Assignment4

June 19, 2024

0.0.1 We read in the data

[3]:
```
import matplotlib.pyplot as plt
%matplotlib inline
from sklearn import linear_model, metrics
plt.rcParams['figure.figsize'] = 20, 10
import pandas as pd
import numpy as np


day_hour_count = pd.read_csv("bikeshare_hour_count.csv")
day_hour_count.dropna(inplace=True)
day_hour_count
```

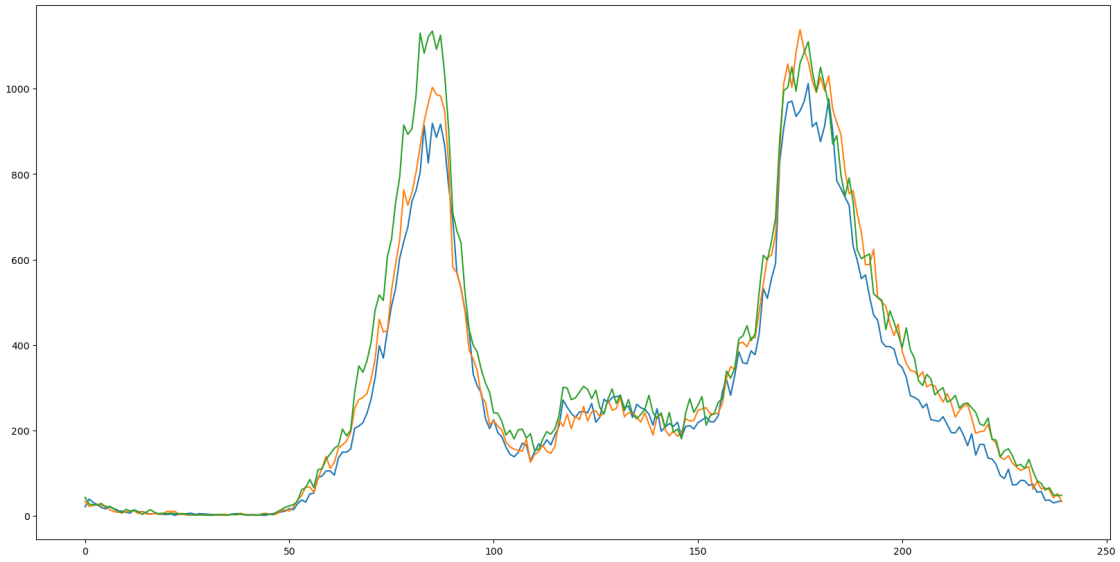
[3]:

	hour	monday	tuesday	wednesday	thursday	friday	saturday	sunday
0	0.0	21.0	34.0	43.0	47.0	51.0	89.0	106.0
1	0.1	39.0	22.0	27.0	37.0	56.0	87.0	100.0
2	0.2	31.0	24.0	26.0	42.0	50.0	98.0	77.0
3	0.3	26.0	27.0	25.0	29.0	52.0	99.0	87.0
4	0.4	19.0	24.0	29.0	29.0	50.0	98.0	69.0
..	…	…	…	…	…	…	…	…
235	23.5	36.0	65.0	60.0	94.0	80.0	93.0	28.0
236	23.6	37.0	61.0	66.0	100.0	81.0	95.0	28.0
237	23.7	30.0	42.0	49.0	80.0	101.0	105.0	27.0
238	23.8	33.0	52.0	47.0	79.0	91.0	93.0	24.0
239	23.9	34.0	33.0	48.0	65.0	105.0	111.0	23.0

[235 rows x 8 columns]

[5]:
```
plt.figure(figsize=(20,10))
plt.plot(day_hour_count.index, day_hour_count["monday"])
plt.plot(day_hour_count.index, day_hour_count["tuesday"])
plt.plot(day_hour_count.index, day_hour_count["wednesday"])
```

[5]:
```
[<matplotlib.lines.Line2D at 0x7f58101b7850>]
```



1 Assignment 4

Explain the results in a **paragraph + charts** of to describe which model you'd recommend. This means show the data and the model's line on the same chart. The paragraph is a simple justification and comparison of the several models you tried.

2 1. Using the `day_hour_count` dataframe create 4 dataframes `monday`, `tuesday`, `saturday` and `sunday` that represent the data for those days. (hint: Monday is day=0)

[8]:
```
monday = day_hour_count[["hour","monday"]].copy()
```

[10]:
```
monday
```

[10]:

	hour	monday
0	0.0	21.0
1	0.1	39.0
2	0.2	31.0
3	0.3	26.0
4	0.4	19.0
..	…	…
235	23.5	36.0
236	23.6	37.0
237	23.7	30.0
238	23.8	33.0
239	23.9	34.0

```
[235 rows x 2 columns]
```

[12]:
```
tuesday = day_hour_count[["hour", "tuesday"]].copy()
```

[14]:
```
tuesday
```

[14]:
```
      hour  tuesday
0      0.0     34.0
1      0.1     22.0
2      0.2     24.0
3      0.3     27.0
4      0.4     24.0
..     …       …
235   23.5     65.0
236   23.6     61.0
237   23.7     42.0
238   23.8     52.0
239   23.9     33.0

[235 rows x 2 columns]
```

[16]:
```
saturday = day_hour_count[["hour", "saturday"]].copy()
```

[18]:
```
saturday
```

[18]:
```
      hour  saturday
0      0.0      89.0
1      0.1      87.0
2      0.2      98.0
3      0.3      99.0
4      0.4      98.0
..     …        …
235   23.5      93.0
236   23.6      95.0
237   23.7     105.0
238   23.8      93.0
239   23.9     111.0

[235 rows x 2 columns]
```

[20]:
```
sunday = day_hour_count[["hour", "sunday"]].copy()
```

[22]:
```
sunday
```

[22]:
```
      hour  sunday
0      0.0   106.0
```

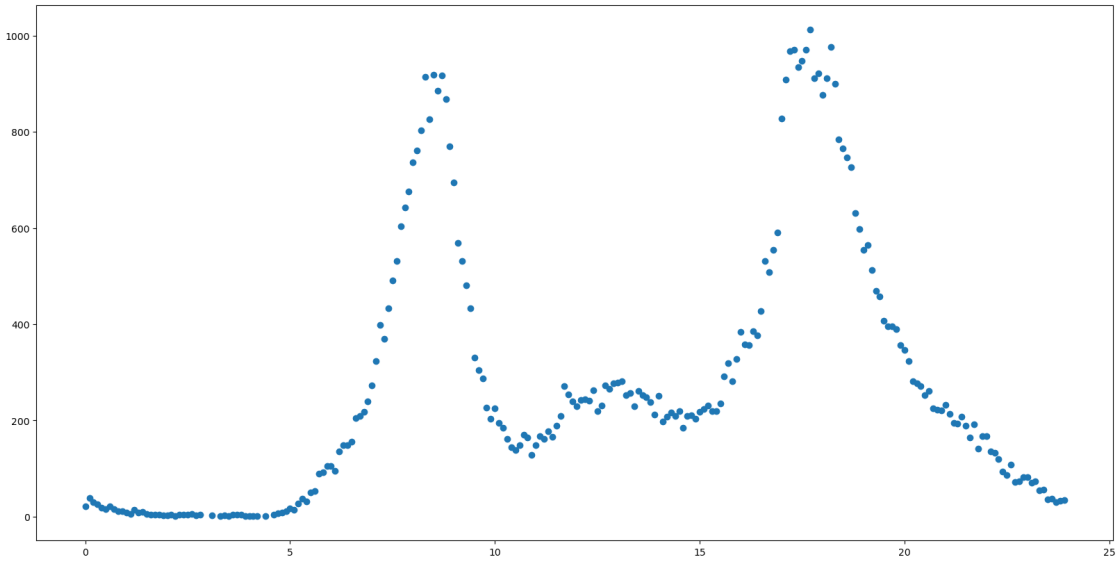
```
1      0.1   100.0
2      0.2    77.0
3      0.3    87.0
4      0.4    69.0
..     …      …
235   23.5    28.0
236   23.6    28.0
237   23.7    27.0
238   23.8    24.0
239   23.9    23.0

[235 rows x 2 columns]
```

