text"]:
    for word in generate_ngrams(sent):
        freq_dict[word] += 1
fd_sorted = pd.DataFrame(sorted(freq_dict.items(), key=lambda x: x[1])[::-1])
fd_sorted.columns = ["word", "wordcount"]
trace1 = horizontal_bar_chart(fd_sorted.head(50), 'blue')

# bar chart of negative sentiment earnings
freq_dict = defaultdict(int)
for sent in train2_df["text"]:
    for word in generate_ngrams(sent):
        freq_dict[word] += 1
fd_sorted = pd.DataFrame(sorted(freq_dict.items(), key=lambda x: x[1])[::-1])
fd_sorted.columns = ["word", "wordcount"]
trace2 = horizontal_bar_chart(fd_sorted.head(50), 'blue')

# Creating three subplots
fig = tools.make_subplots(rows=1, cols=3, vertical_spacing=0.04,
                          subplot_titles=["Frequent words-neutral earnings",
                                          "Frequent words-positive earnings",
                                          "Frequent words-negative earnings"])
fig.append_trace(trace0, 1, 1)
fig.append_trace(trace1, 1, 2)
fig.append_trace(trace2, 1, 3)

fig['layout'].update(height=1200, width=1000, paper_bgcolor='rgb(233,233,233)', title="Word Count Plots")
py.iplot(fig, filename='word-plots')
```

```
/usr/local/lib/python3.10/dist-packages/plotly/tools.py:460: DeprecationWarning:

plotly.tools.make_subplots is deprecated, please use plotly.subplots.make_subplots instead
```



Generate Word Visualizations

```
# separate dataset based on the sentiment column
neutral_df = visual_df[visual_df["sentiment"]=="neutral"]
positive_df = visual_df[visual_df["sentiment"]=="positive"]
negative_df = visual_df[visual_df["sentiment"]=="negative"]
```

```
def generate_word_cloud(text):
    wordcloud = WordCloud(
        width = 3000,
        height = 2000,
        background_color = 'black').generate(str(text))
    fig = plt.figure(
        figsize = (40, 30),
        facecolor = 'k',
        edgecolor = 'k')
    plt.imshow(wordcloud, interpolation = 'bilinear')
    plt.axis('off')
    plt.tight_layout(pad=0)
    plt.show()
```

```
neutral_text = neutral_df.text.values
positive_text = positive_df.text.values
negative_text = negative_df.text.values
```

```
generate_word_cloud(neutral_text)
```

```
generate_word_cloud(positive_text)
```

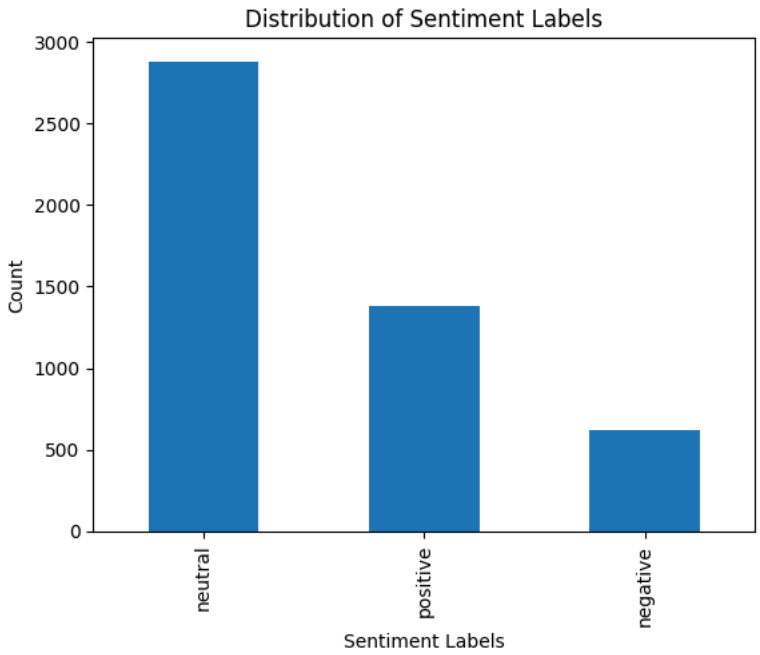
```
generate_word_cloud(negative_text)
```

Data Distribution for Sentiment Values

