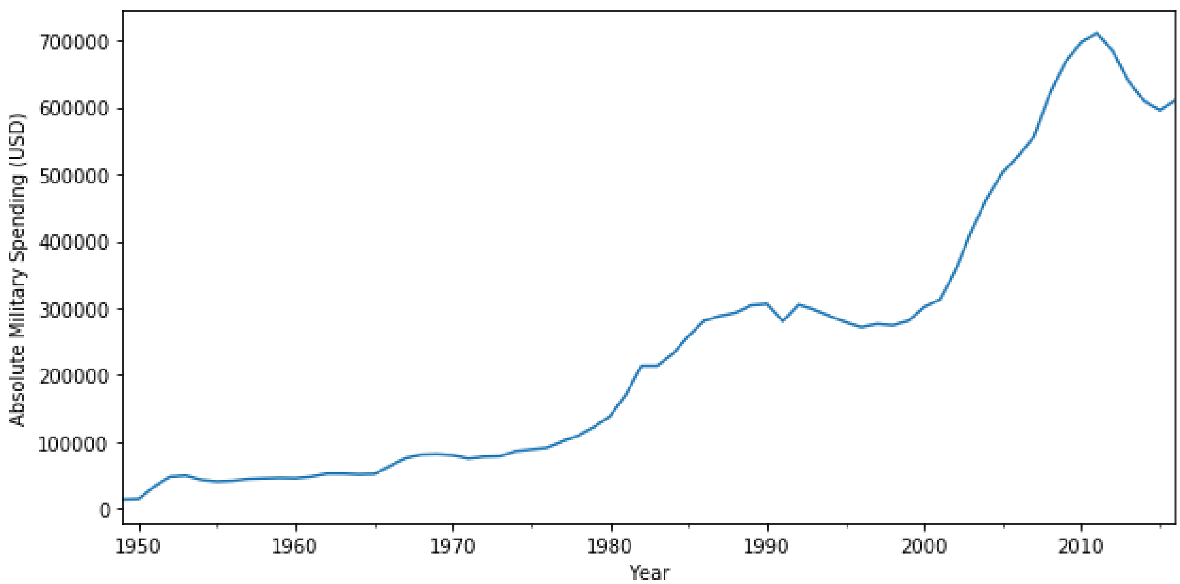
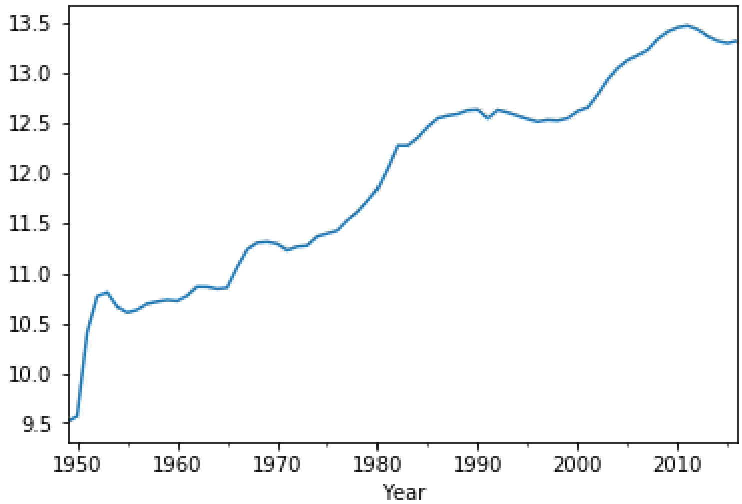
In [34]:
```
from pandas import Series
import numpy as np
from matplotlib import pyplot as plt
from statsmodels.tsa.stattools import acf, pacf
import statsmodels.tsa.stattools as ts
from statsmodels.graphics.tsaplots import plot_acf, plot_pacf
from statsmodels.tsa.arima_model import ARIMA
from scipy import stats
import scipy
import pandas as pd
import math
from statsmodels.graphics.api import qqplot

from sklearn.metrics import mean_squared_error
from numpy import std, mean, sqrt
from statsmodels.stats import diagnostic as diag
```

Exploratory Analysis

In [35]:
```
#plotting the raw time series data
series = Series.from_csv('military.csv', header=0)
plt.ylabel('Absolute Military Spending (USD)')
series.plot(figsize=(10,5))
plt.show()
```

