```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
import seaborn as sns
```

```
ds = pd.read_csv("predictive_maintenance.csv")
```

```
ds.head()
```

	UDI	Product ID	Type	Air temperature [K]	Process temperature [K]	Rotational speed [rpm]	Torque [Nm]	Tool wear [min]	Target	Failure Type
0	1	M14860	M	298.1	308.6	1551	42.8	0	0	No Failure
1	2	L47181	L	298.2	308.7	1408	46.3	3	0	No Failure
2	3	L47182	L	298.1	308.5	1498	49.4	5	0	No Failure

```
ds.shape
```

```
(10000, 10)
```

```
ds.isnull().sum()
```

```
UDI                        0
Product ID                 0
Type                       0
Air temperature [K]        0
Process temperature [K]    0
Rotational speed [rpm]     0
Torque [Nm]                0
Tool wear [min]            0
Target                     0
Failure Type               0
dtype: int64
```

```
ds.describe()
```

	UDI	Air temperature [K]	Process temperature [K]	Rotational speed [rpm]	Torque [Nm]	Tool wear [min]	Target
count	10000.00000	10000.000000	10000.000000	10000.000000	10000.000000	10000.000000	10000.000000
mean	5000.50000	300.004930	310.005560	1538.776100	39.986910	107.951000	0.033900
std	2886.89568	2.000259	1.483734	179.284096	9.968934	63.654147	0.180981
min	1.00000	295.300000	305.700000	1168.000000	3.800000	0.000000	0.000000
25%	2500.75000	298.300000	308.800000	1423.000000	33.200000	53.000000	0.000000
50%	5000.50000	300.100000	310.100000	1503.000000	40.100000	108.000000	0.000000
75%	7500.25000	301.500000	311.100000	1612.000000	46.800000	162.000000	0.000000

```
ds = ds.drop(["UDI", "Product ID"], axis=1)
```

```
ds.head()
```

	Type	Air temperature [K]	Process temperature [K]	Rotational speed [rpm]	Torque [Nm]	Tool wear [min]	Target	Failure Type
0	M	298.1	308.6	1551	42.8	0	0	No Failure
1	L	298.2	308.7	1408	46.3	3	0	No Failure
2	L	298.1	308.5	1498	49.4	5	0	No Failure
3	L	298.2	308.6	1433	39.5	7	0	No Failure

```
ds.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 10000 entries, 0 to 9999
Data columns (total 8 columns):
 #   Column                   Non-Null Count  Dtype  
---  ------                   --------------  -----  
 0   Type                     10000 non-null  object 
 1   Air temperature [K]      10000 non-null  float64
 2   Process temperature [K]  10000 non-null  float64
 3   Rotational speed [rpm]   10000 non-null  int64  
 4   Torque [Nm]              10000 non-null  float64
 5   Tool wear [min]          10000 non-null  int64  
 6   Target                   10000 non-null  int64  
 7   Failure Type             10000 non-null  object 
dtypes: float64(3), int64(3), object(2)
memory usage: 625.1+ KB
```

```
ds.columns
```

```
Index(['Type', 'Air temperature [K]', 'Process temperature [K]',
       'Rotational speed [rpm]', 'Torque [Nm]', 'Tool wear [min]', 'Target',
       'Failure Type'],
      dtype='object')
```

```
old_col = ds.columns
new_col = ['type','air_temp','process_temp','rot_speed','torque','tool_wear','target','failure_type']
ds.columns = new_col
```

```
ds.head()
```

	type	air_temp	process_temp	rot_speed	torque	tool_wear	target	failure_type
0	M	298.1	308.6	1551	42.8	0	0	No Failure
1	L	298.2	308.7	1408	46.3	3	0	No Failure
2	L	298.1	308.5	1498	49.4	5	0	No Failure
3	L	298.2	308.6	1433	39.5	7	0	No Failure
4	L	298.2	308.7	1408	40.0	9	0	No Failure

```
print(ds.type.unique())
print(ds.failure_type.unique())
```

```
['M' 'L' 'H']
['No Failure' 'Power Failure' 'Tool Wear Failure' 'Overstrain Failure'
 'Random Failures' 'Heat Dissipation Failure']
```

```
valueCounts1 = ds.type.value_counts()
valueCounts1
```