2.1 2a. Create 3 models fit to (x=hour, y=monday) with varying polynomial degrees (choose from n=5,15,20). (Repeat for saturday below)

2.2 Plot all the results for each polynomial.

[25]:
```
n = 50
x = monday['hour'].values
y = monday['monday'].values

x = x.reshape(-1, 1)
y = y.reshape(-1, 1)

plt.scatter(x, y)
```

[25]:
```
<matplotlib.collections.PathCollection at 0x7f58101f4550>
```

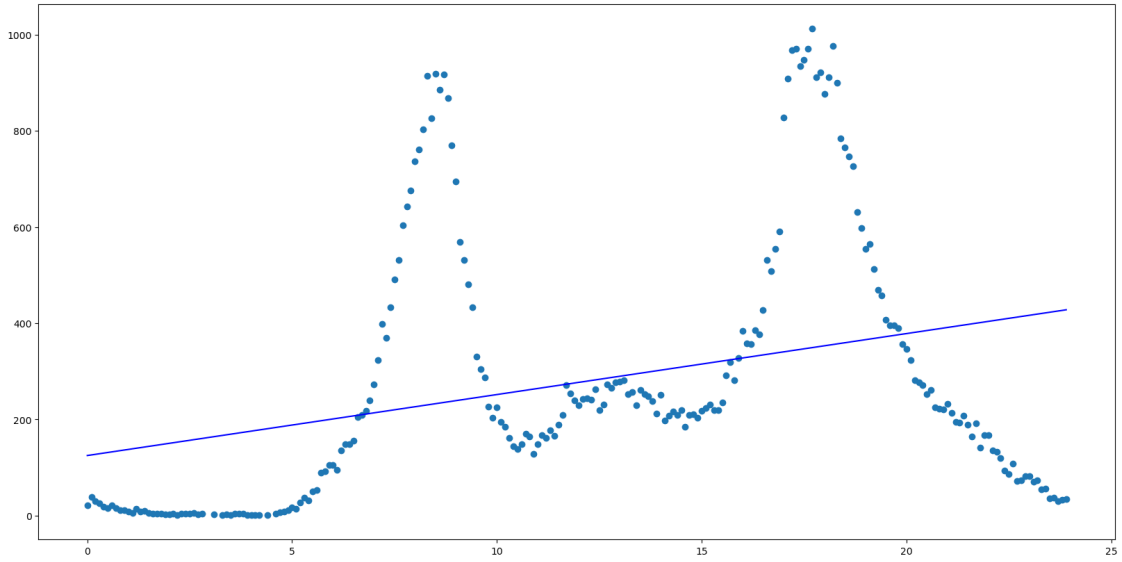


[27]:
```
linear = linear_model.LinearRegression()
linear.fit(x, y)
linear.coef_, linear.intercept_
```

[27]:
```
(array([[12.67240265]]), array([125.0952562]))
```

[29]:
```
plt.scatter(x, y)
plt.plot(x, linear.predict(x), c='b')
```

[29]:
```
[<matplotlib.lines.Line2D at 0x7f5806f49f10>]
```



[31]:
```
from sklearn.preprocessing import PolynomialFeatures
poly5 = PolynomialFeatures(degree=5)
poly15 = PolynomialFeatures(degree=15)
poly20 = PolynomialFeatures(degree=20)
x_5 = poly5.fit_transform(x)
x_15 = poly15.fit_transform(x)
x_20 = poly20.fit_transform(x)
```

[33]:
```
x_5
```

[33]:
```
array([[1.00000000e+00, 0.00000000e+00, 0.00000000e+00, 0.00000000e+00,
        0.00000000e+00, 0.00000000e+00],
       [1.00000000e+00, 1.00000000e-01, 1.00000000e-02, 1.00000000e-03,
        1.00000000e-04, 1.00000000e-05],
       [1.00000000e+00, 2.00000000e-01, 4.00000000e-02, 8.00000000e-03,
        1.60000000e-03, 3.20000000e-04],
       …,
```

```
        [1.00000000e+00, 2.37000000e+01, 5.61690000e+02, 1.33120530e+04,
         3.15495656e+05, 7.47724705e+06],
        [1.00000000e+00, 2.38000000e+01, 5.66440000e+02, 1.34812720e+04,
         3.20854274e+05, 7.63633171e+06],
        [1.00000000e+00, 2.39000000e+01, 5.71210000e+02, 1.36519190e+04,
         3.26280864e+05, 7.79811265e+06]])
```

[35]:
```
x_15
```

[35]:
```
array([[1.00000000e+00, 0.00000000e+00, 0.00000000e+00, …,
        0.00000000e+00, 0.00000000e+00, 0.00000000e+00],
       [1.00000000e+00, 1.00000000e-01, 1.00000000e-02, …,
        1.00000000e-13, 1.00000000e-14, 1.00000000e-15],
       [1.00000000e+00, 2.00000000e-01, 4.00000000e-02, …,
        8.19200000e-10, 1.63840000e-10, 3.27680000e-11],
       …,
       [1.00000000e+00, 2.37000000e+01, 5.61690000e+02, …,
        7.44266546e+17, 1.76391171e+19, 4.18047076e+20],
       [1.00000000e+00, 2.38000000e+01, 5.66440000e+02, …,
        7.86140991e+17, 1.87101556e+19, 4.45301703e+20],
       [1.00000000e+00, 2.39000000e+01, 5.71210000e+02, …,
        8.30180852e+17, 1.98413224e+19, 4.74207605e+20]])
```