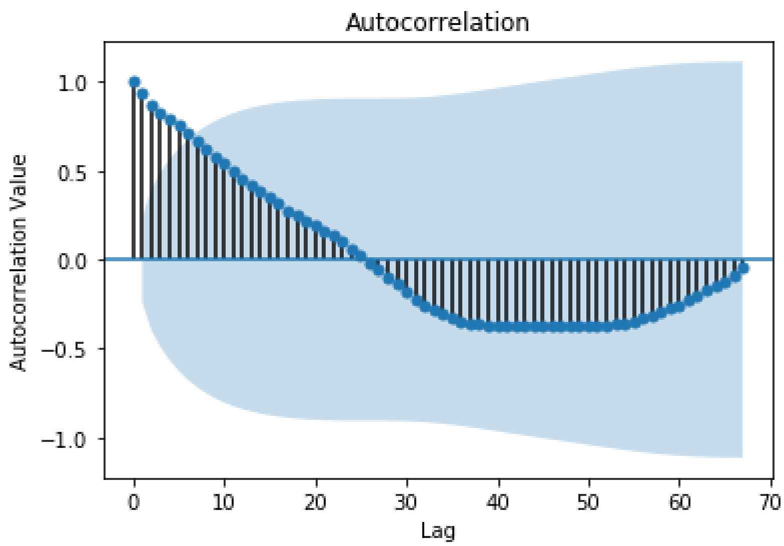


In [36]:
```
#Log-form manipulation to inform on relative changes and improve the efficienc
y of the model.
series = series.apply(np.log)
series.plot()
plt.show()
```

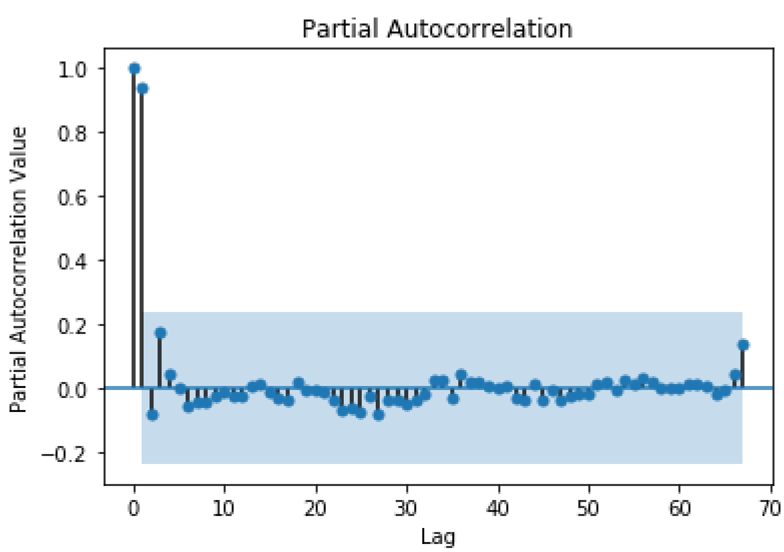


Stationarity Tests

In [37]:
```
#ACF and PACF tests for stationarity.
#The highlighted regions depict a 95% confidence interval,
#under the assumption that the time series is iid, suggesting that correlation
 values outside of this code are very likely a correlation and not a statistic
al fluke.
#Confidence intervals for ACF are drawn as a cone.

plot_acf(series)
plt.xlabel('Lag')
plt.ylabel('Autocorrelation Value')
plt.show()

#steady decrease downwards
## If one or more lags pierce those dashed lines, then the lag(s) is significa
ntly different from zero and the series is not white noise.
```



In [38]:
```
plot_pacf(series)
plt.xlabel('Lag')
plt.ylabel('Partial Autocorrelation Value')
plt.show()
```



Augmented Dickey-Fuller Test

In [21]:
```
result = ts.adfuller(x, 2,regression='c') #maximum lag which is included in te
st
print('ADF Statistic: %f' % result[0])
print('p-value: %f' % result[1])
print('Critical Values:')
for key, value in result[4].items():
        print('\t%s: %.3f' % (key, value))
```

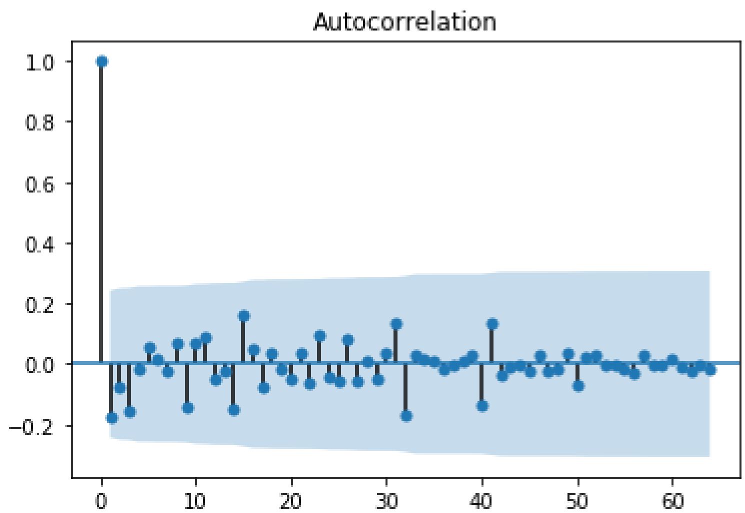
```
ADF Statistic: -0.546798
p-value: 0.882556
Critical Values:
        1%: -3.535
        5%: -2.907
        10%: -2.591
```

