In [21]:
```python
import numpy as np
import pandas as pd
import matplotlib.pylab as plt
%matplotlib inline
from matplotlib.pylab import rcParams
rcParams['figure.figsize'] = 14, 6
from statsmodels.tsa.stattools import adfuller
from statsmodels.graphics.tsaplots import plot_acf, plot_pacf
from statsmodels.tsa.seasonal import seasonal_decompose
import statsmodels.api as sm
from statsmodels.tsa.arima_model import ARIMA
import pmdarima as pm
from sklearn.metrics import mean_squared_error, mean_absolute_error
from math import sqrt

import warnings
warnings.filterwarnings('ignore')
```

In [22]:
```python
df = pd.read_csv('D:/PROJECTS/Time Series/orders.csv')
df
```

Out[22]:

| | Unnamed: 0 | date | total_orders |
|---|---|---|---|
| 0 | 0 | 2021-08-10 | 455 |
| 1 | 1 | 2021-08-11 | 553 |
| 2 | 2 | 2021-08-12 | 569 |
| 3 | 3 | 2021-08-13 | 426 |
| 4 | 4 | 2021-08-14 | 536 |
| ... | ... | ... | ... |
| 85 | 85 | 2021-11-04 | 386 |
| 86 | 86 | 2021-11-05 | 375 |
| 87 | 87 | 2021-11-06 | 441 |
| 88 | 88 | 2021-11-07 | 421 |
| 89 | 89 | 2021-11-08 | 526 |

90 rows × 3 columns

In [23]:
```python
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 90 entries, 0 to 89
Data columns (total 3 columns):
 #   Column        Non-Null Count  Dtype
---  ------        --------------  -----
 0   Unnamed: 0    90 non-null     int64
 1   date          90 non-null     object
 2   total_orders  90 non-null     int64
dtypes: int64(2), object(1)
memory usage: 2.2+ KB
```

In [24]:
```python
df['date'] = pd.to_datetime(df.date)
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 90 entries, 0 to 89
Data columns (total 3 columns):
 #   Column        Non-Null Count  Dtype
---  ------        --------------  -----
 0   Unnamed: 0    90 non-null     int64
 1   date          90 non-null     datetime64[ns]
 2   total_orders  90 non-null     int64
dtypes: datetime64[ns](1), int64(2)
memory usage: 2.2 KB
```

In [25]:
```python
df.set_index('date', inplace=True)
df
```

Out[25]:

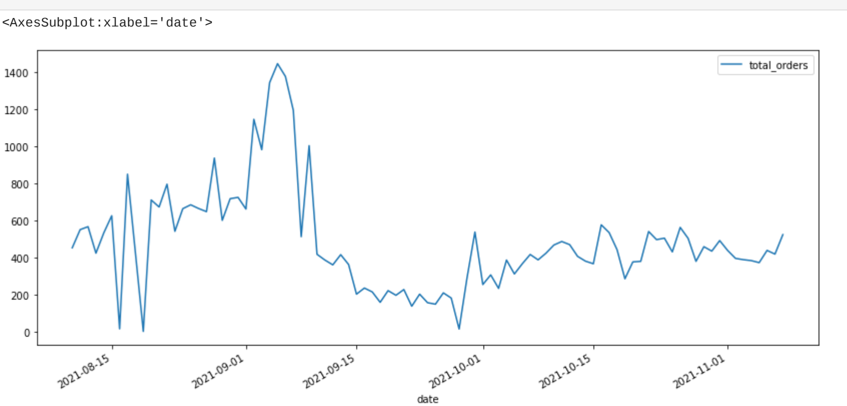
| date | Unnamed: 0 | total_orders |
|---|---|---|
| 2021-08-10 | 0 | 455 |
| 2021-08-11 | 1 | 553 |
| 2021-08-12 | 2 | 569 |
| 2021-08-13 | 3 | 426 |
| 2021-08-14 | 4 | 536 |
| ... | ... | ... |
| 2021-11-04 | 85 | 386 |
| 2021-11-05 | 86 | 375 |
| 2021-11-06 | 87 | 441 |
| 2021-11-07 | 88 | 421 |
| 2021-11-08 | 89 | 526 |