[37]:
```
x_20
```

[37]:
```
array([[1.00000000e+00, 0.00000000e+00, 0.00000000e+00, …,
        0.00000000e+00, 0.00000000e+00, 0.00000000e+00],
       [1.00000000e+00, 1.00000000e-01, 1.00000000e-02, …,
        1.00000000e-18, 1.00000000e-19, 1.00000000e-20],
       [1.00000000e+00, 2.00000000e-01, 4.00000000e-02, …,
        2.62144000e-13, 5.24288000e-14, 1.04857600e-14],
       …,
       [1.00000000e+00, 2.37000000e+01, 5.61690000e+02, …,
        5.56506483e+24, 1.31892037e+26, 3.12584127e+27],
       [1.00000000e+00, 2.38000000e+01, 5.66440000e+02, …,
        6.00323338e+24, 1.42876954e+26, 3.40047151e+27],
       [1.00000000e+00, 2.39000000e+01, 5.71210000e+02, …,
        6.47384381e+24, 1.54724867e+26, 3.69792432e+27]])
```

[39]:
```
linear5 = linear_model.LinearRegression()
linear5.fit(x_5, y)
(linear5.coef_, linear.intercept_)
```

[39]:
```
(array([[ 0.00000000e+00, -9.38648794e+01,  4.70261167e+01,
         -5.96385814e+00,  3.08540510e-01, -5.66580989e-03]]),
 array([125.0952562]))
```

[41]:
```
linear15 = linear_model.LinearRegression()
linear15.fit(x_15, y)
(linear15.coef_, linear.intercept_)
```

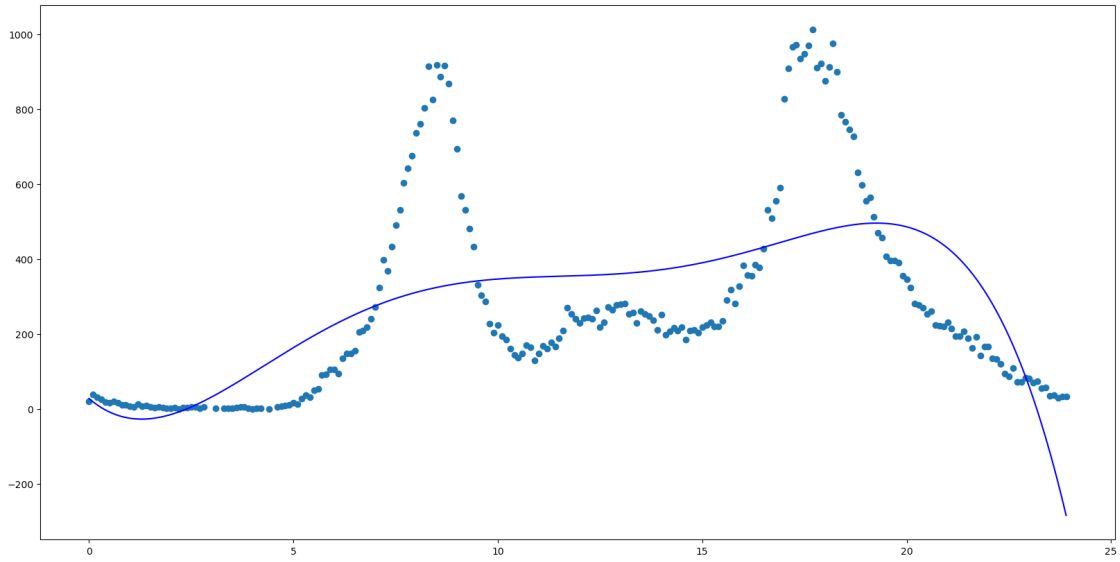
[41]:
```
(array([[ 0.00000000e+00, -7.04495788e-06,  1.29210404e-07,
          9.14244302e-07,  5.78971350e-06,  3.21984520e-05,
          1.49237087e-04,  5.14176945e-04,  9.56557102e-04,
         -3.93334038e-04,  6.34757457e-05, -5.53231200e-06,
          2.84601443e-07, -8.68037720e-09,  1.45683149e-10,
         -1.03944975e-12]]),
 array([125.0952562]))
```

[43]:
```
linear20 = linear_model.LinearRegression()
linear20.fit(x_20, y)
(linear20.coef_, linear.intercept_)
```

[43]:
```
(array([[ 0.00000000e+00, -2.33430060e-14, -2.45423168e-17,
         -3.34582991e-20, -7.67880219e-21, -8.96294071e-20,
         -9.80954003e-19, -1.02698825e-17, -1.01930252e-16,
         -9.45645170e-16, -8.02783400e-15, -6.03272724e-14,
         -3.79432563e-13, -1.78973295e-12, -4.72011008e-12,
          1.29456318e-12, -1.37271109e-13,  7.36226418e-15,
         -2.08427122e-16,  2.85648117e-18, -1.34792031e-20]]),
 array([125.0952562]))
```

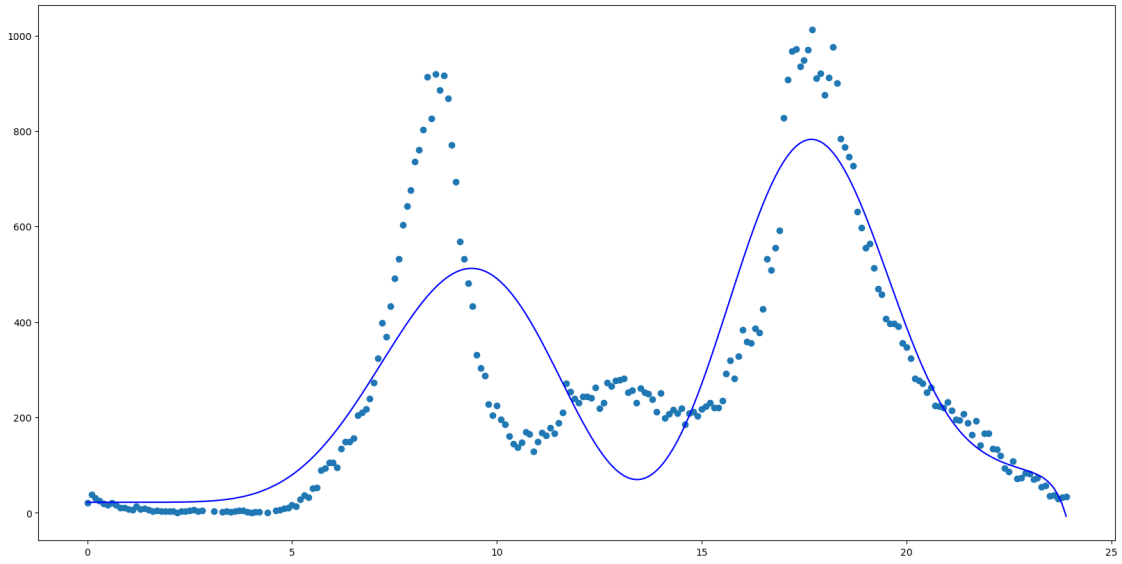
[45]:
```
plt.scatter(x, y)
plt.plot(x, linear5.predict(x_5), c='b')
```