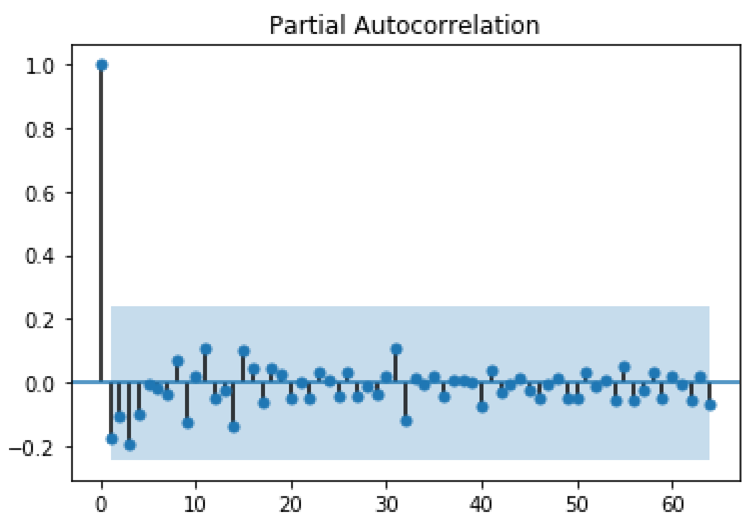
In [98]:
```
x_diff = np.diff(x)
x_diff = np.diff(x_diff)
x_diff = np.diff(x_diff)
result = ts.adfuller(x_diff, 2,regression='c') #maximum lag which is included
 in test
print('ADF Statistic: %f' % result[0])
print('p-value: %f' % result[1])
print('Critical Values:')
for key, value in result[4].items():
        print('\t%s: %.3f' % (key, value))
```

```
ADF Statistic: -9.102921
p-value: 0.000000
Critical Values:
        1%: -3.541
        5%: -2.909
        10%: -2.592
```

In [108]:

```
# acf and pacf
plot_acf(x_diff)
plot_pacf(x_diff)

# hist plot
count, division = np.histogram(x_diff)
plt.show()


#histogram
count, division = np.histogram(x_diff)
plt.show()
```





Practical signifiance

In [77]:
```
#Practical significance for difference in means between training and test dat
a.

size = len(x_diff)//2
train, test= x_diff[:size], x_diff[size:]

def cohen_d(x,y):
    nx = len(x)
    ny = len(y)
    dof = nx + ny - 2
    return (mean(x) - mean(y)) / sqrt(((nx-1)*std(x, ddof=1) ** 2 + (ny-1)*std
(y, ddof=1) ** 2) / dof)

print(cohen_d(test,train))
```

```
0.0177790794304
```