90 rows × 2 columns

In [26]:
```python
df.drop('Unnamed: 0', axis=1, inplace=True)
```

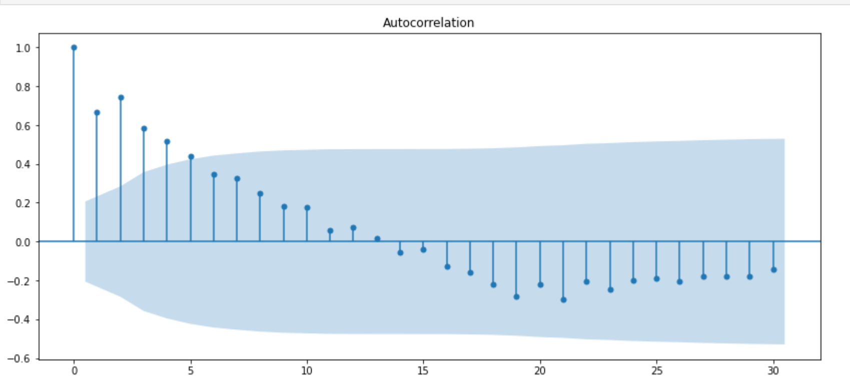
In [27]:
```python
df.plot()
```

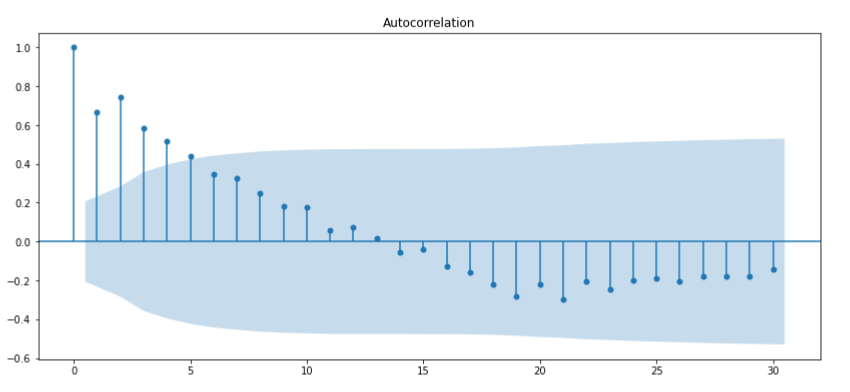
Out[27]: <AxesSubplot:xlabel='date'>




In [28]:
```python
plot_acf(df.total_orders, lags=30)
```

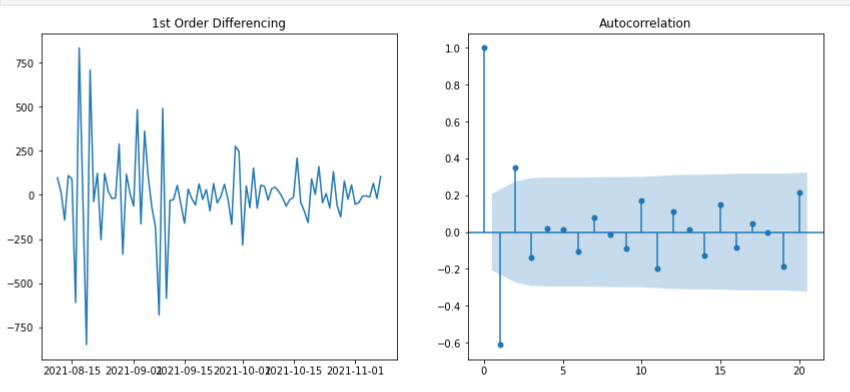
Out[28]:



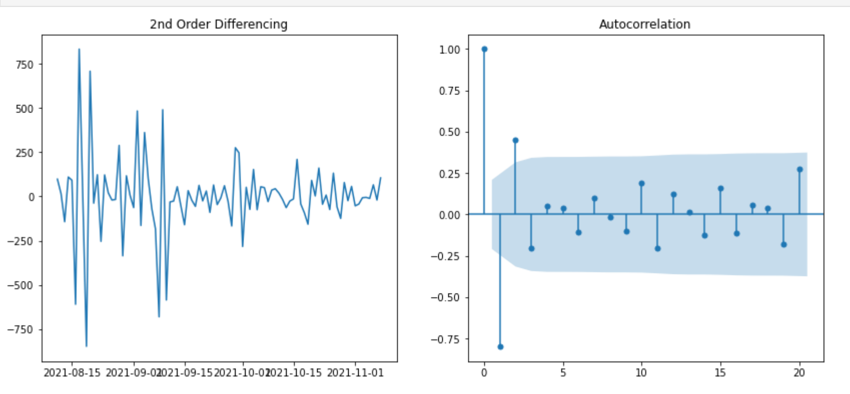

In [29]:
```python
f = plt.figure()
ax1 = f.add_subplot(121)
ax1.set_title('1st Order Differencing')
ax1.plot(df.total_orders.diff())

ax2 = f.add_subplot(122)
plot_acf(df.total_orders.diff().dropna(), ax=ax2)
plt.show()
```




In [30]:
```python
f = plt.figure()
ax1 = f.add_subplot(121)
ax1.set_title('2nd Order Differencing')
ax1.plot(df.total_orders.diff())

ax2 = f.add_subplot(122)
plot_acf(df.total_orders.diff().diff().dropna(), ax=ax2)
plt.show()
```



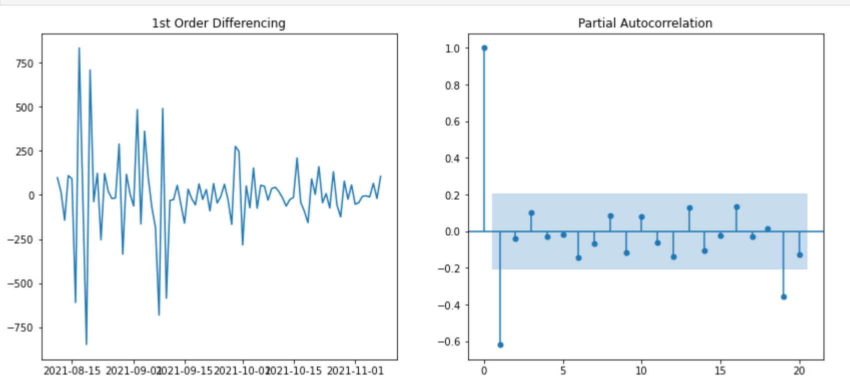

In [31]:
```python
# adfuller test
def test_stationarity(data):
    result = adfuller(data.dropna())
    print('p_value: ', result[1])

test_stationarity(df.total_orders)
test_stationarity(df.total_orders.diff())
test_stationarity(df.total_orders.diff().diff())
```

```
p_value:  0.25760121445028594
p_value:  0.0
p_value:  9.238340684201137e-05
```

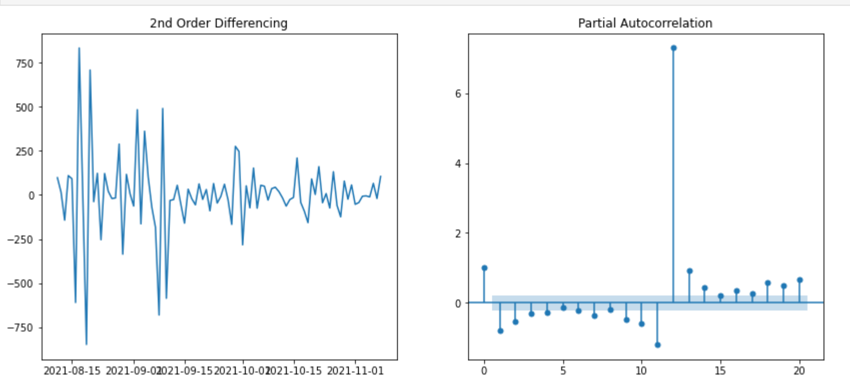
In [32]:
```python
f = plt.figure()
ax1 = f.add_subplot(121)
ax1.set_title('1st Order Differencing')
ax1.plot(df.total_orders.diff())

ax2 = f.add_subplot(122)
plot_pacf(df.total_orders.diff().dropna(), ax=ax2)
plt.show()
```