[45]:
```
[<matplotlib.lines.Line2D at 0x7f5806fd5350>]
```



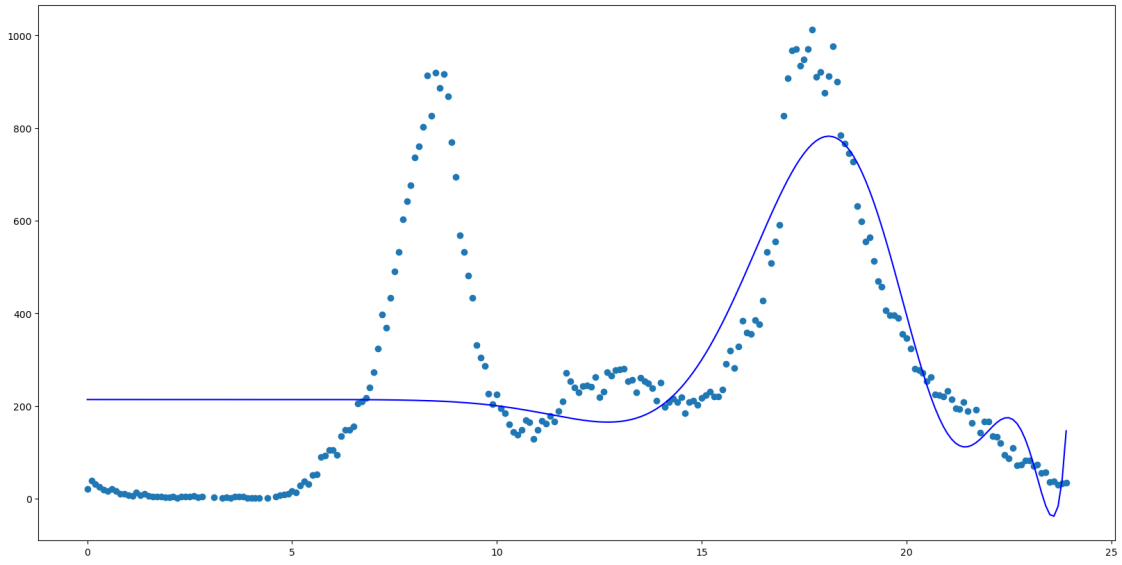
[47]:
```
plt.scatter(x, y)
plt.plot(x, linear15.predict(x_15), c='b')
```

[47]: [<matplotlib.lines.Line2D at 0x7f5806fad750>]



[49]:
```
plt.scatter(x, y)
plt.plot(x, linear20.predict(x_20), c='b')
```

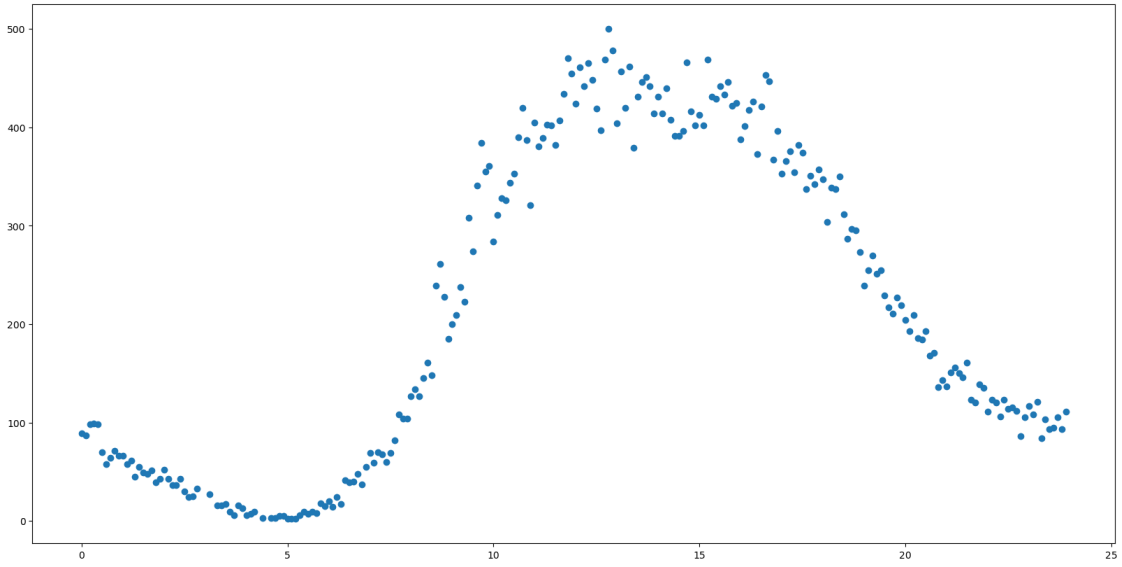
[49]: [<matplotlib.lines.Line2D at 0x7f5810144910>]



2.3 2b. Repeat 2a for saturday

[52]:
```
n = 50
x = saturday['hour'].values
y = saturday['saturday'].values

x = x.reshape(-1, 1)
y = y.reshape(-1, 1)

plt.scatter(x, y)
```

[52]:
```
<matplotlib.collections.PathCollection at 0x7f580ffeead0>
```

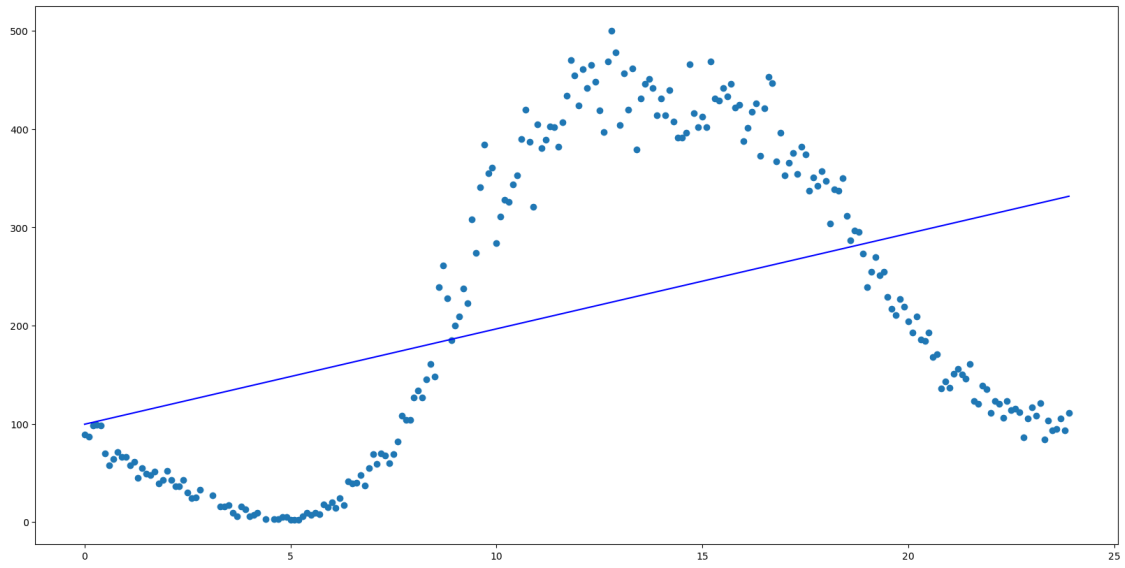


[54]:
```
linear = linear_model.LinearRegression()
linear.fit(x, y)
linear.coef_, linear.intercept_
```