Model Identification

In [78]:
```
#Source: https://stackoverflow.com/questions/30901460/non-invertible-of-a-arim
a-model

p_values = [0, 1, 2, 4]
d_values = range(0, 3)
q_values = range(0, 3)

pdq = []
stderr = []

for p in p_values:
        for d in d_values:
            for q in q_values:
                order = (p,d,q)
                pdq.append(order)
                history = [x for x in train]
                predictions = []
                try:
                    for t in range(len(test)):
                        model = ARIMA(history, order)
                        model_fit = model.fit(disp=0)
                        output = model_fit.forecast()
                        yhat = output[0]
                        predictions.append(yhat)
                        obs = test[t]
                        history.append(obs)
                    error = mean_squared_error(test, predictions)
                    stderr.append(error)

                except: # ignore the error and go on

                    pass
```

```
C:\ProgramData\Anaconda3\lib\site-packages\statsmodels\base\model.py:496: Con
vergenceWarning: Maximum Likelihood optimization failed to converge. Check ml
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  "Check mle_retvals", ConvergenceWarning)
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C:\ProgramData\Anaconda3\lib\site-packages\statsmodels\base\model.py:473: Hes
sianInversionWarning: Inverting hessian failed, no bse or cov_params availabl
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  'available', HessianInversionWarning)
C:\ProgramData\Anaconda3\lib\site-packages\statsmodels\tsa\tsatools.py:628: R
untimeWarning: overflow encountered in exp
  newparams = ((1-np.exp(-params))/(1+np.exp(-params))).copy()
C:\ProgramData\Anaconda3\lib\site-packages\statsmodels\tsa\tsatools.py:628: R
untimeWarning: invalid value encountered in true_divide
  newparams = ((1-np.exp(-params))/(1+np.exp(-params))).copy()
C:\ProgramData\Anaconda3\lib\site-packages\statsmodels\tsa\tsatools.py:629: R
untimeWarning: overflow encountered in exp
  tmp = ((1-np.exp(-params))/(1+np.exp(-params))).copy()
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C:\ProgramData\Anaconda3\lib\site-packages\statsmodels\tsa\tsatools.py:584: R
untimeWarning: overflow encountered in exp
  newparams = ((1-np.exp(-params))/
C:\ProgramData\Anaconda3\lib\site-packages\statsmodels\tsa\tsatools.py:585: R
untimeWarning: overflow encountered in exp
  (1+np.exp(-params))).copy()
C:\ProgramData\Anaconda3\lib\site-packages\statsmodels\tsa\tsatools.py:585: R
untimeWarning: invalid value encountered in true_divide
  (1+np.exp(-params))).copy()
C:\ProgramData\Anaconda3\lib\site-packages\statsmodels\tsa\tsatools.py:586: R
untimeWarning: overflow encountered in exp
  tmp = ((1-np.exp(-params))/
C:\ProgramData\Anaconda3\lib\site-packages\statsmodels\tsa\tsatools.py:587: R
untimeWarning: overflow encountered in exp
  (1+np.exp(-params))).copy()
C:\ProgramData\Anaconda3\lib\site-packages\statsmodels\tsa\tsatools.py:587: R
untimeWarning: invalid value encountered in true_divide
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C:\ProgramData\Anaconda3\lib\site-packages\statsmodels\tsa\tsatools.py:612: R
untimeWarning: divide by zero encountered in true_divide
  invarcoefs = -np.log((1-params)/(1+params))
C:\ProgramData\Anaconda3\lib\site-packages\statsmodels\tsa\tsatools.py:654: R
untimeWarning: invalid value encountered in log
  invmacoefs = -np.log((1-macoefs)/(1+macoefs))
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```

In [81]:

```
keys = pdq
values = stderr
d = dict(zip(keys, values))
print (d)
```

```
{(0, 0, 0): 2.9270637251015354e-06, (0, 0, 1): 3.9560322657175338e-06, (0, 0,
2): 2.8977320818170993e-06, (0, 1, 0): 1.1617086909392845e-05, (0, 1, 1): 3.0
984474614688966e-06, (0, 1, 2): 7.7248472306088377e-06, (0, 2, 0): 3.84947578
28279521e-05, (0, 2, 1): 1.2555802040464861e-05, (0, 2, 2): 3.383762245727189
1e-06, (1, 0, 0): 2.5902093332326673e-06, (1, 0, 1): 6.8999283052727381e-06,
(1, 0, 2): 2.0930473825749393e-05, (1, 1, 0): 3.351523538509614e-06, (1, 1,
1): 4.4089501631587672e-06, (1, 1, 2): 1.863421723412184e-05, (1, 2, 0): 1.44
54719318780986e-05}
```

In [102]:
```
min(d, key=d.get)
```

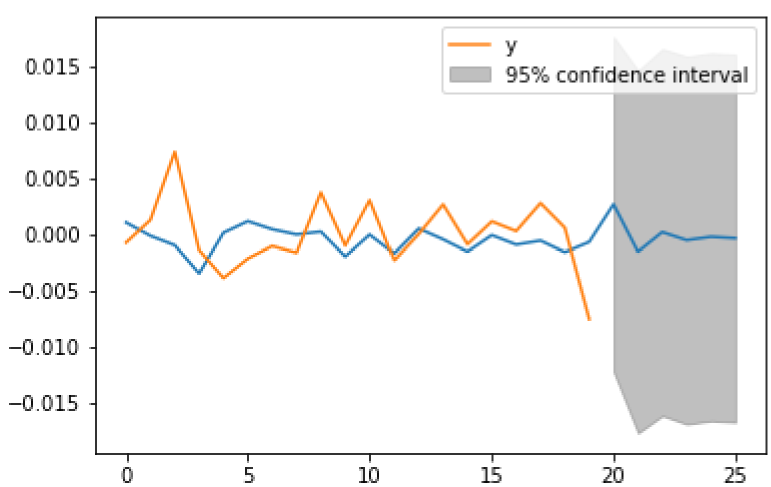
Out[102]:
```
(1, 0, 0)
```

In [103]:
```
#note that ARIMA model will fit to the differenced data
model = ARIMA(train, order=(1,0,0))
model_fit = model.fit(disp=False)
```

In [104]:
```
forecast, stderr, conf = model_fit.forecast() #The forecast() function allows
 the confidence interval to be specified.
#The alpha argument on the forecast() function specifies the confidence level.
 It is set by default to alpha=0.05, which is a 95% confidence interval. This
 is a sensible and widely used confidence interval.
#An alpha of 0.05 means that the ARIMA model will estimate the upper and lower
 values around the forecast where there is a only 5% of the time the real valu
e will not be in that range.
print('Expected: %.3f' % test[0])
print('Forecast: %.3f' % forecast)
print('Standard Error: %.3f' % stderr)
intervals = [0.2, 0.1, 0.05, 0.01]
for a in intervals:
        forecast, stderr, conf = model_fit.forecast(alpha=a)
        print('%.1f%% Confidence Interval: %.3f between %.3f and %.3f' % ((1-a
)*100, forecast, conf[0][0], conf[0][1]))
```