In [33]:
```python
f = plt.figure()
ax1 = f.add_subplot(121)
ax1.set_title('2nd Order Differencing')
ax1.plot(df.total_orders.diff())

ax2 = f.add_subplot(122)
plot_pacf(df.total_orders.diff().diff().dropna(), ax=ax2)
plt.show()
```




In [34]:
```python
# p = 1-2, d = 1-2, q = 1-2
# fitting
model = pm.auto_arima(df.total_orders, start_p=1, start_q=1,
                      test='adf',       # use adftest to find optimal 'd'
                      max_p=4, max_q=1, # maximum p and q
                      m=1,              # frequency of series
                      d=None,           # let model determine 'd'
                      seasonal=False,   # No Seasonality
                      start_P=0,
                      D=0,
                      trace=True,
                      error_action='ignore',
                      suppress_warnings=True,
                      stepwise=True)

print(model.summary())
```

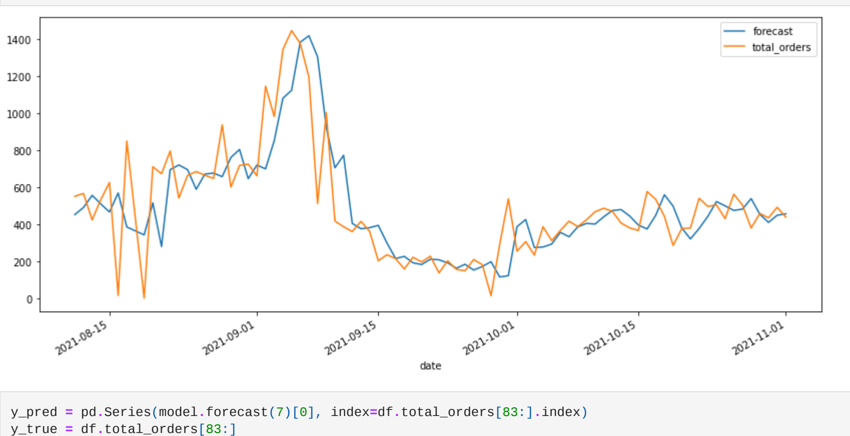
```
Performing stepwise search to minimize aic
 ARIMA(1,1,1)(0,0,0)[0] intercept   : AIC=1186.793, Time=0.08 sec
 ARIMA(0,1,0)(0,0,0)[0] intercept   : AIC=1224.165, Time=0.02 sec
 ARIMA(1,1,0)(0,0,0)[0] intercept   : AIC=1184.900, Time=0.03 sec
 ARIMA(0,1,1)(0,0,0)[0] intercept   : AIC=1195.559, Time=0.11 sec
 ARIMA(0,1,0)(0,0,0)[0]             : AIC=1222.166, Time=0.02 sec
 ARIMA(2,1,0)(0,0,0)[0] intercept   : AIC=1186.762, Time=0.12 sec
 ARIMA(2,1,1)(0,0,0)[0] intercept   : AIC=1188.266, Time=0.21 sec
 ARIMA(1,1,0)(0,0,0)[0]             : AIC=1182.899, Time=0.02 sec
 ARIMA(2,1,0)(0,0,0)[0]             : AIC=1184.761, Time=0.07 sec
 ARIMA(1,1,1)(0,0,0)[0]             : AIC=1184.793, Time=0.07 sec
 ARIMA(0,1,1)(0,0,0)[0]             : AIC=1193.559, Time=0.05 sec
 ARIMA(2,1,1)(0,0,0)[0]             : AIC=1186.266, Time=0.14 sec

Best model:  ARIMA(1,1,0)(0,0,0)[0]
Total fit time: 0.952 seconds
                               SARIMAX Results
==============================================================================
Dep. Variable:                      y   No. Observations:                   90
Model:               SARIMAX(1, 1, 0)   Log Likelihood                -589.449
Date:                Sat, 26 Mar 2022   AIC                           1182.899
Time:                        22:50:23   BIC                           1187.876
Sample:                             0   HQIC                          1184.905
                                 - 90
Covariance Type:                  opg
==============================================================================
                 coef    std err          z      P>|z|      [0.025      0.975]
------------------------------------------------------------------------------
ar.L1         -0.6065      0.053    -11.538      0.000      -0.710      -0.503
sigma2      3.325e+04   2849.771     11.666      0.000    2.77e+04    3.88e+04
===================================================================================
Ljung-Box (L1) (Q):                   0.08   Jarque-Bera (JB):                78.78
Prob(Q):                              0.78   Prob(JB):                         0.00
Heteroskedasticity (H):               0.10   Skew:                            -0.79
Prob(H) (two-sided):                  0.00   Kurtosis:                         7.33
===================================================================================

Warnings:
[1] Covariance matrix calculated using the outer product of gradients (complex-step).
```