[54]:
```
(array([[9.71309939]]), array([99.50083162]))
```

[56]:
```
plt.scatter(x, y)
plt.plot(x, linear.predict(x), c='b')
```

[56]:
```
[<matplotlib.lines.Line2D at 0x7f5810048f10>]
```



[58]:
```
from sklearn.preprocessing import PolynomialFeatures
poly5 = PolynomialFeatures(degree=5)
poly15 = PolynomialFeatures(degree=15)
poly20 = PolynomialFeatures(degree=20)
x_5 = poly5.fit_transform(x)
x_15 = poly15.fit_transform(x)
x_20 = poly20.fit_transform(x)
```

[60]:
```
x_5
```

[60]:
```
array([[1.00000000e+00, 0.00000000e+00, 0.00000000e+00, 0.00000000e+00,
        0.00000000e+00, 0.00000000e+00],
       [1.00000000e+00, 1.00000000e-01, 1.00000000e-02, 1.00000000e-03,
        1.00000000e-04, 1.00000000e-05],
       [1.00000000e+00, 2.00000000e-01, 4.00000000e-02, 8.00000000e-03,
        1.60000000e-03, 3.20000000e-04],
       …,
       [1.00000000e+00, 2.37000000e+01, 5.61690000e+02, 1.33120530e+04,
        3.15495656e+05, 7.47724705e+06],
       [1.00000000e+00, 2.38000000e+01, 5.66440000e+02, 1.34812720e+04,
        3.20854274e+05, 7.63633171e+06],
       [1.00000000e+00, 2.39000000e+01, 5.71210000e+02, 1.36519190e+04,
        3.26280864e+05, 7.79811265e+06]])
```

[62]:
```
x_15
```

[62]:
```
array([[1.00000000e+00, 0.00000000e+00, 0.00000000e+00, …,
        0.00000000e+00, 0.00000000e+00, 0.00000000e+00],
```

```
        [1.00000000e+00, 1.00000000e-01, 1.00000000e-02, …,
         1.00000000e-13, 1.00000000e-14, 1.00000000e-15],
        [1.00000000e+00, 2.00000000e-01, 4.00000000e-02, …,
         8.19200000e-10, 1.63840000e-10, 3.27680000e-11],
        …,
        [1.00000000e+00, 2.37000000e+01, 5.61690000e+02, …,
         7.44266546e+17, 1.76391171e+19, 4.18047076e+20],
        [1.00000000e+00, 2.38000000e+01, 5.66440000e+02, …,
         7.86140991e+17, 1.87101556e+19, 4.45301703e+20],
        [1.00000000e+00, 2.39000000e+01, 5.71210000e+02, …,
         8.30180852e+17, 1.98413224e+19, 4.74207605e+20]])
```

[64]:
```
x_20
```

[64]:
```
array([[1.00000000e+00, 0.00000000e+00, 0.00000000e+00, …,
        0.00000000e+00, 0.00000000e+00, 0.00000000e+00],
       [1.00000000e+00, 1.00000000e-01, 1.00000000e-02, …,
        1.00000000e-18, 1.00000000e-19, 1.00000000e-20],
       [1.00000000e+00, 2.00000000e-01, 4.00000000e-02, …,
        2.62144000e-13, 5.24288000e-14, 1.04857600e-14],
       …,
       [1.00000000e+00, 2.37000000e+01, 5.61690000e+02, …,
        5.56506483e+24, 1.31892037e+26, 3.12584127e+27],
       [1.00000000e+00, 2.38000000e+01, 5.66440000e+02, …,
        6.00323338e+24, 1.42876954e+26, 3.40047151e+27],
       [1.00000000e+00, 2.39000000e+01, 5.71210000e+02, …,
        6.47384381e+24, 1.54724867e+26, 3.69792432e+27]])
```

[66]:
```
linear5 = linear_model.LinearRegression()
linear5.fit(x_5, y)
(linear5.coef_, linear.intercept_)
```

[66]:
```
(array([[ 0.00000000e+00, -8.05769578e+01,  9.76092944e+00,
          6.67872455e-01, -8.92147403e-02,  2.09670715e-03]]),
 array([99.50083162]))
```

[68]:
```
linear15 = linear_model.LinearRegression()
linear15.fit(x_15, y)
(linear15.coef_, linear.intercept_)
```

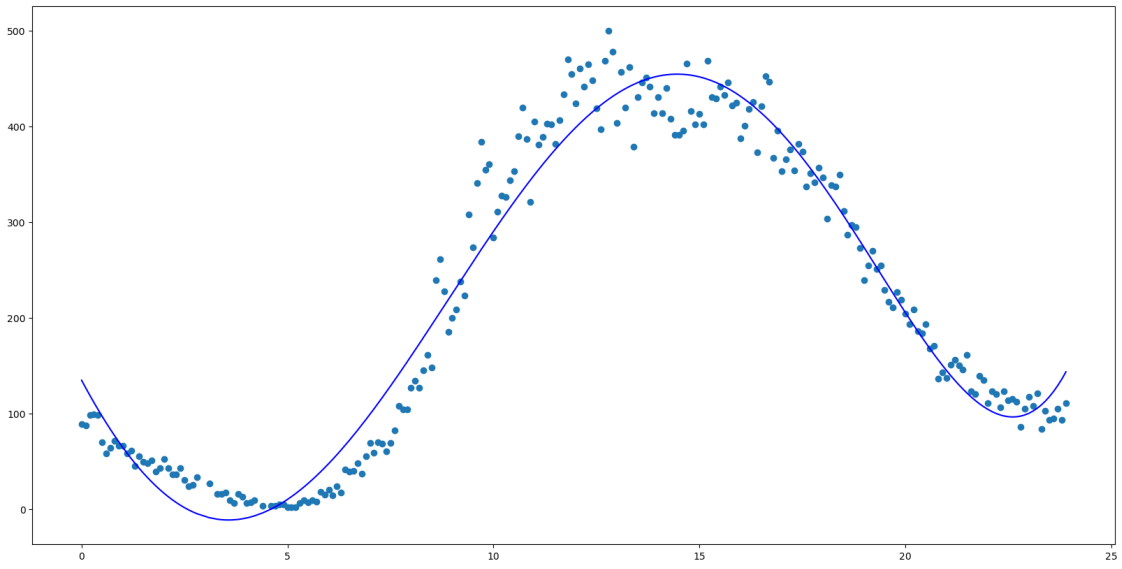
[68]:
```
(array([[ 0.00000000e+00, -3.66796019e-07,  6.79559243e-09,
          4.81330912e-08,  3.05804184e-07,  1.70896551e-06,
          7.98580500e-06,  2.79745560e-05,  5.48677912e-05,
         -8.57328067e-06, -4.64495197e-07,  1.86313163e-07,
         -1.66660632e-08,  7.17598818e-10, -1.55068939e-11,
          1.35291916e-13]]),
 array([99.50083162]))
```

[70]:
```
linear20 = linear_model.LinearRegression()
linear20.fit(x_20, y)
(linear20.coef_, linear.intercept_)
```