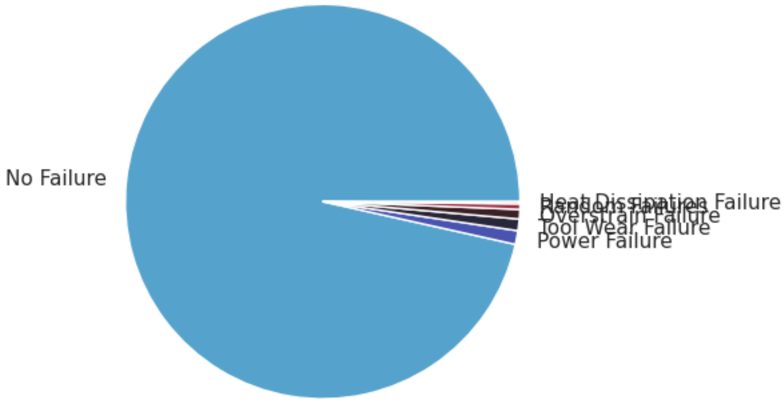
```
L    6000
M    2997
H    1003
Name: type, dtype: int64
```

```
sns.set_theme(style='darkgrid',palette='icefire')
plt.pie(valueCounts1, labels = ds.type.unique())
plt.show()
```

```
valueCounts2 = ds.failure_type.value_counts()
valueCounts2
```

```
No Failure                  9652
Heat Dissipation Failure     112
Power Failure                 95
Overstrain Failure            78
Tool Wear Failure             45
Random Failures               18
Name: failure_type, dtype: int64
```

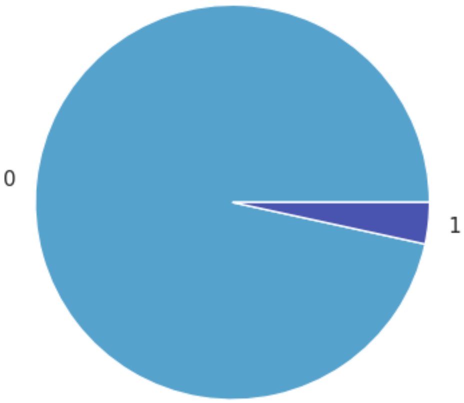
```
plt.pie(valueCounts2, labels = ds.failure_type.unique())
plt.show()
```



```
valueCounts3 = ds.target.value_counts()
valueCounts3
```

```
0    9661
1     339
Name: target, dtype: int64
```

```
plt.pie(valueCounts3, labels=ds.target.unique())
plt.show()
```



```
failure_dtype = ds[['target','failure_type']][ds['failure_type'] == 'No Failure']
failure_dtype
```

	target	failure_type
0	0	No Failure
1	0	No Failure
2	0	No Failure
3	0	No Failure
4	0	No Failure
...	...	...
9995	0	No Failure
9996	0	No Failure
9997	0	No Failure
9998	0	No Failure
9999	0	No Failure

9652 rows × 2 columns

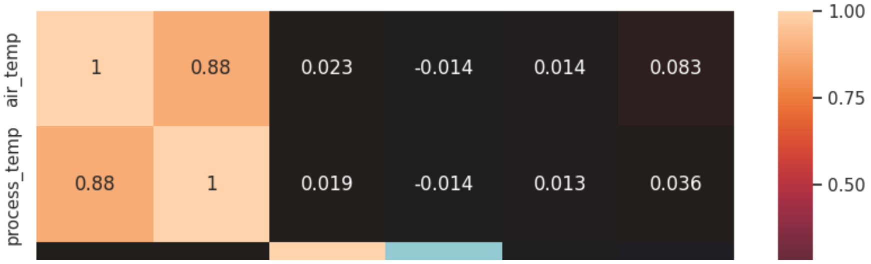
```
failure_dtype.value_counts()
```

```
target  failure_type
0       No Failure      9643
1       No Failure         9
dtype: int64
```

```
ds.head()
```

	type	air_temp	process_temp	rot_speed	torque	tool_wear	target	failure_type
0	M	298.1	308.6	1551	42.8	0	0	No Failure
1	L	298.2	308.7	1408	46.3	3	0	No Failure
2	L	298.1	308.5	1498	49.4	5	0	No Failure
3	L	298.2	308.6	1433	39.5	7	0	No Failure
4	L	298.2	308.7	1408	40.0	9	0	No Failure

```
all_num = ['air_temp','process_temp','rot_speed','torque','tool_wear','target']
data_corr = ds[all_num].corr()
plt.figure(figsize=(10,8))
corrplot = sns.heatmap(data_corr, vmin=-1, vmax = 1, cmap='icefire',annot=True)
```



```
from sklearn.preprocessing import OneHotEncoder
ohe = OneHotEncoder(handle_unknown='ignore',sparse=False)
oh_cols = pd.DataFrame(ohe.fit_transform(ds['type'].array.reshape(-1,1)))
oh_cols = oh_cols.rename(columns={0:'H',1:'L',2:'M'})
ds[['H','L','M']] = oh_cols[['H','L','M']]
ds.drop(columns='type',inplace=True)
```

```
/usr/local/lib/python3.9/dist-packages/sklearn/preprocessing/_encoders.py:868: FutureWarning: `sparse` was renamed to `sparse_output` ir
  warnings.warn(
```

```
ds_drop_index = ds.loc[(ds.target==1) & (ds['failure_type']=='No Failure')]
ds.drop(index = ds_drop_index.index, inplace=True)
ds.drop(columns = ['failure_type'],inplace=True)
ds = ds.reset_index(drop=True)
```

```
ds.head()
```

	air_temp	process_temp	rot_speed	torque	tool_wear	target	H	L	M
0	298.1	308.6	1551	42.8	0	0	0.0	0.0	1.0
1	298.2	308.7	1408	46.3	3	0	0.0	1.0	0.0
2	298.1	308.5	1498	49.4	5	0	0.0	1.0	0.0
3	298.2	308.6	1433	39.5	7	0	0.0	1.0	0.0
4	298.2	308.7	1408	40.0	9	0	0.0	1.0	0.0

```
x = ds.drop(columns='target')
y = ds['target']
```

```
from sklearn.model_selection import train_test_split
x_train, x_test, y_train, y_test = train_test_split(x, y, test_size=0.2,random_state=0)
```

```
from sklearn.preprocessing import StandardScaler
sc = StandardScaler()
x_train = sc.fit_transform(x_train)
x_test = sc.transform(x_test)
```

```
x_train
```

```
array([[ 0.99674427,  0.46691306, -0.48846795, ..., -0.33513777,
         0.82101636, -0.65726816],
       [-1.19172549, -1.06992201, -0.79674768, ..., -0.33513777,
        -1.21800252,  1.52144902],
       [-0.54513215, -0.53537068, -0.71827647, ..., -0.33513777,
        -1.21800252,  1.52144902],
       ...,
       [ 0.64857862,  0.06599957, -1.51980376, ..., -0.33513777,
         0.82101636, -0.65726816],
       [-0.694346  , -0.40173285, -0.99853077, ...,  2.98384747,
        -1.21800252, -0.65726816],
       [-0.14722856, -0.53537068, -0.66222561, ..., -0.33513777,
         0.82101636, -0.65726816]])
```

```
x_test
```

```
array([[-0.84355985, -0.40173285,  0.30745425, ..., -0.33513777,
        -1.21800252,  1.52144902],
       [-1.04251164, -0.66900851, -1.40209696, ..., -0.33513777,
         0.82101636, -0.65726816],
       [-0.54513215, -0.06763827, -0.76311716, ..., -0.33513777,
         0.82101636, -0.65726816],
       ...,
       [ 0.44962683,  0.46691306, -0.17458314, ..., -0.33513777,
         0.82101636, -0.65726816],
       [-1.29120139, -0.86946526,  0.46439666, ...,  2.98384747,
        -1.21800252, -0.65726816],
       [ 1.14595811,  0.13281848, -0.1913984 , ...,  2.98384747,
        -1.21800252, -0.65726816]])
```

```
#DECISION TREE
from sklearn.tree import DecisionTreeClassifier
dtc = DecisionTreeClassifier(criterion='entropy',random_state=0)
dtc.fit(x_train,y_train)
```

```
▾                  DecisionTreeClassifier
DecisionTreeClassifier(criterion='entropy', random_state=0)
```

```
y_pred_dtc = dtc.predict(x_test)
y_pred_dtc
```

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

```
from sklearn.metrics import confusion_matrix, accuracy_score
print("confusion matrix is: \n",confusion_matrix(y_test,y_pred_dtc))
print("accuracy is: ",accuracy_score(y_test,y_pred_dtc))
```

```
confusion matrix is: 
 [[1899   19]
 [  28   53]]
accuracy is:  0.976488244122061
```

```
#RANDOM FOREST
from sklearn.ensemble import RandomForestClassifier
rfc = RandomForestClassifier()
rfc.fit(x_train, y_train)
```

```
▾ RandomForestClassifier
RandomForestClassifier()
```

```
y_pred_rfc = rfc.predict(x_test)
y_pred_rfc
```

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

```
from sklearn.metrics import confusion_matrix, accuracy_score
print("confusion matrix is: \n",confusion_matrix(y_test,y_pred_rfc))
print("accuracy is: ",accuracy_score(y_test,y_pred_rfc))
```

```
confusion matrix is: 
 [[1915    3]
 [  39   42]]
accuracy is:  0.9789894947473737
```

```
#GRADIENT BOOSTING CLASSIFIER
from sklearn.ensemble import GradientBoostingClassifier
gbc = GradientBoostingClassifier()
gbc.fit(x_train, y_train)
```

```
▾ GradientBoostingClassifier
GradientBoostingClassifier()
```

```
y_pred_gbc = gbc.predict(x_test)
y_pred_gbc
```

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

```
from sklearn.metrics import confusion_matrix, accuracy_score
print("confusion matrix is: \n",confusion_matrix(y_test,y_pred_gbc))
print("accuracy is: ",accuracy_score(y_test,y_pred_gbc))
```

```
confusion matrix is:
 [[1908   10]
 [  27   54]]
accuracy is:  0.9814907453726863
```

```
#XGB
import xgboost as xgb
xgb = xgb.XGBClassifier()
xgb.fit(x_train,y_train)
```

```
▾                              XGBClassifier
XGBClassifier(base_score=None, booster=None, callbacks=None,
              colsample_bylevel=None, colsample_bynode=None,
              colsample_bytree=None, early_stopping_rounds=None,
              enable_categorical=False, eval_metric=None, feature_types=None,
              gamma=None, gpu_id=None, grow_policy=None, importance_type=None,
              interaction_constraints=None, learning_rate=None, max_bin=None,
              max_cat_threshold=None, max_cat_to_onehot=None,
              max_delta_step=None, max_depth=None, max_leaves=None,
              min_child_weight=None, missing=nan, monotone_constraints=None,
              n_estimators=100, n_jobs=None, num_parallel_tree=None,
              predictor=None, random_state=None, ...)
```

```
y_pred_xgb = xgb.predict(x_test)
y_pred_xgb
```

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

```
from sklearn.metrics import confusion_matrix, accuracy_score
print("confusion matrix is: \n",confusion_matrix(y_test,y_pred_xgb))
print("accuracy is: ",accuracy_score(y_test,y_pred_xgb))
```

```
confusion matrix is:
 [[1911    7]
 [  25   56]]
accuracy is:  0.983991995997999
```

```
# RESULTS FROM THE PROGRAM SHOW XGB WITH THE MOST ACCURACY OF 98.3%
```

✓ 0s completed at 6:39 PM