```
import pandas as pd
```

```
df = pd.read_excel("EVS.xlsx")
```

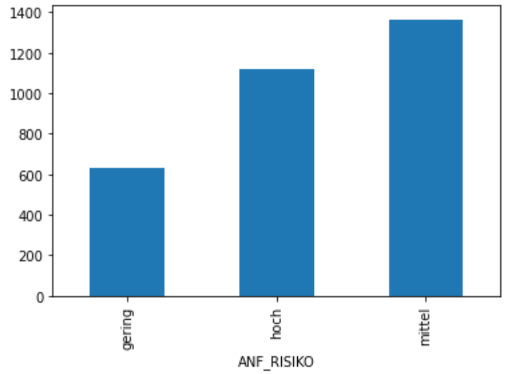
```
/usr/local/lib/python3.8/dist-packages/openpyxl/styles/stylesheet.py:226: UserWarning: Workbook contains no default style, apply openpyxl's default
  warn("Workbook contains no default style, apply openpyxl's default")
```

```
df = df[["ANF_BESCHREIBUNG", "ANF_RISIKO"]]
#df['ANF_RISIKO'] = df['ANF_RISIKO'].replace("gering", 3)
#df['ANF_RISIKO'] = df['ANF_RISIKO'].replace("mittel", 2)
#df['ANF_RISIKO'] = df['ANF_RISIKO'].replace("hoch", 1)
df.head()
```

	ANF_BESCHREIBUNG	ANF_RISIKO
0	CR 58564 Bankverb. mit dem Länderkennzeichen I...	mittel
1	CR 58564 Bankverb. mit dem Länderkennzeichen I...	mittel
2	CR55459 - Fachkonzept PTAR: 27075-EVS/K4\n\n- ...	mittel
3	CR55459 - Fachkonzept PTAR: 27075-EVS/K4\n\n- ...	mittel
4	Hier hat der Benutzer die Möglichkeit, Dokumen...	gering

```
df.groupby(['ANF_RISIKO']).size().plot.bar()
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7fb0db3c5070>
```



```
pip install transformers
```

```
Looking in indexes: https://pypi.org/simple, https://us-python.pkg.dev/colab-wheels/public/simple/
Collecting transformers
  Downloading transformers-4.25.1-py3-none-any.whl (5.8 MB)
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 5.8/5.8 MB 45.6 MB/s eta 0:00:00
Requirement already satisfied: tqdm>=4.27 in /usr/local/lib/python3.8/dist-packages (from transformers) (4.64.1)
Requirement already satisfied: regex!=2019.12.17 in /usr/local/lib/python3.8/dist-packages (from transformers) (2022.6.2)
Requirement already satisfied: filelock in /usr/local/lib/python3.8/dist-packages (from transformers) (3.9.0)
Collecting tokenizers!=0.11.3,<0.14,>=0.11.1
```

```
  Downloading tokenizers-0.13.2-cp38-cp38-manylinux_2_17_x86_64.manylinux2014_x86_64.whl (7.6 MB)
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 7.6/7.6 MB 102.8 MB/s eta 0:00:00
Requirement already satisfied: numpy>=1.17 in /usr/local/lib/python3.8/dist-packages (from transformers) (1.21.6)
Requirement already satisfied: pyyaml>=5.1 in /usr/local/lib/python3.8/dist-packages (from transformers) (6.0)
Requirement already satisfied: packaging>=20.0 in /usr/local/lib/python3.8/dist-packages (from transformers) (21.3)
Collecting huggingface-hub<1.0,>=0.10.0
  Downloading huggingface_hub-0.11.1-py3-none-any.whl (182 kB)
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 182.4/182.4 KB 27.2 MB/s eta 0:00:00
Requirement already satisfied: requests in /usr/local/lib/python3.8/dist-packages (from transformers) (2.25.1)
Requirement already satisfied: typing-extensions>=3.7.4.3 in /usr/local/lib/python3.8/dist-packages (from huggingface-hub<1.0,>=0.10.0->transformers) (4.4.0)
Requirement already satisfied: pyparsing!=3.0.5,>=2.0.2 in /usr/local/lib/python3.8/dist-packages (from packaging>=20.0->transformers) (3.0.9)
Requirement already satisfied: urllib3<1.27,>=1.21.1 in /usr/local/lib/python3.8/dist-packages (from requests->transformers) (1.24.3)
Requirement already satisfied: certifi>=2017.4.17 in /usr/local/lib/python3.8/dist-packages (from requests->transformers) (2022.12.7)
Requirement already satisfied: idna<3,>=2.5 in /usr/local/lib/python3.8/dist-packages (from requests->transformers) (2.10)
Requirement already satisfied: chardet<5,>=3.0.2 in /usr/local/lib/python3.8/dist-packages (from requests->transformers) (4.0.0)
Installing collected packages: tokenizers, huggingface-hub, transformers
Successfully installed huggingface-hub-0.11.1 tokenizers-0.13.2 transformers-4.25.1
```

```
from transformers import BertTokenizer

tokenizer = BertTokenizer.from_pretrained('bert-base-german-cased')

example_text = 'Ich werde heute lange schlafen'
bert_input = tokenizer(example_text,padding='max_length', max_length = 10,
                       truncation=True, return_tensors="pt")


print(bert_input['input_ids'])
print(bert_input['token_type_ids'])
print(bert_input['attention_mask'])
```

```
Downloading: 100%                                          255k/255k [00:00<00:00, 1.45MB/s]

Downloading: 100%                                          29.0/29.0 [00:00<00:00, 1.89kB/s]

Downloading: 100%                                          433/433 [00:00<00:00, 12.4kB/s]

tensor([[    3,  1671,  1631,  1138,  2197, 21872,     4,     0,     0,     0]])
tensor([[0, 0, 0, 0, 0, 0, 0, 0, 0, 0]])
tensor([[1, 1, 1, 1, 1, 1, 1, 0, 0, 0]])
```

```
example_text = tokenizer.decode(bert_input.input_ids[0])

print(example_text)
```

```
[CLS] Ich werde heute lange schlafen [SEP] [PAD] [PAD] [PAD]
```

```
import torch
import numpy as np
from transformers import BertTokenizer

tokenizer = BertTokenizer.from_pretrained('bert-base-german-cased')
labels = {'gering':3,
          'mittel':2,
          'hoch':1
          }
```

```
class Dataset(torch.utils.data.Dataset):

    def __init__(self, df):

        self.labels = [labels[label] for label in df['ANF_RISIKO']]
        self.texts = [tokenizer(text,
                               padding='max_length', max_length = 512, truncation=True,
                                return_tensors="pt") for text in df['ANF_BESCHREIBUNG']]

    def classes(self):
        return self.labels

    def __len__(self):
        return len(self.labels)

    def get_batch_labels(self, idx):
        # Fetch a batch of labels
        return np.array(self.labels[idx])

    def get_batch_texts(self, idx):
        # Fetch a batch of inputs
        return self.texts[idx]

    def __getitem__(self, idx):

        batch_texts = self.get_batch_texts(idx)
        batch_y = self.get_batch_labels(idx)

        return batch_texts, batch_y
```

```
np.random.seed(1234)
df_train, df_val, df_test = np.split(df.sample(frac=1, random_state=42),
                                     [int(.8*len(df)), int(.9*len(df))])

print(len(df_train), len(df_val), len(df_test))
```

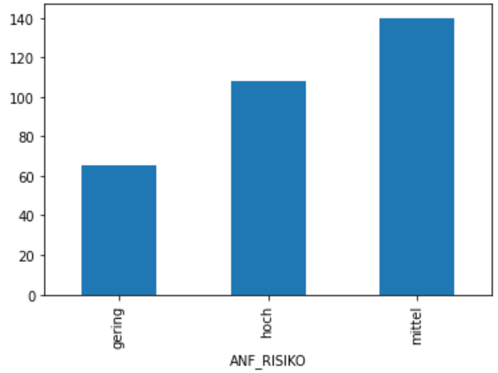
```
2496 312 313
```

```
df_train.groupby(['ANF_RISIKO']).size().plot.bar()
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7fb002115730>
```

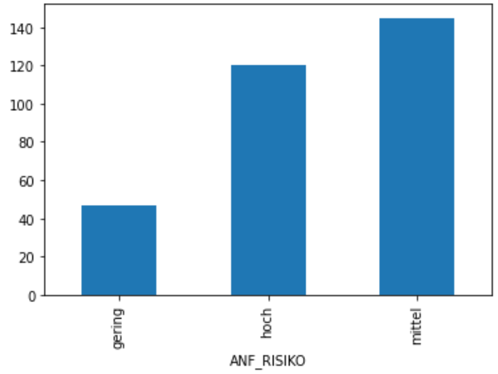
```
df_test.groupby(['ANF_RISIKO']).size().plot.bar()
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7fb0021425b0>
```



```
df_val.groupby(['ANF_RISIKO']).size().plot.bar()
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7fb07a850430>
```



```
df_train
```

	ANF_BESCHREIBUNG	ANF_RISIKO
1697	Individuell\n\nGAPAplus: \nBasischutz:\n- Unfa...	gering
2998	Notes://AT2AOD0003AAT/C1256754004BDEED/106156F...	mittel
2131	REQM-345 Abbildung der Rahmenvereinbarungen St...	mittel
214	Die Partnergruppen Schnelleingabemaske wird ge...	gering

```
from torch import nn
from transformers import BertModel

class BertClassifier(nn.Module):

    def __init__(self, dropout=0.5):

        super(BertClassifier, self).__init__()

        self.bert = BertModel.from_pretrained('bert-base-german-cased')
        self.dropout = nn.Dropout(dropout)
        self.linear = nn.Linear(768, 5)
        self.relu = nn.ReLU()

    def forward(self, input_id, mask):

        _, pooled_output = self.bert(input_ids= input_id, attention_mask=mask,return_dict=False)
        dropout_output = self.dropout(pooled_output)
        linear_output = self.linear(dropout_output)
        final_layer = self.relu(linear_output)

        return final_layer
```

```
from torch.optim import Adam
from tqdm import tqdm

def train(model, train_data, val_data, learning_rate, epochs):

    train, val = Dataset(train_data), Dataset(val_data)

    train_dataloader = torch.utils.data.DataLoader(train, batch_size=2, shuffle=True)
    val_dataloader = torch.utils.data.DataLoader(val, batch_size=2)

    use_cuda = torch.cuda.is_available()
    device = torch.device("cuda" if use_cuda else "cpu")

    criterion = nn.CrossEntropyLoss()
    optimizer = Adam(model.parameters(), lr= learning_rate)

    if use_cuda:

            model = model.cuda()
            criterion = criterion.cuda()

    train_loss = []
    train_acc = []
    val_loss = []
    val_acc = []

    for epoch_num in range(epochs):

            total_acc_train = 0
            total_loss_train = 0

            for train_input, train_label in tqdm(train_dataloader):

                train_label = train_label.to(device)
                mask = train_input['attention_mask'].to(device)
                input_id = train_input['input_ids'].squeeze(1).to(device)

                output = model(input_id, mask)

                batch_loss = criterion(output, train_label.long())
                total_loss_train += batch_loss.item()

                acc = (output.argmax(dim=1) == train_label).sum().item()
                total_acc_train += acc

                model.zero_grad()
                batch_loss.backward()
                optimizer.step()

            total_acc_val = 0
            total_loss_val = 0

            with torch.no_grad():

                for val_input, val_label in val_dataloader:

                    val_label = val_label.to(device)
                    mask = val_input['attention_mask'].to(device)
                    input_id = val_input['input_ids'].squeeze(1).to(device)

                    output = model(input_id, mask)

                    batch_loss = criterion(output, val_label.long())
                    total_loss_val += batch_loss.item()

                    acc = (output.argmax(dim=1) == val_label).sum().item()
                    total_acc_val += acc


            train_loss = np.append(train_loss, (total_loss_train / len(train_data)))
            train_acc = np.append(train_acc, (total_acc_train / len(train_data)))
            val_loss = np.append(val_loss, (total_loss_val / len(val_data)))
            val_acc = np.append(val_acc, (total_acc_val / len(val_data)))

    return train_loss, train_acc, val_loss, val_acc
```

```
EPOCHS = 5
model = BertClassifier()
LR = 1e-5
```

```
loss_tr, acc_tr, loss_val, acc_val = train(model, df_train, df_val, LR, EPOCHS)
```

```
Downloading: 100%                                    439M/439M [00:11<00:00, 39.1MB/s]
Some weights of the model checkpoint at bert-base-german-cased were not used when initializing BertMode
- This IS expected if you are initializing BertModel from the checkpoint of a model trained on another
- This IS NOT expected if you are initializing BertModel from the checkpoint of a model that you expect
100%|██████████| 1248/1248 [04:29<00:00,  4.63it/s]
100%|██████████| 1248/1248 [04:28<00:00,  4.64it/s]
100%|██████████| 1248/1248 [04:28<00:00,  4.64it/s]
100%|██████████| 1248/1248 [04:28<00:00,  4.64it/s]
100%|██████████| 1248/1248 [04:28<00:00,  4.64it/s]
```

```
print("loss_tr: ", loss_tr)
print("acc_tr: ", acc_tr)
print("loss_val: ", loss_val)
print("acc_val: ", acc_val)
```

```
loss_tr:  [0.38197518 0.15011828 0.04676881 0.02947498 0.02552669]
acc_tr:  [0.65945513 0.88661859 0.96915064 0.97996795 0.98237179]
loss_val:  [0.24697133 0.13631317 0.12414584 0.26618652 0.12264567]
acc_val:  [0.81410256 0.89423077 0.92948718 0.85576923 0.91987179]
```

```
def evaluate(model, test_data):

    test = Dataset(test_data)

    test_dataloader = torch.utils.data.DataLoader(test, batch_size=1)

    use_cuda = torch.cuda.is_available()
    device = torch.device("cuda" if use_cuda else "cpu")

    if use_cuda:

        model = model.cuda()

    total_acc_test = 0
    zuhochkl = 0
    zuniedrigkl = 0
    richtigkl = 0
    with torch.no_grad():

        for test_input, test_label in test_dataloader:

              test_label = test_label.to(device)
              mask = test_input['attention_mask'].to(device)
              input_id = test_input['input_ids'].squeeze(1).to(device)

              output = model(input_id, mask)

              pred = output.argmax(dim=1)[0].item()
              trcl = test_label[0].item()

              if (pred < trcl):
                  zuhochkl = zuhochkl + 1
              if (pred > trcl):
                  zuniedrigkl = zuniedrigkl + 1
              if (pred == trcl):
                  richtigkl = richtigkl + 1

              acc = (output.argmax(dim=1) == test_label).sum().item()
              total_acc_test += acc

    print(f'Test Accuracy: {total_acc_test / len(test_data): .3f}')

    checksum = zuhochkl + zuniedrigkl + richtigkl
    print("zu hoch klassifiziert: ", zuhochkl)
    print("zu niedrig klassifiziert: ", zuniedrigkl)
    print("richtig klassifiziert: ", richtigkl)
    print("checksum: ", checksum)
    print("meine acc: ", richtigkl/checksum)
```

```
print(df_test.shape)
evaluate(model, df_test)
```

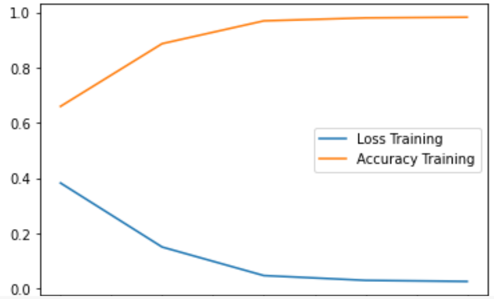
```
(313, 2)
Test Accuracy:  0.933
zu hoch klassifiziert:  11
zu niedrig klassifiziert:  10
richtig klassifiziert:  292
checksum:  313
meine acc:  0.9329073482428115
```

```
p1 = pd.DataFrame({
    'Loss Training': loss_tr,
    'Accuracy Training': acc_tr
    }, index=[1,2,3,4,5])

p2 = pd.DataFrame({
    'Loss Test': loss_val,
    'Accuracy Test': acc_val
    }, index=[1,2,3,4,5])

p1.plot.line()
p2.plot.line()
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7fb07a58fd00>
```



```
def get_pred(model, test_data):

    test = Dataset(test_data)

    test_dataloader = torch.utils.data.DataLoader(test, batch_size=1)

    use_cuda = torch.cuda.is_available()
    device = torch.device("cuda" if use_cuda else "cpu")

    if use_cuda:

        model = model.cuda()

    with torch.no_grad():

        pred = []

        for test_input, test_label in test_dataloader:

              test_label = test_label.to(device)
              mask = test_input['attention_mask'].to(device)
              input_id = test_input['input_ids'].squeeze(1).to(device)

              output = model(input_id, mask)

              if output.argmax(dim=1)[0].item() == 3:
                pred = np.append(pred, 'gering')
              if output.argmax(dim=1)[0].item() == 2:
                pred = np.append(pred, 'mittel')
              if output.argmax(dim=1)[0].item() == 1:
                pred = np.append(pred, 'hoch')

    test_data['Vorhersage'] = pred
    print(test_data)
```

```
var = pd.DataFrame({'ANF_BESCHREIBUNG': [
    "ich bin ein test text für das tolle modell",
    "ein text mit informationsdialog ist vielleicht richtig",
    "Die Sonne lacht vom Himmel doch die Software stürzt ab"
    ],
    'ANF_RISIKO': ["hoch", "gering", "mittel"]})
var.head()
```

	ANF_BESCHREIBUNG	ANF_RISIKO
0	ich bin ein test text für das tolle modell	hoch
1	ein text mit informationsdialog ist vielleicht...	gering
2	Die Sonne lacht vom Himmel doch die Software s...	mittel

```
get_pred(model, var)
```

```
                                    ANF_BESCHREIBUNG ANF_RISIKO Vorhersage
0          ich bin ein test text für das tolle modell       hoch     mittel
1  ein text mit informationsdialog ist vielleicht...     gering     mittel
2  Die Sonne lacht vom Himmel doch die Software s...     mittel     mittel
```

✓ 0 s Abgeschlossen um 17:42