[70]:
```
(array([[ 0.00000000e+00,  1.43767566e-13,  1.51224794e-16,
          2.06434812e-19,  4.72830554e-20,  5.51872018e-19,
          6.03935240e-18,  6.32192726e-17,  6.27354222e-16,
          5.81887065e-15,  4.93821049e-14,  3.70915637e-13,
          2.33100911e-12,  1.09769775e-11,  2.88002864e-11,
         -8.88446800e-12,  1.09166592e-12, -7.06632697e-14,
          2.55717452e-15, -4.91511185e-17,  3.92342017e-19]]),
 array([99.50083162]))
```

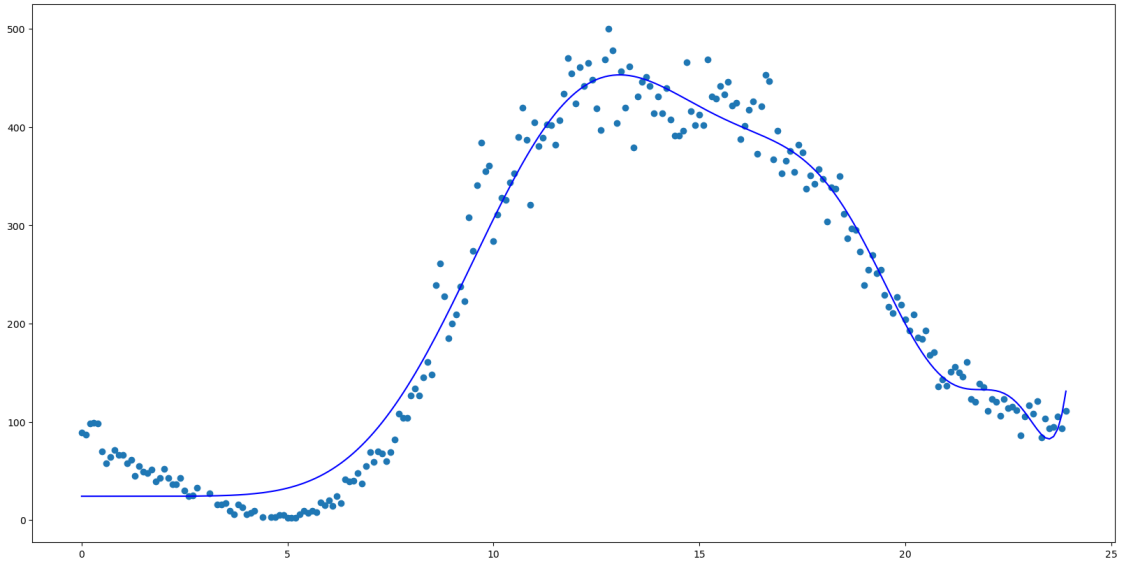
[72]:
```
plt.scatter(x, y)
plt.plot(x, linear5.predict(x_5), c='b')
```

[72]:
```
[<matplotlib.lines.Line2D at 0x7f580fec0850>]
```



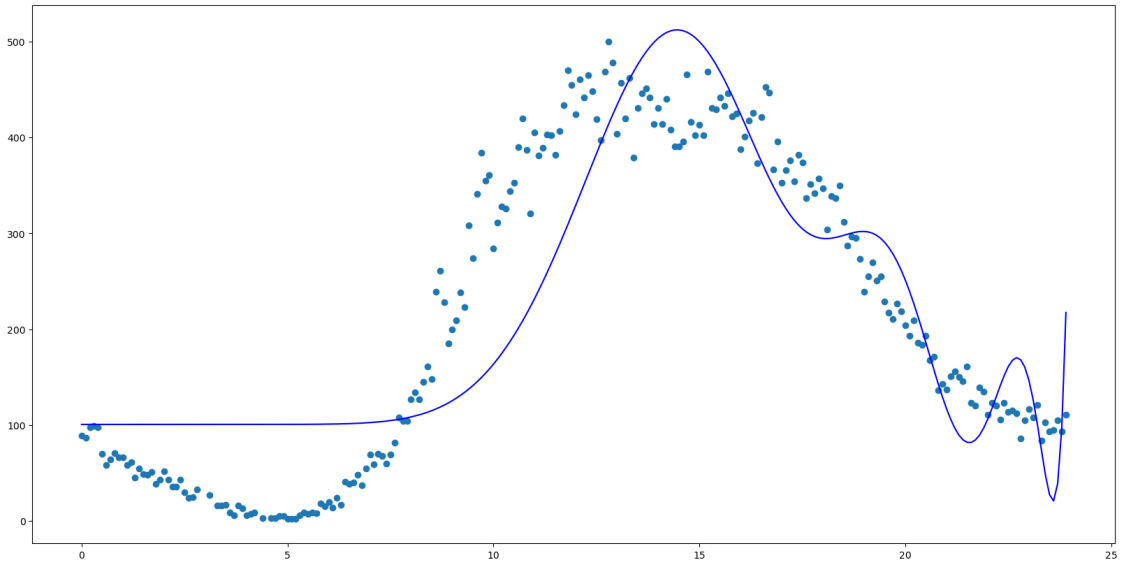
[74]:
```
plt.scatter(x, y)
plt.plot(x, linear15.predict(x_15), c='b')
```

[74]:
```
[<matplotlib.lines.Line2D at 0x7f580fec76d0>]
```



[76]:
```
plt.scatter(x, y)
plt.plot(x, linear20.predict(x_20), c='b')
```

[76]: [<matplotlib.lines.Line2D at 0x7f580ff91090>]



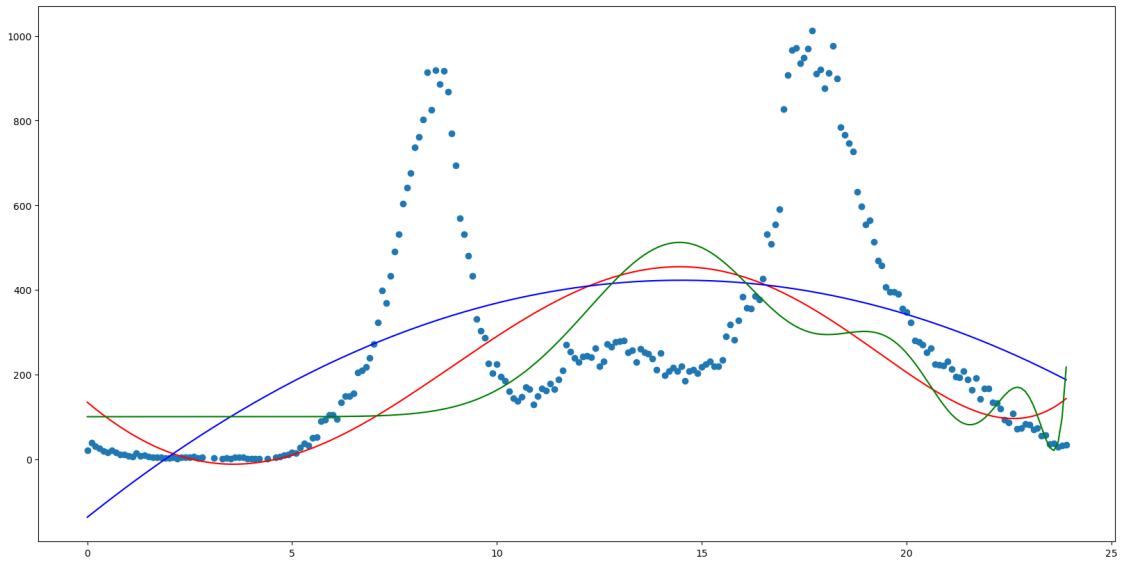
2.4 3. Using the best monday model's prediction, determine the errors (MSE, MAE, MAPE) between the prediction with the monday and tuesday datasets

2.5 Repeat for saturday/sunday

[115]:
```
#Monday/Tuesday
n = 50
x = monday['hour'].values
y = monday['monday'].values

x = x.reshape(-1, 1)
y = y.reshape(-1, 1)
```

[123]:
```
x_15 = PolynomialFeatures(degree=2).fit_transform(x)

linear15 = linear_model.LinearRegression().fit(x_15[:-4], y[:-4])

plt.scatter(x,y)
plt.plot(x, linear5.predict(x_5), c='r')
plt.plot(x, linear15.predict(x_15), c='b')
plt.plot(x, linear20.predict(x_20), c='g')
```

[123]:
```
[<matplotlib.lines.Line2D at 0x7f580484f890>]
```



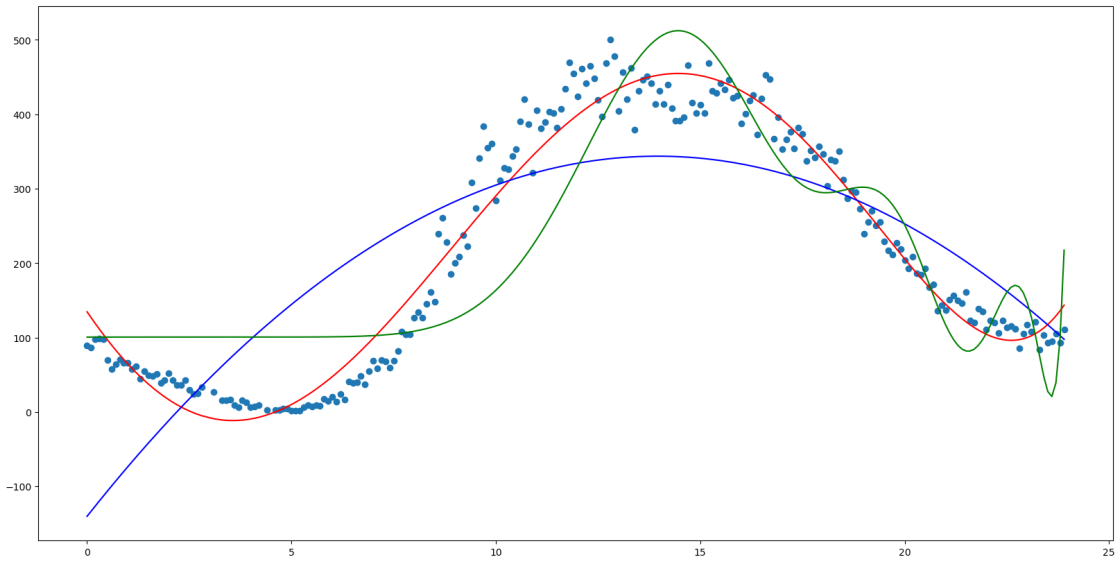
[129]:
```
(
metrics.mean_squared_error(y[-4:], linear15.predict(x_15[-4:])),
metrics.mean_absolute_error(y[-4:], linear15.predict(x_15[-4:])),
metrics.mean_absolute_percentage_error(y[-4:], linear15.predict(x_15[-4:]))
)
```

[129]: (26206.23449528423, 161.7930010693937, 4.8599698925415495)

[131]:
```
#Saturday/Sunday
n = 50
x = saturday['hour'].values
y = saturday['saturday'].values

x = x.reshape(-1, 1)
y = y.reshape(-1, 1)
```

[133]:
```
x_15 = PolynomialFeatures(degree=2).fit_transform(x)

linear15 = linear_model.LinearRegression().fit(x_15[:-4], y[:-4])

plt.scatter(x,y)
plt.plot(x, linear5.predict(x_5), c='r')
plt.plot(x, linear15.predict(x_15), c='b')
plt.plot(x, linear20.predict(x_20), c='g')
```

[133]: [<matplotlib.lines.Line2D at 0x7f5804701b90>]



[135]:
```
(
metrics.mean_squared_error(y[-4:], linear15.predict(x_15[-4:])),
metrics.mean_absolute_error(y[-4:], linear15.predict(x_15[-4:])),
metrics.mean_absolute_percentage_error(y[-4:], linear15.predict(x_15[-4:]))
)
```

[135]: (143.791777798967, 10.677904122674434, 0.10727283880319574)

2.6 4. With saturday, use train_test_split to create training and test sets and build a model. Create predictions using the xtest from and determine the errors between these predictions and the ytest (MSE, MAE, MAPE).

2.7 repeat for monday

[ ]:
```
#saturday
```

[ ]:
```
n = 50
x = saturday['hour'].values
y = saturday['saturday'].values

x = x.reshape(-1, 1)
y = y.reshape(-1, 1)
```

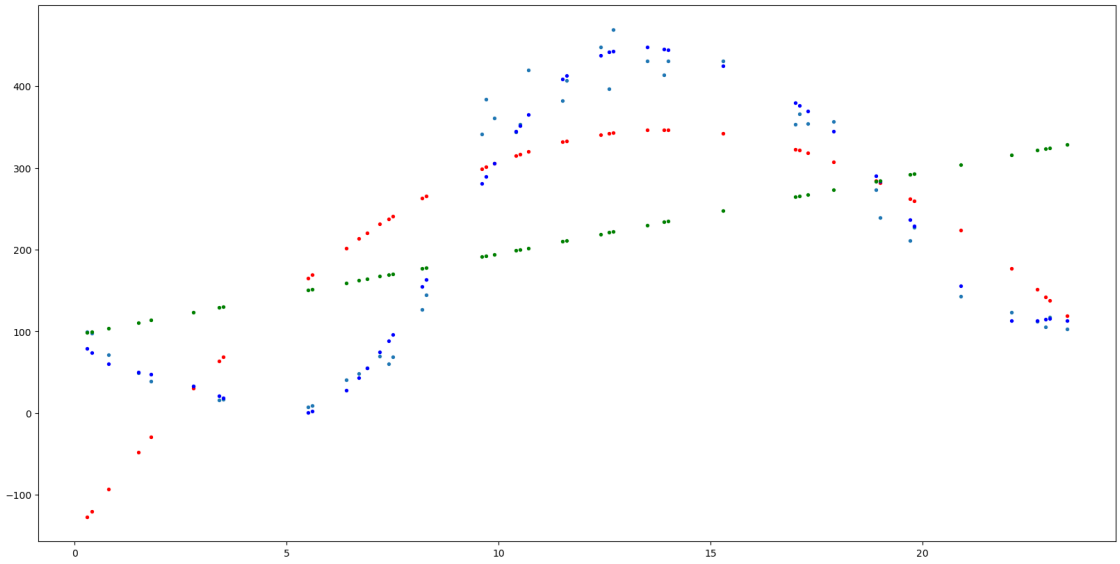
[79]:
```
from sklearn.model_selection import train_test_split
xtrain, xtest, ytrain, ytest = train_test_split(x, y, test_size=0.2)
linear = linear_model.LinearRegression().fit(xtrain, ytrain)
```