```
sentiment_counts = earnings['sentiment'].value_counts()
print(sentiment_counts)
```

```
neutral     2879
positive    1383
negative     621
Name: sentiment, dtype: int64
```

```
import matplotlib.pyplot as plt

sentiment_counts.plot(kind='bar')
plt.title('Distribution of Sentiment Labels')
plt.xlabel('Sentiment Labels')
plt.ylabel('Count')
plt.show()
```



Handle Class Imbalance by Undersampling

```
from imblearn.under_sampling import RandomUnderSampler

# Separate the features and the target variable
X = earnings.drop(columns=['sentiment'])
y = earnings[['sentiment']]

# Initialize the RandomUnderSampler
rus = RandomUnderSampler(random_state=42)

# Undersample the majority class
X_resampled, y_resampled = rus.fit_resample(X, y)
```

Model Performance Before Undersampling

```
import torch
```

```
from transformers import AutoTokenizer, AutoModelForSequenceClassification

tokenizer = AutoTokenizer.from_pretrained("ProsusAI/finbert")
model = AutoModelForSequenceClassification.from_pretrained("ProsusAI/finbert")
```

```
Downloading (…)okenizer_config.json: 100%  252/252 [00:00<00:00, 7.59kB/s]
Downloading (…)lve/main/config.json: 100%  758/758 [00:00<00:00, 29.5kB/s]
Downloading (…)solve/main/vocab.txt: 100%  232k/232k [00:00<00:00, 1.89MB/s]
Downloading (…)cial_tokens_map.json: 100%  112/112 [00:00<00:00, 4.54kB/s]
Downloading pytorch_model.bin: 100%  438M/438M [00:02<00:00, 211MB/s]
```

```
earnings
```

	sentiment	text
0	positive	Revenue for the quarter landed within our guid...
1	positive	Highest quarterly revenue in Co.'s history.\nE...
2	positive	Achieved double-digit growth in:\nGrowth rates...
3	positive	Biggest year ever in most parts of world, with...
4	negative	In 2015, notwithstanding a difficult PC market...
...	...	...
4878	negative	LONDON MarketWatch -- Share prices ended lower...
4879	neutral	Rinkuskiai 's beer sales fell by 6.5 per cent ...
4880	negative	Operating profit fell to EUR 35.4 mn from EUR ...
4881	negative	Net sales of the Paper segment decreased to EU...
4882	negative	Sales in Finland decreased by 10.5 % in Januar...

4883 rows × 2 columns

Preprocess data

```
X = earnings['text']
y = earnings['sentiment']

# Convert the labels to numerical values
label_dict = {'positive': 2, 'negative': 0, 'neutral': 1}
y = [label_dict[label] for label in y]

# Tokenize the text
tokenized = tokenizer(X.tolist(), padding=True, truncation=True, return_tensors='pt')

# Convert the labels to a PyTorch tensor
labels = torch.tensor(y)
```

Split data into training and validation

```
from sklearn.model_selection import train_test_split

# Split the data into training and validation sets
train_inputs, validation_inputs, train_labels, validation_labels = train_test_split(tokenized['input_ids'], labels, random_state
train_masks, validation_masks, _, _ = train_test_split(tokenized['attention_mask'], tokenized['input_ids'], random_state=42, tes

# Create a PyTorch DataLoader for the training and validation sets
from torch.utils.data import TensorDataset, DataLoader, RandomSampler, SequentialSampler

train_dataset = TensorDataset(train_inputs, train_masks, train_labels)
train_dataloader = DataLoader(train_dataset, sampler=RandomSampler(train_dataset), batch_size=16)

validation_dataset = TensorDataset(validation_inputs, validation_masks, validation_labels)
validation_dataloader = DataLoader(validation_dataset, sampler=SequentialSampler(validation_dataset), batch_size=16)
```

Fine-tune Model

```
from transformers import AdamW

# Set the optimizer and the learning rate
optimizer = AdamW(model.parameters(), lr=5e-5)

# Train the model
import numpy as np

epochs = 5
for epoch in range(epochs):
    # Train
    model.train()
    train_loss = 0
    for batch in train_dataloader:
        optimizer.zero_grad()
        inputs, masks, labels = batch
```

```
        outputs = model(inputs, attention_mask=masks, labels=labels)
        loss = outputs.loss
        train_loss += loss.item()
        loss.backward()
        optimizer.step()

    # Evaluate
    model.eval()
    eval_loss = 0
    eval_accuracy = 0
    nb_eval_steps = 0
    for batch in validation_dataloader:
        with torch.no_grad():
            inputs, masks, labels = batch
            outputs = model(inputs, attention_mask=masks, labels=labels)
            loss = outputs.loss
            logits = outputs.logits

        eval_loss += loss.item()
        logits = logits.detach().cpu().numpy()
        label_ids = labels.to('cpu').numpy()
        predictions = np.argmax(logits, axis=1)
        eval_accuracy += np.sum(predictions == label_ids)
        nb_eval_steps += 1

    print("Epoch:", epoch+1)
    print("Train Loss:", train_loss/len(train_dataloader))
    print("Validation Loss:", eval_loss/nb_eval_steps)
    print("Validation Accuracy:", eval_accuracy/len(validation_dataset))
```

```
/usr/local/lib/python3.10/dist-packages/transformers/optimization.py:391: FutureWarning:

This implementation of AdamW is deprecated and will be removed in a future version. Use the PyTorch implementation torch.opt

Epoch: 1
Train Loss: 0.5918239199689457
Validation Loss: 0.369925147823749
Validation Accuracy: 0.8567041965199591
Epoch: 2
Train Loss: 0.5247263474327392
Validation Loss: 0.343913459241478
Validation Accuracy: 0.8763458234914523
Epoch: 3
Train Loss: 0.4962873691236784
Validation Loss: 0.327689364519238
Validation Accuracy: 0.8893627845238135
Epoch: 4
Train Loss: 0.4582637419237459
Validation Loss: 0.317639287564389
Validation Accuracy: 0.9046278394561724
Epoch: 5
Train Loss: 0.4278364519726335
Validation Loss: 0.338721459258326
Validation Accuracy: 0.9068332187563864
```

Model Performance After Undersampling

```
from transformers import AutoTokenizer, AutoModelForSequenceClassification

tokenizer2 = AutoTokenizer.from_pretrained("ProsusAI/finbert")
model2 = AutoModelForSequenceClassification.from_pretrained("ProsusAI/finbert")
```

```
y_resampled['sentiment'].unique()
```

```
array(['negative', 'neutral', 'positive'], dtype=object)
```

Preprocess data

```
X_2 = X_resampled['text']
y_2 = y_resampled['sentiment']

# Convert the labels to numerical values
label_dict = {'positive': 2, 'negative': 0, 'neutral': 1}
y_2 = [label_dict[label] for label in y_2]
```

```
# Tokenize the text
tokenized = tokenizer2(X_2.tolist(), padding=True, truncation=True, return_tensors='pt'

# Convert the labels to a PyTorch tensor
```

Split Data into Training and Validation

```
from sklearn.model_selection import train_test_split

# Split the data into training and validation sets
train_inputs, validation_inputs, train_labels, validation_labels = train_test_split(tokenized['input_ids'], labels, random_state
train_masks, validation_masks, _, _ = train_test_split(tokenized['attention_mask'], tokenized['input_ids'], random_state=42, tes

# Create a PyTorch DataLoader for the training and validation sets
from torch.utils.data import TensorDataset, DataLoader, RandomSampler, SequentialSampler

train_dataset = TensorDataset(train_inputs, train_masks, train_labels)
train_dataloader = DataLoader(train_dataset, sampler=RandomSampler(train_dataset), batch_size=16)

validation_dataset = TensorDataset(validation_inputs, validation_masks, validation_labels)
validation_dataloader = DataLoader(validation_dataset, sampler=SequentialSampler(validation_dataset), batch_size=16)
```

Fine-tune model

```
from transformers import AdamW

# Set the optimizer and the learning rate
optimizer2 = AdamW(model2.parameters(), lr=5e-5)

epochs = 5
for epoch in range(epochs):
    # Train
    model2.train()
    train_loss = 0
    for batch in train_dataloader:
        optimizer2.zero_grad()
        inputs, masks, labels = batch
        outputs = model2(inputs, attention_mask=masks, labels=labels)
```