```
Expected: 0.003
Forecast: 0.003
Standard Error: 0.008
80.0% Confidence Interval: 0.003 between -0.007 and 0.012
90.0% Confidence Interval: 0.003 between -0.010 and 0.015
95.0% Confidence Interval: 0.003 between -0.012 and 0.018
99.0% Confidence Interval: 0.003 between -0.017 and 0.022
```

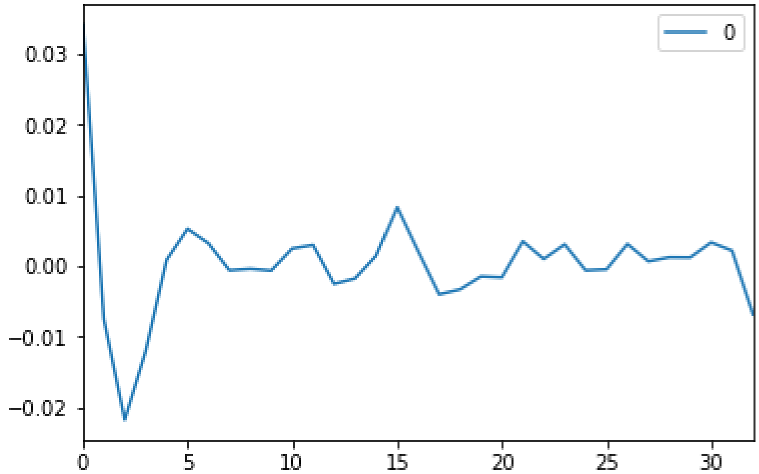
In [107]:
```
model_fit.plot_predict(len(train)-20, len(train)+5)
plt.show()
```

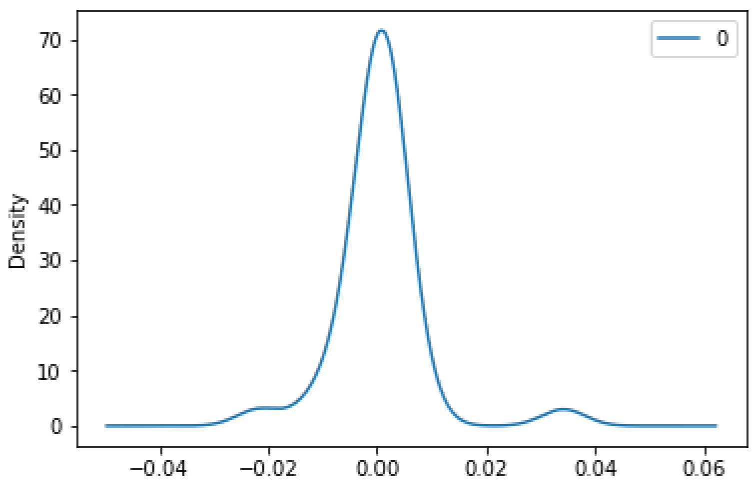


Model Diagnostics

In [109]:
```
# plot residual erros

residuals = pd.DataFrame(model_fit.resid)
residuals.plot()
residuals.plot(kind='kde')
plt.show()
print(residuals.describe())
```






```
               0
count  33.000000
mean    0.000427
std     0.008103
min    -0.021742
25%    -0.001621
50%     0.000853
75%     0.002958
max     0.034111
```