In [35]:
```python
model_arima = ARIMA(df.total_orders[:83], order=(1,1,0))
model = model_arima.fit()

model.plot_predict(dynamic=False)
plt.show()
```




In [36]:
```python
y_pred = pd.Series(model.forecast(7)[0], index=df.total_orders[83:].index)
y_true = df.total_orders[83:]

print(np.ceil(np.array(y_pred)).astype(int))
print(np.array(y_true))
```

```
[473 453 465 457 461 458 459]
[398 391 386 375 441 421 526]
```

In [37]:
```python
n = np.array(df[:83]).shape[0]
d = np.abs(np.diff(np.array(df[:83].total_orders))).sum() / (n-1)
mase = (np.abs(y_true - y_pred).mean()) / d
mase
```

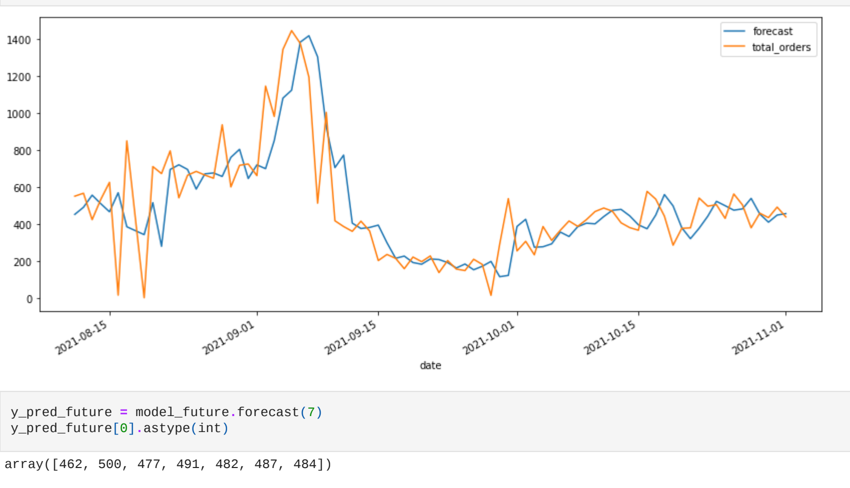
Out[37]: 0.411984368350348

In [38]:
```python
mape = np.mean(np.abs(y_pred - y_true)/np.abs(y_true))  # MAPE
mape
```

Out[38]: 0.14639417616266187

In [39]:
```python
# again fit model on whole data
model_arima_future = ARIMA(df.total_orders, order=(1,1,0))
model_future = model_arima_future.fit()

model.plot_predict(dynamic=False)
plt.show()
```




In [40]:
```python
y_pred_future = model_future.forecast(7)
y_pred_future[0].astype(int)
```

Out[40]: array([462, 500, 477, 491, 482, 487, 484])

In [ ]: