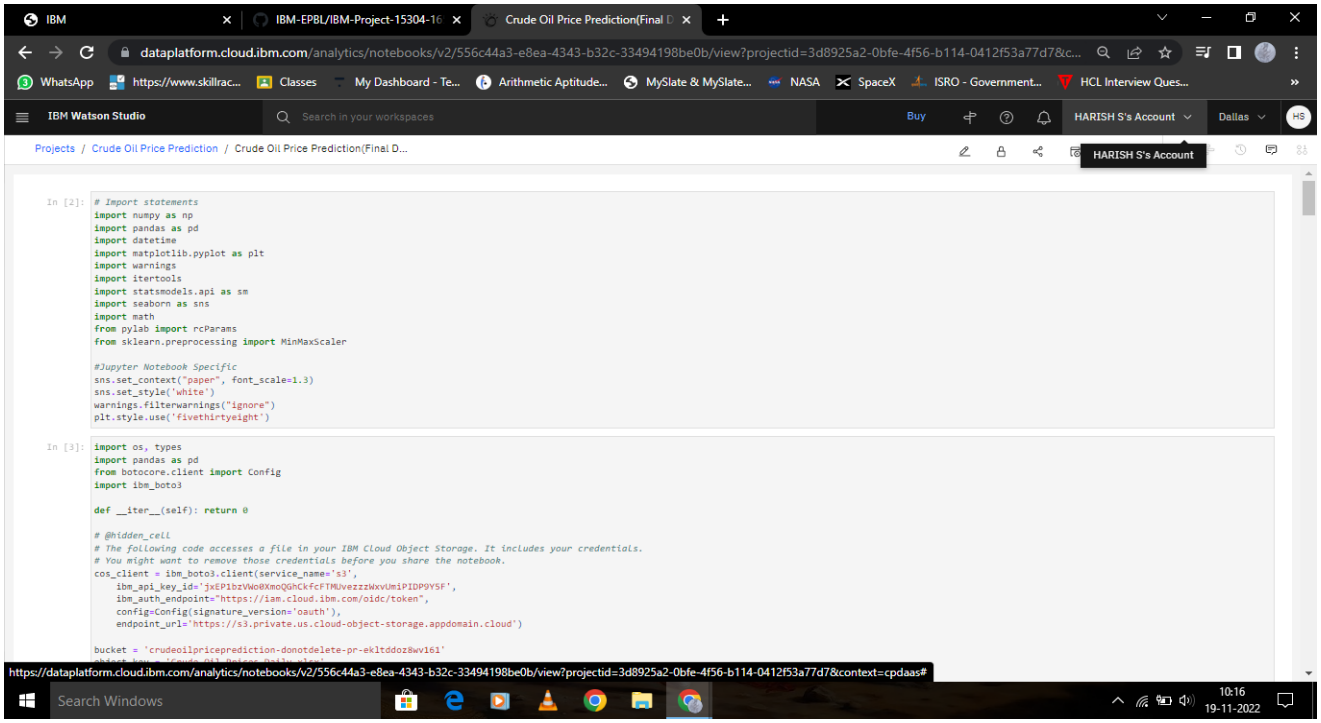
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In [2]:
# Import statements
import numpy as np
import pandas as pd
import datetime
import matplotlib.pyplot as plt
import warnings
import itertools
import statsmodels.api as sm
import seaborn as sns
import math
from pylab import rcParams
from sklearn.preprocessing import MinMaxScaler
#Jupyter Notebook Specific
sns.set_context("paper", font_scale=1.3)
sns.set_style('white')
warnings.filterwarnings("ignore")
plt.style.use('fivethirtyeight')
In [3]:
import os, types
import pandas as pd
from botocore.client import Config
import ibm_boto3
def __iter__(self): return 0
# @hidden_cell
# The following code accesses a file in your IBM Cloud Object Storage. It includes your credentials.
# You might want to remove those credentials before you share the notebook.
cos_client = ibm_boto3.client(service_name='s3',
ibm_api_key_id='jxEP1bzVWo0XmoQGhCkfcFTMUvezzzkWxvUmiPIDP9Y5F',
ibm_auth_endpoint="https://iam.cloud.ibm.com/oidc/token",
config=Config(signature_version='oauth'),
endpoint_url='https://s3.private.us.cloud-object-storage.appdomain.cloud')
bucket = 'crudeoilpriceprediction-donotdelete-pr-ekltddoz8wv161'
https://dataplatform.cloud.ibm.com/analytics/notebooks/v2/556c44a3-e8ea-4343-b32c-33494198be0b/view?projectid=3d8925a2-0bfe-4f56-b114-0412f53a77d7&context=cpdaas#
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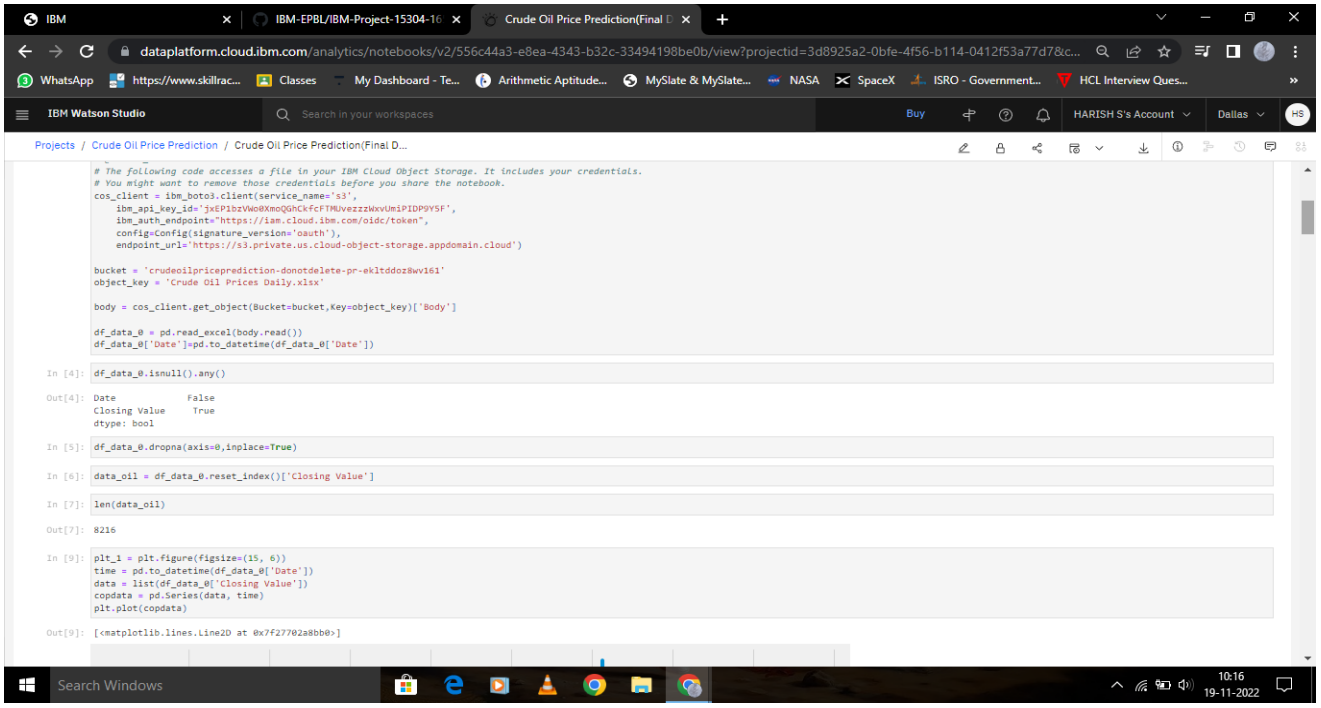
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# The following code accesses a file in your IBM Cloud Object Storage. It includes your credentials.
# You might want to remove those credentials before you share the notebook.
cos_client = ibm_boto3.client(service_name='s3',
ibm_api_key_id='jxEP1bzVWo0XmoQGhCkfcFTMUvezzzkWxvUmiPIDP9Y5F',
ibm_auth_endpoint="https://iam.cloud.ibm.com/oidc/token",
config=Config(signature_version='oauth'),
endpoint_url='https://s3.private.us.cloud-object-storage.appdomain.cloud')
bucket = 'crudeoilpriceprediction-donotdelete-pr-ekltddoz8wv161'
object_key = 'Crude Oil Prices Daily.xlsx'
body = cos_client.get_object(Bucket=bucket,Key=object_key)['Body']
df_data_0 = pd.read_excel(body.read())
df_data_0['Date']=pd.to_datetime(df_data_0['Date'])
In [4]:
df_data_0.isnull().any()
Out[4]:
Date False
Closing Value True
dtype: bool
In [5]:
df_data_0.dropna(axis=0,inplace=True)
In [6]:
data_oil = df_data_0.reset_index()['Closing Value']
In [7]:
len(data_oil)
Out[7]:
8216
In [9]:
plt_1 = plt.figure(figsize=(15, 6))
time = pd.to_datetime(df_data_0['Date'])
data = list(df_data_0['Closing Value'])
copdata = pd.Series(data, time)
plt.plot(copdata)
Out[9]:
[<matplotlib.lines.Line2D at 0x7f27702a8bb0>]
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In [7]:
```
len(data_oil)
```

Out[7]: 8216

In [9]:
```
plt_1 = plt.figure(figsize=(15, 6))
time = pd.to_datetime(df_data_0['Date'])
data = list(df_data_0['Closing Value'])
copdata = pd.Series(data, time)
plt.plot(copdata)
```

Out[9]: [<matplotlib.lines.Line2D at 0x7f27702a8bb0>]

In [10]:
```
#observe for any seasonal patterns
ax = df_data_0.plot(x='Date', y='Closing Value', figsize=(12,6))
xcoords = ['1988-01-01','1989-01-01','1990-01-01','1991-01-01','1992-01-01','1993-01-01','1994-01-01',
```

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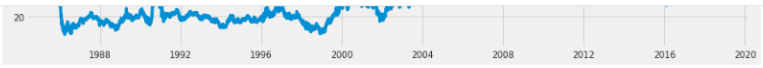
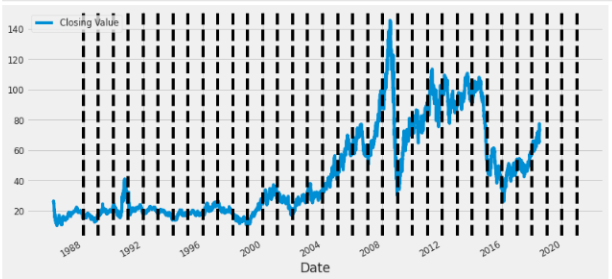


In [10]:
```
#observe for any seasonal patterns
ax = df_data_0.plot(x='Date', y='Closing Value', figsize=(12,6))
xcoords = ['1988-01-01','1989-01-01','1990-01-01','1991-01-01','1992-01-01','1993-01-01','1994-01-01',
           '1995-01-01','1996-01-01','1997-01-01','1998-01-01','1999-01-01','2000-01-01','2001-01-01',
           '2002-01-01','2003-01-01','2004-01-01','2005-01-01','2006-01-01','2007-01-01','2008-01-01',
           '2009-01-01','2010-01-01','2011-01-01','2012-01-01','2013-01-01','2014-01-01','2015-01-01',
           '2016-01-01','2017-01-01', '2018-01-01', '2019-01-01', '2020-01-01','2021-01-01']
for xc in xcoords:
    plt.axvline(x=xc, color='black', linestyle='--')
```



In [12]:
```
#Decompose the plot
```

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In [12]:
#Decompose the plot
df1 = df_data_0
df1 = df1.sort_values('Date')
df1 = df1.groupby('Date')['Closing Value'].sum().reset_index()
df1.set_index('Date', inplace=True)
df1=df1.loc[datetime.date(year=1988,month=1,day=1):]
q = df1['Closing Value'].resample('MS').mean()
q.plot(figsize=(15, 6))
plt.show()
140
120
100
80
60
40
20
1989
1994
1999
2004
2009
2014
Date
In [13]:
rcParams['figure.figsize'] = 18, 8
decomposition = sm.tsa.seasonal_decompose(q, model='additive')
fig = decomposition.plot()
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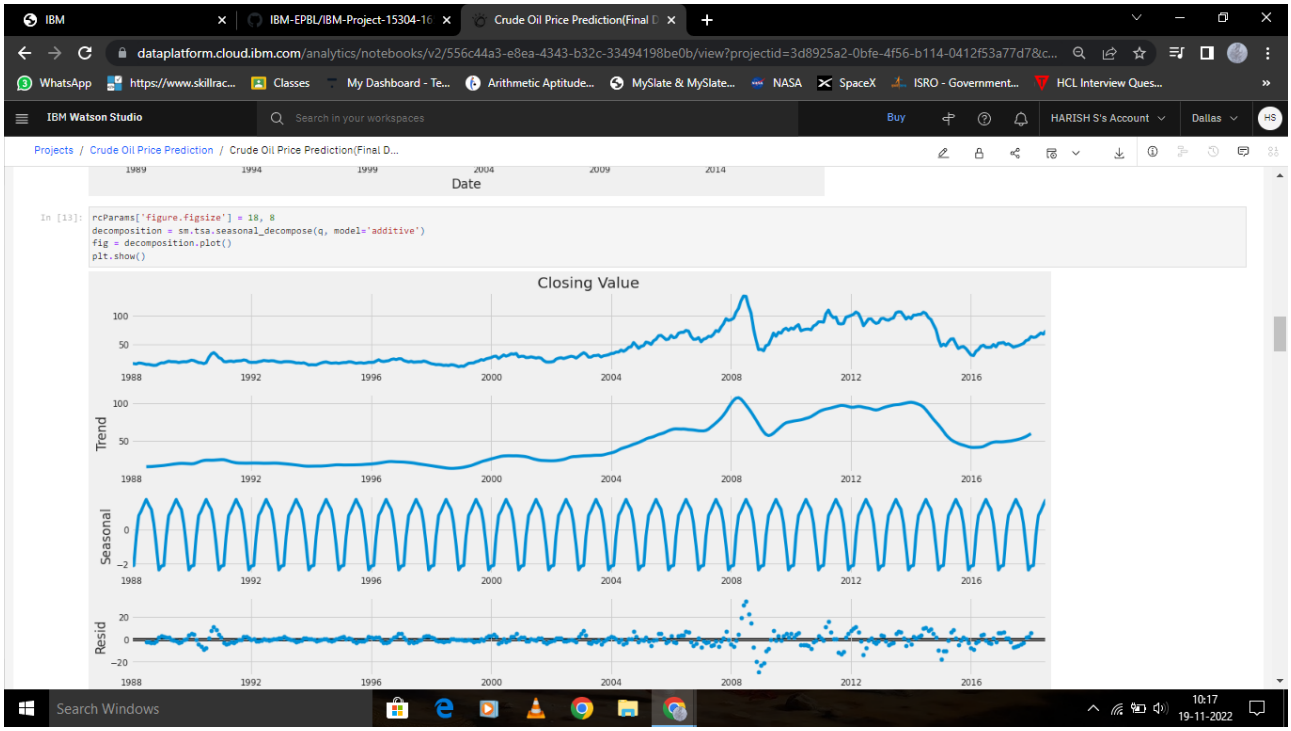
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1989
1994
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2004
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In [13]:
rcParams['figure.figsize'] = 18, 8
decomposition = sm.tsa.seasonal_decompose(q, model='additive')
fig = decomposition.plot()
plt.show()
Closing Value
Trend
Seasonal
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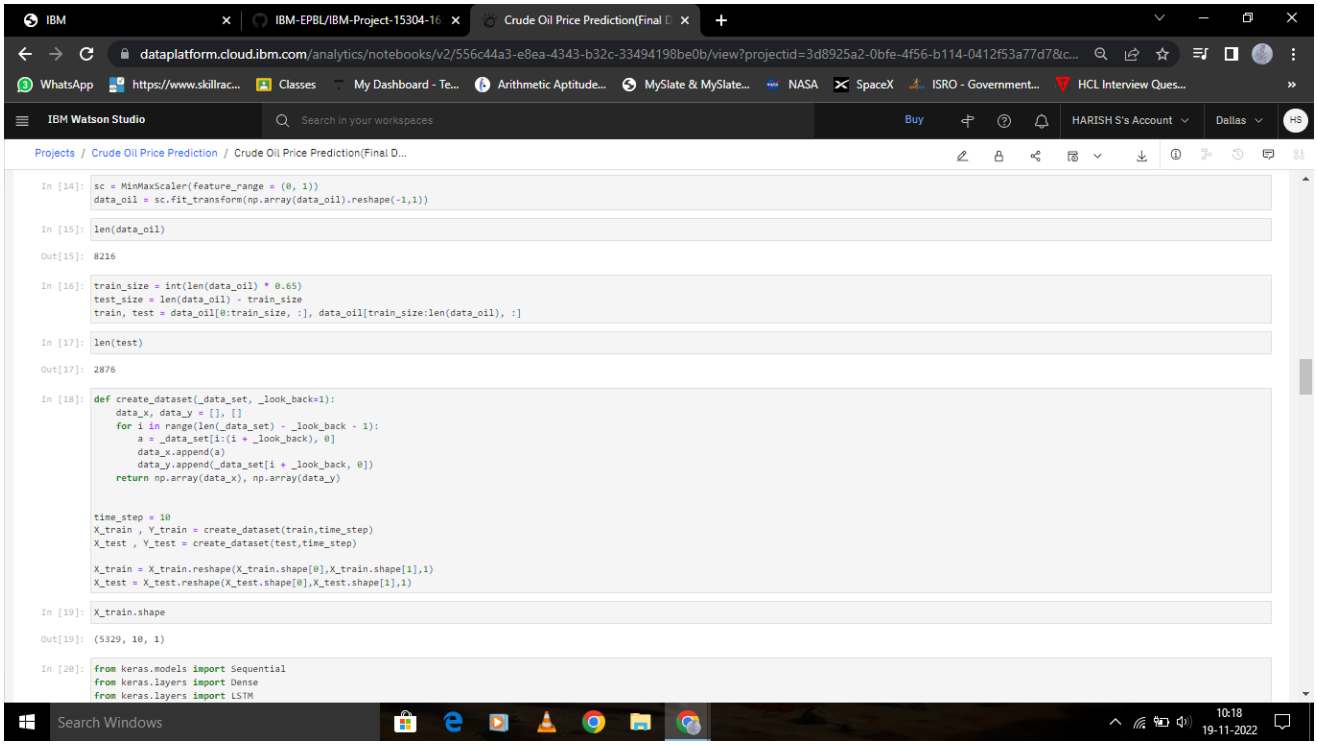

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```
In [14]: sc = MinMaxScaler(feature_range = (0, 1))
         data_oil = sc.fit_transform(np.array(data_oil).reshape(-1,1))

In [15]: len(data_oil)

Out[15]: 8216

In [16]: train_size = int(len(data_oil) * 0.65)
         test_size = len(data_oil) - train_size
         train, test = data_oil[0:train_size, :], data_oil[train_size:len(data_oil), :]

In [17]: len(test)

Out[17]: 2876

In [18]: def create_dataset(_data_set, _look_back=1):
             data_x, data_y = [], []
             for i in range(len(_data_set) - _look_back - 1):
                 a = _data_set[i:(i + _look_back), 0]
                 data_x.append(a)
                 data_y.append(_data_set[i + _look_back, 0])
             return np.array(data_x), np.array(data_y)


         time_step = 10
         X_train , Y_train = create_dataset(train,time_step)
         X_test , Y_test = create_dataset(test,time_step)

         X_train = X_train.reshape(X_train.shape[0],X_train.shape[1],1)
         X_test = X_test.reshape(X_test.shape[0],X_test.shape[1],1)

In [19]: X_train.shape

Out[19]: (5329, 10, 1)

In [20]: from keras.models import Sequential
         from keras.layers import Dense
         from keras.layers import LSTM
```

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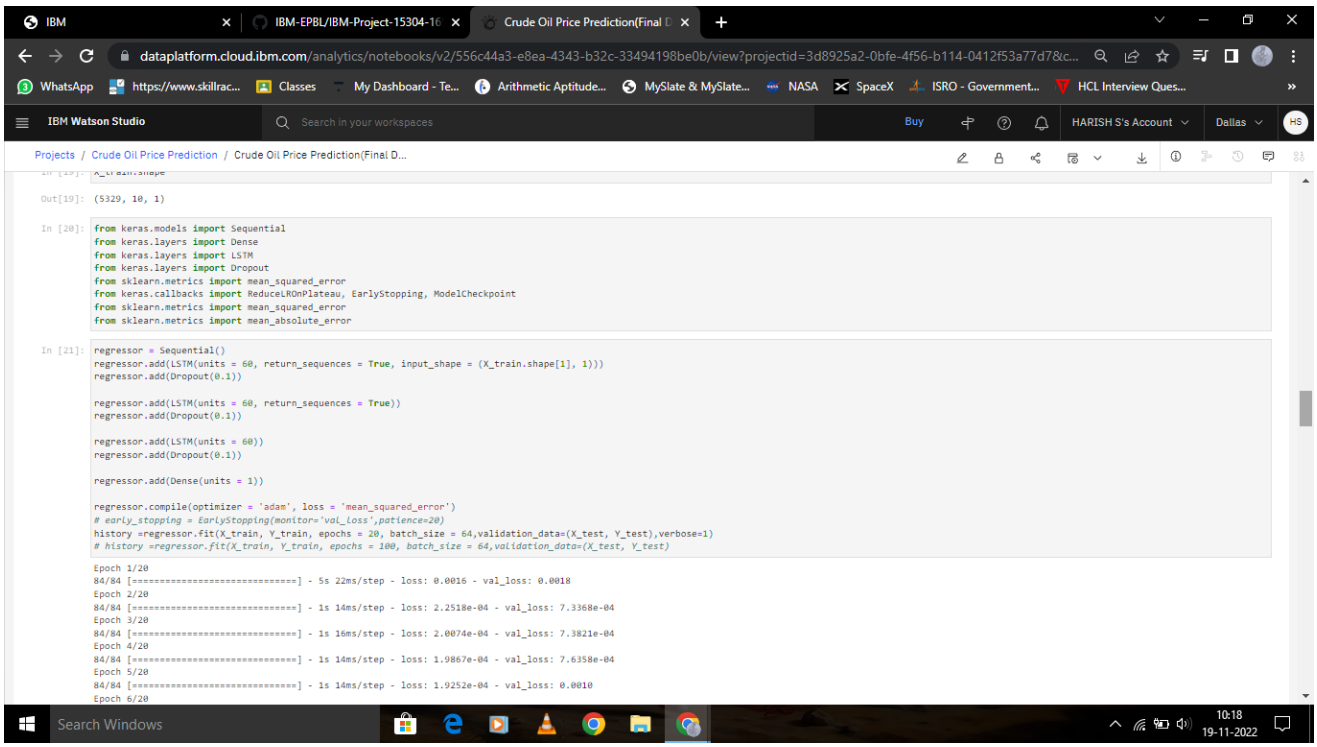

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```
Out[19]: (5329, 10, 1)

In [20]: from keras.models import Sequential
         from keras.layers import Dense
         from keras.layers import LSTM
         from keras.layers import Dropout
         from sklearn.metrics import mean_squared_error
         from keras.callbacks import ReduceLROnPlateau, EarlyStopping, ModelCheckpoint
         from sklearn.metrics import mean_squared_error
         from sklearn.metrics import mean_absolute_error

In [21]: regressor = Sequential()
         regressor.add(LSTM(units = 60, return_sequences = True, input_shape = (X_train.shape[1], 1)))
         regressor.add(Dropout(0.1))

         regressor.add(LSTM(units = 60, return_sequences = True))
         regressor.add(Dropout(0.1))

         regressor.add(LSTM(units = 60))
         regressor.add(Dropout(0.1))

         regressor.add(Dense(units = 1))

         regressor.compile(optimizer = 'adam', loss = 'mean_squared_error')
         # early_stopping = EarlyStopping(monitor='val_loss',patience=20)
         history =regressor.fit(X_train, Y_train, epochs = 20, batch_size = 64,validation_data=(X_test, Y_test),verbose=1)
         # history =regressor.fit(X_train, Y_train, epochs = 100, batch_size = 64,validation_data=(X_test, Y_test)

         Epoch 1/20
         84/84 [==============================] - 5s 22ms/step - loss: 0.0016 - val_loss: 0.0018
         Epoch 2/20
         84/84 [==============================] - 1s 14ms/step - loss: 2.2518e-04 - val_loss: 7.3368e-04
         Epoch 3/20
         84/84 [==============================] - 1s 16ms/step - loss: 2.0074e-04 - val_loss: 7.3821e-04
         Epoch 4/20
         84/84 [==============================] - 1s 14ms/step - loss: 1.9867e-04 - val_loss: 7.6358e-04
         Epoch 5/20
         84/84 [==============================] - 1s 14ms/step - loss: 1.9252e-04 - val_loss: 0.0010
         Epoch 6/20
```

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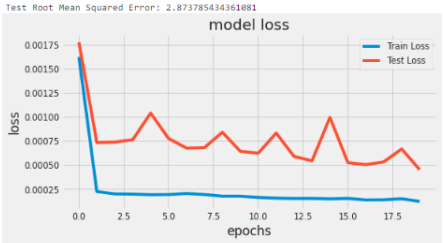
```
regressor.add(Dropout(0.1))

regressor.add(Dense(units = 1))

regressor.compile(optimizer = 'adam', loss = 'mean_squared_error')
# early_stopping = EarlyStopping(monitor='val_loss',patience=20)
history =regressor.fit(X_train, Y_train, epochs = 20, batch_size = 64,validation_data=(X_test, Y_test),verbose=1)
# history =regressor.fit(X_train, Y_train, epochs = 100, batch_size = 64,validation_data=(X_test, Y_test)
```

```
Epoch 1/20
84/84 [==============================] - 5s 22ms/step - loss: 0.0016 - val_loss: 0.0018
Epoch 2/20
84/84 [==============================] - 1s 14ms/step - loss: 2.2518e-04 - val_loss: 7.3368e-04
Epoch 3/20
84/84 [==============================] - 1s 16ms/step - loss: 2.0074e-04 - val_loss: 7.3821e-04
Epoch 4/20
84/84 [==============================] - 1s 14ms/step - loss: 1.9867e-04 - val_loss: 7.6358e-04
Epoch 5/20
84/84 [==============================] - 1s 14ms/step - loss: 1.9252e-04 - val_loss: 0.0010
Epoch 6/20
84/84 [==============================] - 1s 14ms/step - loss: 1.9391e-04 - val_loss: 7.7598e-04
Epoch 7/20
84/84 [==============================] - 1s 15ms/step - loss: 2.0522e-04 - val_loss: 6.7660e-04
Epoch 8/20
84/84 [==============================] - 2s 20ms/step - loss: 1.9437e-04 - val_loss: 6.8141e-04
Epoch 9/20
84/84 [==============================] - 1s 16ms/step - loss: 1.7695e-04 - val_loss: 8.4088e-04
Epoch 10/20
84/84 [==============================] - 2s 18ms/step - loss: 1.7679e-04 - val_loss: 6.4298e-04
Epoch 11/20
84/84 [==============================] - 1s 14ms/step - loss: 1.6428e-04 - val_loss: 6.2306e-04
Epoch 12/20
84/84 [==============================] - 1s 16ms/step - loss: 1.5652e-04 - val_loss: 8.3206e-04
Epoch 13/20
84/84 [==============================] - 1s 17ms/step - loss: 1.5308e-04 - val_loss: 5.8922e-04
Epoch 14/20
84/84 [==============================] - 2s 18ms/step - loss: 1.5349e-04 - val_loss: 5.4442e-04
Epoch 15/20
84/84 [==============================] - 2s 21ms/step - loss: 1.4928e-04 - val_loss: 9.9499e-04
Epoch 16/20
84/84 [==============================] - 1s 15ms/step - loss: 1.5365e-04 - val_loss: 5.2495e-04
```

```
# invert predictions
train_predict = sc.inverse_transform(train_predict)
Y_train = sc.inverse_transform([Y_train])
test_predict = sc.inverse_transform(test_predict)
Y_test = sc.inverse_transform([Y_test])
```

```
print('Train Mean Absolute Error:', mean_absolute_error(Y_train[0], train_predict[:,0]))
print('Train Root Mean Squared Error:',np.sqrt(mean_squared_error(Y_train[0], train_predict[:,0])))
print('Test Mean Absolute Error:', mean_absolute_error(Y_test[0], test_predict[:,0]))
print('Test Root Mean Squared Error:',np.sqrt(mean_squared_error(Y_test[0], test_predict[:,0])))
plt.figure(figsize=(8,4))
plt.plot(history.history['loss'], label='Train Loss')
plt.plot(history.history['val_loss'], label='Test Loss')
plt.title('model loss')
plt.ylabel('loss')
plt.xlabel('epochs')
plt.legend(loc='upper right')
plt.show();
```

```
Train Mean Absolute Error: 0.8082561245454949
Train Root Mean Squared Error: 1.205364160453239
Test Mean Absolute Error: 2.1252786170200526
Test Root Mean Squared Error: 2.8737854343610815
```



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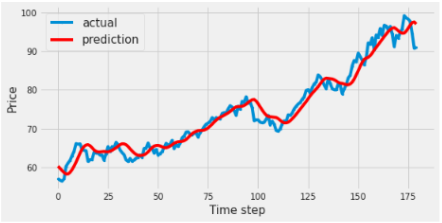
In [25]:
```
aa=[x for x in range(180)]
plt.figure(figsize=(8,4))
plt.plot(aa, Y_test[0][:180], marker='.', label="actual")
plt.plot(aa, test_predict[:,0][:180], 'r', label="prediction")
plt.tight_layout()
sns.despine(top=True)
plt.subplots_adjust(left=0.07)
plt.ylabel('Closing Values', size=15)
plt.xlabel('Time step', size=15)
plt.legend(fontsize=15)
plt.show();
```



In [26]:
```
#test the model
look_back = 10
trainPredictPlot = np.empty_like(data_oil)
trainPredictPlot[:,:] = np.nan
trainPredictPlot[look_back:len(train_predict)+look_back,:] = train_predict

testPredictPlot = np.empty_like(data_oil)
testPredictPlot[:,:] = np.nan
testPredictPlot[len(train_predict)+(look_back*2)+1:len(data_oil)-1,:] = test_predict
```

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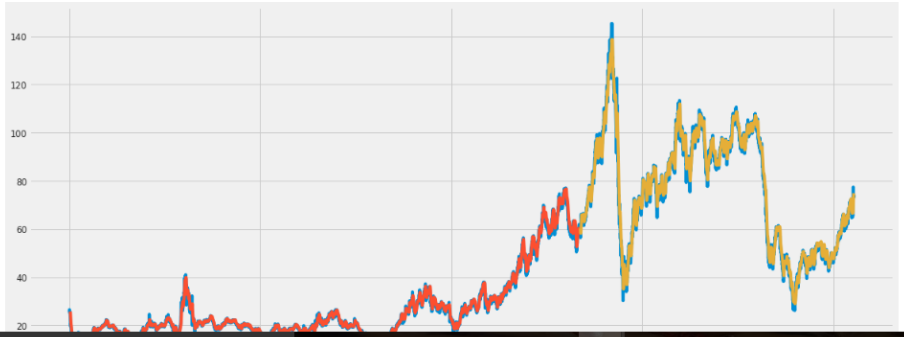
In [26]:
```
#test the model
look_back = 10
trainPredictPlot = np.empty_like(data_oil)
trainPredictPlot[:,:] = np.nan
trainPredictPlot[look_back:len(train_predict)+look_back,:] = train_predict

testPredictPlot = np.empty_like(data_oil)
testPredictPlot[:,:] = np.nan
testPredictPlot[len(train_predict)+(look_back*2)+1:len(data_oil)-1,:] = test_predict

plt.plot(sc.inverse_transform(data_oil))
plt.plot(trainPredictPlot)
plt.plot(testPredictPlot)
plt.show()
```



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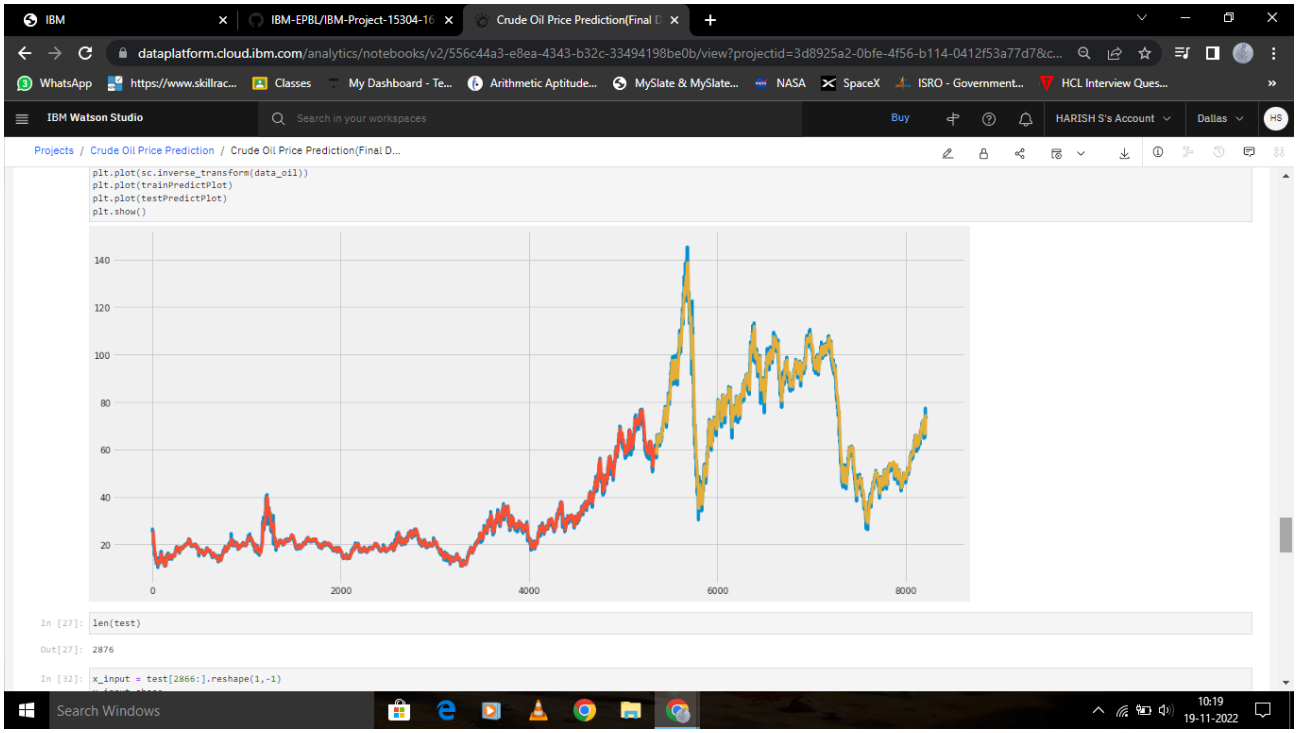
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plt.plot(sc.inverse_transform(data_oil))
plt.plot(trainPredictPlot)
plt.plot(testPredictPlot)
plt.show()
140
120
100
80
60
40
20
0
2000
4000
6000
8000
In [27]:
len(test)
Out[27]:
2876
In [32]:
x_input = test[2866:].reshape(1,-1)
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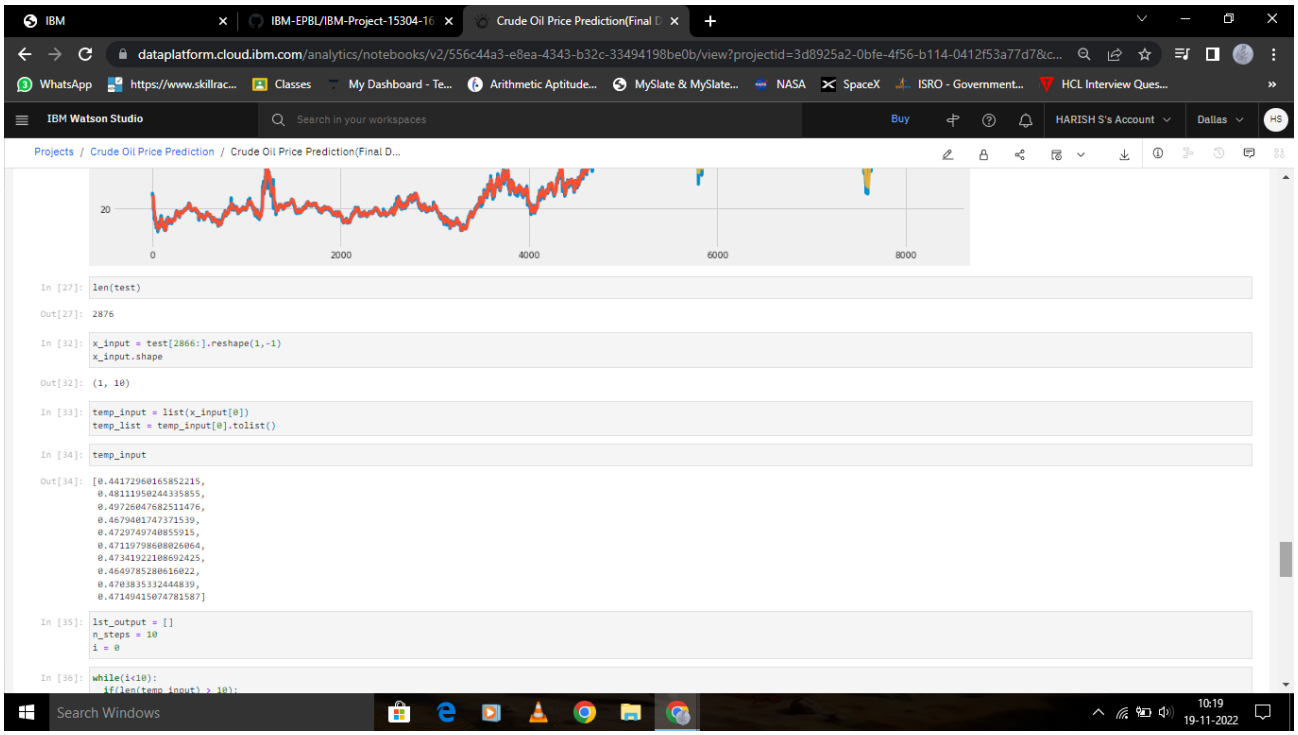
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20
0
2000
4000
6000
8000
In [27]:
len(test)
Out[27]:
2876
In [32]:
x_input = test[2866:].reshape(1,-1)
x_input.shape
Out[32]:
(1, 10)
In [33]:
temp_input = list(x_input[0])
temp_list = temp_input[0].tolist()
In [34]:
temp_input
Out[34]:
[0.4417296016585221,
0.48111950244335855,
0.4972604768251147,
0.467940174737153,
0.4729749740855915,
0.47119798608026064,
0.4734192210869242,
0.4649785280616022,
0.4703835332444839,
0.47149415074781587]
In [35]:
lst_output = []
n_steps = 10
i = 0
In [36]:
while(i<10):
if(len(temp_input) > 10):
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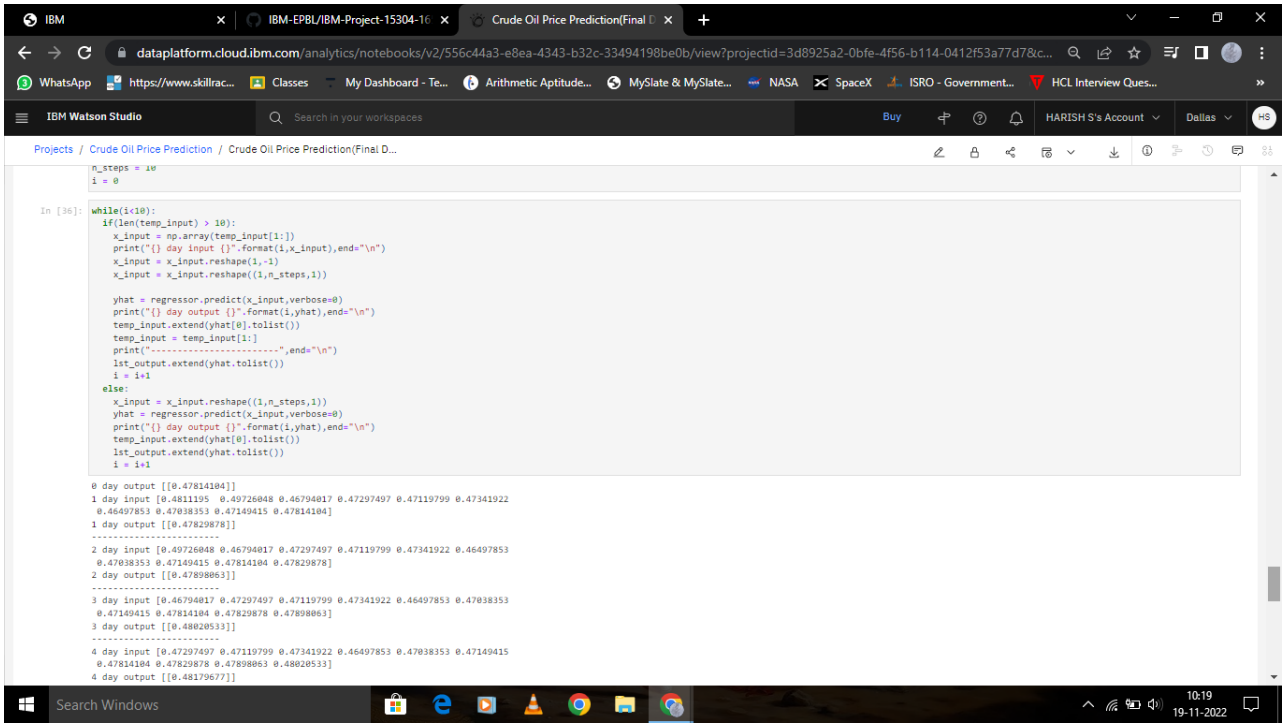
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n_steps = 10
i = 0
In [36]:
while(i<10):
if(len(temp_input) > 10):
x_input = np.array(temp_input[1:])
print("{} day input {}".format(i,x_input),end="\n")
x_input = x_input.reshape(1,-1)
x_input = x_input.reshape((1,n_steps,1))
yhat = regressor.predict(x_input,verbose=0)
print("{} day output {}".format(i,yhat),end="\n")
temp_input.extend(yhat[0].tolist())
temp_input = temp_input[1:]
print("----------",end="\n")
lst_output.extend(yhat.tolist())
i = i+1
else:
x_input = x_input.reshape((1,n_steps,1))
yhat = regressor.predict(x_input,verbose=0)
print("{} day output {}".format(i,yhat),end="\n")
temp_input.extend(yhat[0].tolist())
lst_output.extend(yhat.tolist())
i = i+1
0 day output [[0.47814104]]
1 day input [0.4811195 0.49726048 0.46794017 0.47297497 0.47119799 0.47341922
0.46497853 0.47038353 0.47149415 0.47814104]
1 day output [[0.47829878]]
----
2 day input [0.49726048 0.46794017 0.47297497 0.47119799 0.47341922 0.46497853
0.47038353 0.47149415 0.47814104 0.47829878]
2 day output [[0.47898063]]
----
3 day input [0.46794017 0.47297497 0.47119799 0.47341922 0.46497853 0.47038353
0.47149415 0.47814104 0.47829878 0.47898063]
3 day output [[0.48020533]]
----
4 day input [0.47297497 0.47119799 0.47341922 0.46497853 0.47038353 0.47149415
0.47814104 0.47829878 0.47898063 0.48020533]
4 day output [[0.48179677]]
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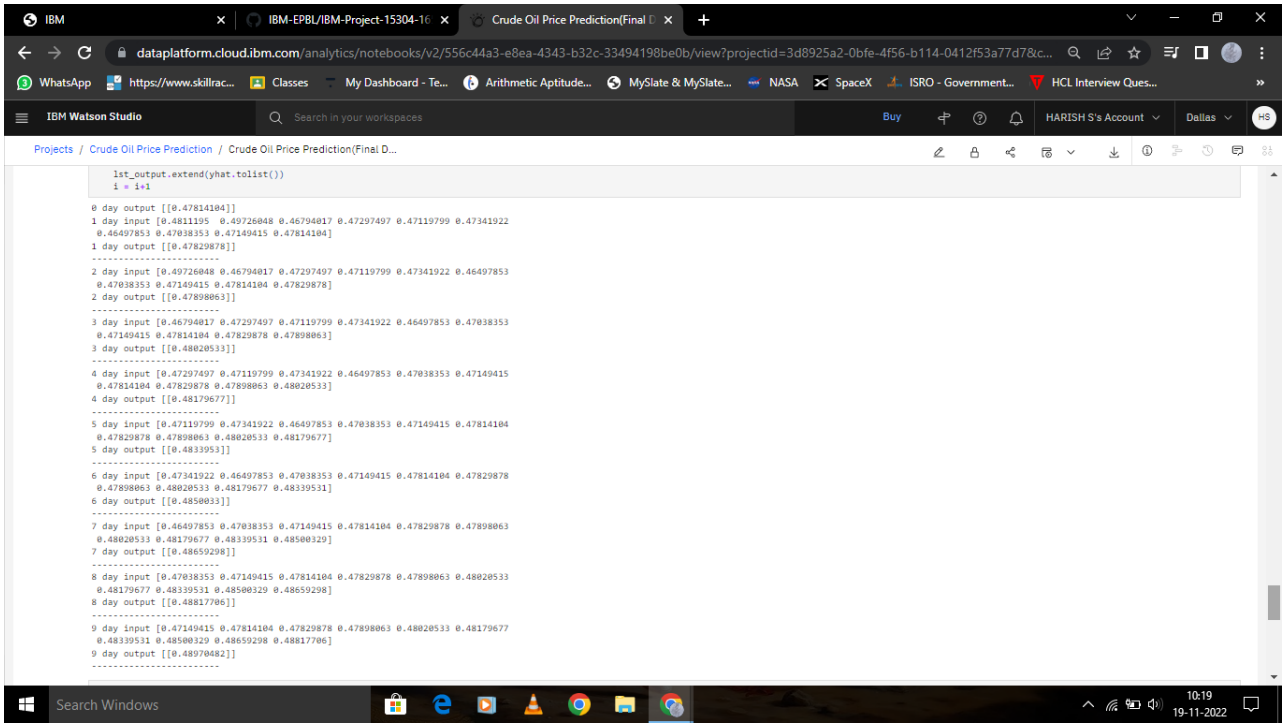
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lst_output.extend(yhat.tolist())
i = i+1
0 day output [[0.47814104]]
1 day input [0.4811195 0.49726048 0.46794017 0.47297497 0.47119799 0.47341922
0.46497853 0.47038353 0.47149415 0.47814104]
1 day output [[0.47829878]]
----
2 day input [0.49726048 0.46794017 0.47297497 0.47119799 0.47341922 0.46497853
0.47038353 0.47149415 0.47814104 0.47829878]
2 day output [[0.47898063]]
----
3 day input [0.46794017 0.47297497 0.47119799 0.47341922 0.46497853 0.47038353
0.47149415 0.47814104 0.47829878 0.47898063]
3 day output [[0.48020533]]
----
4 day input [0.47297497 0.47119799 0.47341922 0.46497853 0.47038353 0.47149415
0.47814104 0.47829878 0.47898063 0.48020533]
4 day output [[0.48179677]]
----
5 day input [0.47119799 0.47341922 0.46497853 0.47038353 0.47149415 0.47814104
0.47829878 0.47898063 0.48020533 0.48179677]
5 day output [[0.4833953]]
----
6 day input [0.47341922 0.46497853 0.47038353 0.47149415 0.47814104 0.47829878
0.47898063 0.48020533 0.48179677 0.48339531]
6 day output [[0.4850033]]
----
7 day input [0.46497853 0.47038353 0.47149415 0.47814104 0.47829878 0.47898063
0.48020533 0.48179677 0.48339531 0.48500329]
7 day output [[0.48659298]]
----
8 day input [0.47038353 0.47149415 0.47814104 0.47829878 0.47898063 0.48020533
0.48179677 0.48339531 0.48500329 0.48659298]
8 day output [[0.48817706]]
----
9 day input [0.47149415 0.47814104 0.47829878 0.47898063 0.48020533 0.48179677
0.48339531 0.48500329 0.48659298 0.48817706]
9 day output [[0.48970482]]

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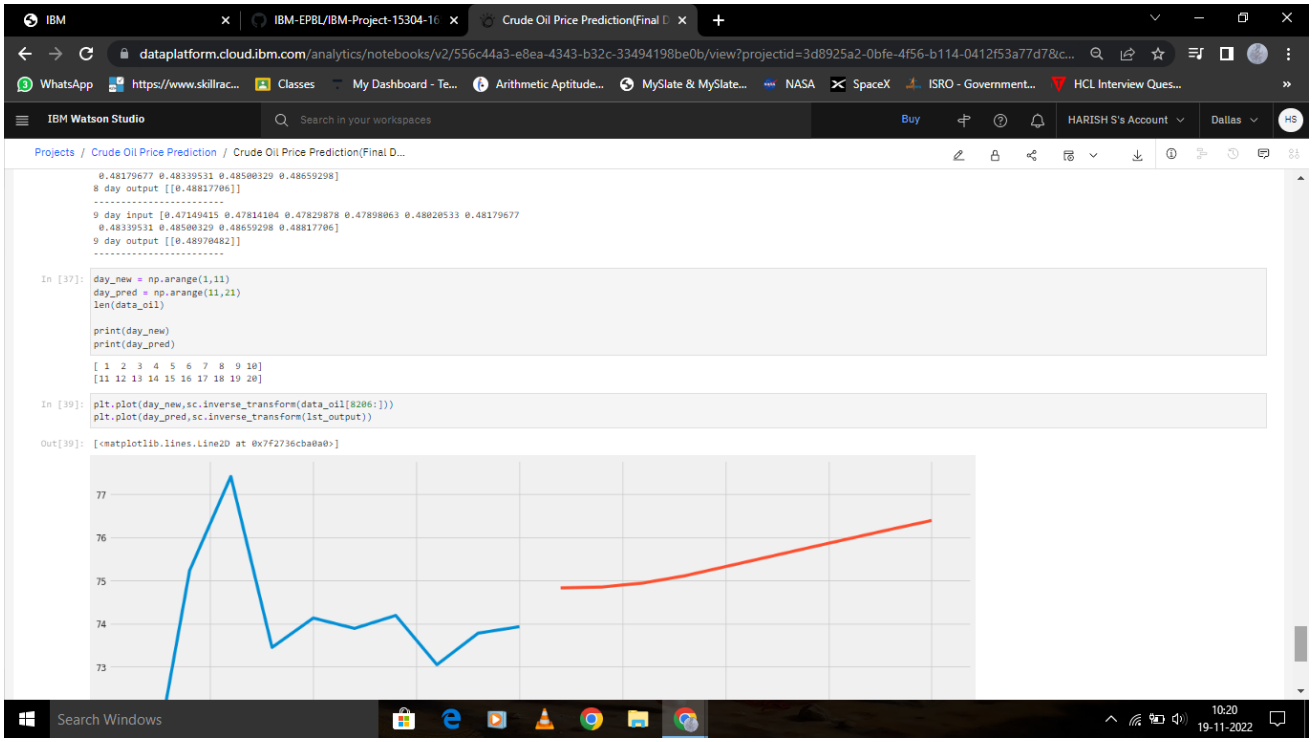
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0.48179677 0.48339531 0.48500329 0.48659298]
8 day output [[0.48817706]]
9 day input [0.47149415 0.47814104 0.47829878 0.47898063 0.48020533 0.48179677
0.48339531 0.48500329 0.48659298 0.48817706]
9 day output [[0.48970482]]
In [37]:
day_new = np.arange(1,11)
day_pred = np.arange(11,21)
len(data_oil)
print(day_new)
print(day_pred)
[1 2 3 4 5 6 7 8 9 10]
[11 12 13 14 15 16 17 18 19 20]
In [39]:
plt.plot(day_new,sc.inverse_transform(data_oil[8206:]))
plt.plot(day_pred,sc.inverse_transform(lst_output))
Out[39]:
[<matplotlib.lines.Line2D at 0x7f2736cba0a0>]
77
76
75
74
73
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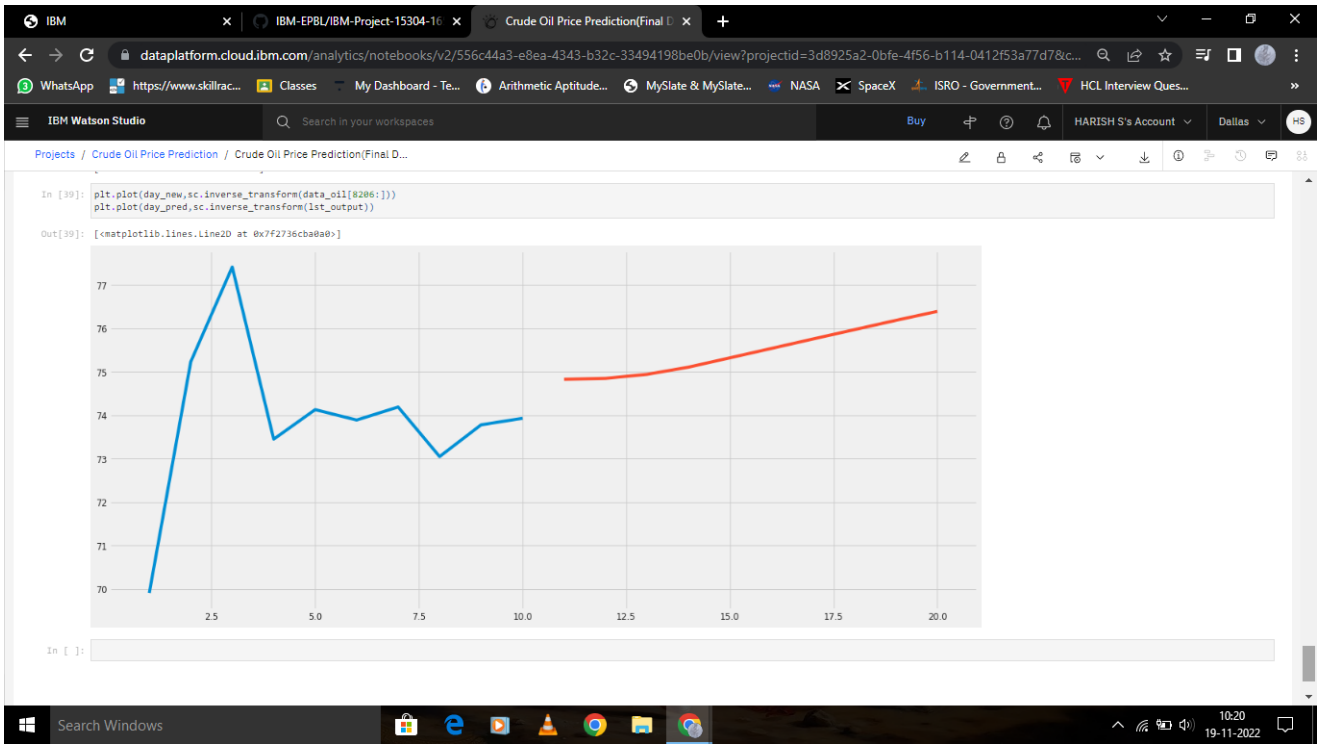
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In [39]:
plt.plot(day_new,sc.inverse_transform(data_oil[8206:]))
plt.plot(day_pred,sc.inverse_transform(lst_output))
Out[39]:
[<matplotlib.lines.Line2D at 0x7f2736cba0a0>]
77
76
75
74
73
72
71
70
2.5
5.0
7.5
10.0
12.5
15.0
17.5
20.0
In [ ]:
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