[81]:
```
xtrain2 = PolynomialFeatures(degree=2).fit_transform(xtrain)
xtest2 = PolynomialFeatures(degree=2).fit_transform(xtest)
linear2 = linear_model.LinearRegression().fit(xtrain2, ytrain)
```

[83]:
```
xtrain10 = PolynomialFeatures(degree=10).fit_transform(xtrain)
xtest10 = PolynomialFeatures(degree=10).fit_transform(xtest)
linear10 = linear_model.LinearRegression().fit(xtrain10, ytrain)
```

[85]:
```
size = 8
plt.scatter(xtest, ytest, s=size)
plt.scatter(xtest, linear2.predict(xtest2), c='r', s=size)
plt.scatter(xtest, linear10.predict(xtest10), c='b', s=size)
plt.scatter(xtest, linear.predict(xtest), c='g', s=size)
```

[85]:
```
<matplotlib.collections.PathCollection at 0x7f580fe2ed90>
```



[87]:
```
(
    metrics.mean_squared_error(ytest, linear10.predict(xtest10)),
    metrics.mean_squared_error(ytest, linear.predict(xtest)),
    metrics.mean_squared_error(ytest, linear2.predict(xtest2))
)
```

[87]: (692.5094610244397, 21045.925798888376, 10869.769569838238)

[89]:
```
(
    metrics.mean_absolute_error(ytest, linear10.predict(xtest10)),
    metrics.mean_absolute_error(ytest, linear.predict(xtest)),
    metrics.mean_absolute_error(ytest, linear2.predict(xtest2))
)
```

[89]: (18.227693916345075, 129.48977407286762, 86.87040806879763)

[91]:
```
(
    metrics.mean_absolute_percentage_error(ytest, linear10.predict(xtest10)),
    metrics.mean_absolute_percentage_error(ytest, linear.predict(xtest)),
    metrics.mean_absolute_percentage_error(ytest, linear2.predict(xtest2))
)
```

[91]: (0.1400449263054141, 1.8826382219879725, 1.7634853077925974)

[ ]:
```
#monday
```

[93]:
```
n = 50
x = monday['hour'].values
```

```
y = monday['monday'].values

x = x.reshape(-1, 1)
y = y.reshape(-1, 1)
```

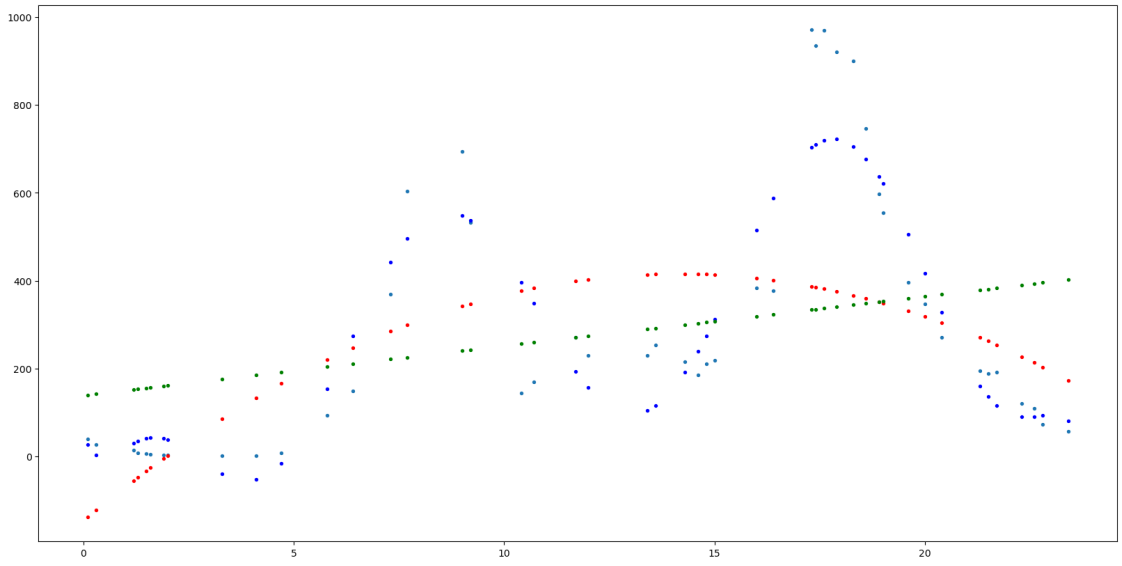
[95]:
```
from sklearn.model_selection import train_test_split
xtrain, xtest, ytrain, ytest = train_test_split(x, y, test_size=0.2)
linear = linear_model.LinearRegression().fit(xtrain, ytrain)
```

[97]:
```
xtrain2 = PolynomialFeatures(degree=2).fit_transform(xtrain)
xtest2 = PolynomialFeatures(degree=2).fit_transform(xtest)
linear2 = linear_model.LinearRegression().fit(xtrain2, ytrain)
```

[99]:
```
xtrain10 = PolynomialFeatures(degree=10).fit_transform(xtrain)
xtest10 = PolynomialFeatures(degree=10).fit_transform(xtest)
linear10 = linear_model.LinearRegression().fit(xtrain10, ytrain)
```

[101]:
```
size = 8
plt.scatter(xtest, ytest, s=size)
plt.scatter(xtest, linear2.predict(xtest2), c='r', s=size)
plt.scatter(xtest, linear10.predict(xtest10), c='b', s=size)
plt.scatter(xtest, linear.predict(xtest), c='g', s=size)
```

[101]:
```
<matplotlib.collections.PathCollection at 0x7f580fcad7d0>
```



[103]:
```
(
    metrics.mean_squared_error(ytest, linear10.predict(xtest10)),
    metrics.mean_squared_error(ytest, linear.predict(xtest)),
```

```
    metrics.mean_squared_error(ytest, linear2.predict(xtest2))
)
```

[103]: (12667.695863339188, 71674.32047968346, 56902.37770088219)

[105]:
```
(
    metrics.mean_absolute_error(ytest, linear10.predict(xtest10)),
    metrics.mean_absolute_error(ytest, linear.predict(xtest)),
    metrics.mean_absolute_error(ytest, linear2.predict(xtest2))
)
```

[105]: (86.92027826488788, 207.34595309124168, 179.96316805400375)

[107]:
```
(
    metrics.mean_absolute_percentage_error(ytest, linear10.predict(xtest10)),
    metrics.mean_absolute_percentage_error(ytest, linear.predict(xtest)),
    metrics.mean_absolute_percentage_error(ytest, linear2.predict(xtest2))
)
```

[107]: (2.3284368298385423, 9.355058052383505, 4.128645899194121)