Homework 4

Load packages

In [1]:

```
# packages
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
%matplotlib inline
import scipy.stats as stats
# you may add more if you need
```

Data Relationships

Question: Load the `insurance.csv` dataset.

In [2]:

```
# load the insurance data
insurance = pd.read_csv("./insurance.csv")

print (insurance.shape)
insurance.head()
```

```
(1338, 7)
```

Out[2]:

	age	sex	bmi	children	smoker	region	charges
0	19	female	27.900	0	yes	southwest	16884.92400
1	18	male	33.770	1	no	southeast	1725.55230
2	28	male	33.000	3	no	southeast	4449.46200
3	33	male	22.705	0	no	northwest	21984.47061
4	32	male	28.880	0	no	northwest	3866.85520

Do younger people smoker less?

Question: Create a new dummy variable called `younger` which split the observations into 2 groups based on age. 1 for people with age <=25; 0 for others.

In [3]:

```
younger = (insurance["age"] <= 25).map({True:1,False:0})
younger
```

Out[3]:

```
0       1
1       1
2       0
3       0
4       0
5       0
6       0
7       0
8       0
9       0
10      1
11      0
12      1
13      0
14      0
15      1
16      0
17      1
18      0
19      0
20      0
21      0
22      1
23      0
24      0
25      0
26      0
27      0
28      1
29      0
       ..
1308    1
1309    0
1310    0
1311    0
1312    0
1313    1
1314    0
1315    1
1316    1
1317    1
1318    0
1319    0
1320    0
1321    0
1322    0
1323    0
1324    0
1325    0
1326    0
1327    0
```

```
1328    1
1329    0
1330    0
1331    1
1332    0
1333    0
1334    1
1335    1
1336    1
1337    0
Name: age, Length: 1338, dtype: int64
```

Question: For female and male person respectively, what's the percentage of smokers for younger and older persons? i.e., make a dataframe like this:

sex	younger	%smoker
F	1	
F	0	
M	1	
M	0	

In [4]:

```
g = pd.concat([insurance,pd.DataFrame({"younger":younger})],axis = 1).groupby(["sex","young

def st_smoker(x):
    return "{s}%".format(s = round(100 * x.value_counts()["yes"] / len(x),2))

a = g.aggregate({"smoker":st_smoker})
a.columns = a.columns.str.replace("smoker","%smoker")
a = a.reset_index()
a["sex"] = a["sex"].str.replace("female","F")
a["sex"] = a["sex"].str.replace("male","M")
a
```

Out[4]:

	sex	younger	%smoker
0	F	0	16.89%
1	F	1	19.05%
2	M	0	23.6%
3	M	1	23.27%

For younger people, the health charges of smokers and non-smokers differ or not?

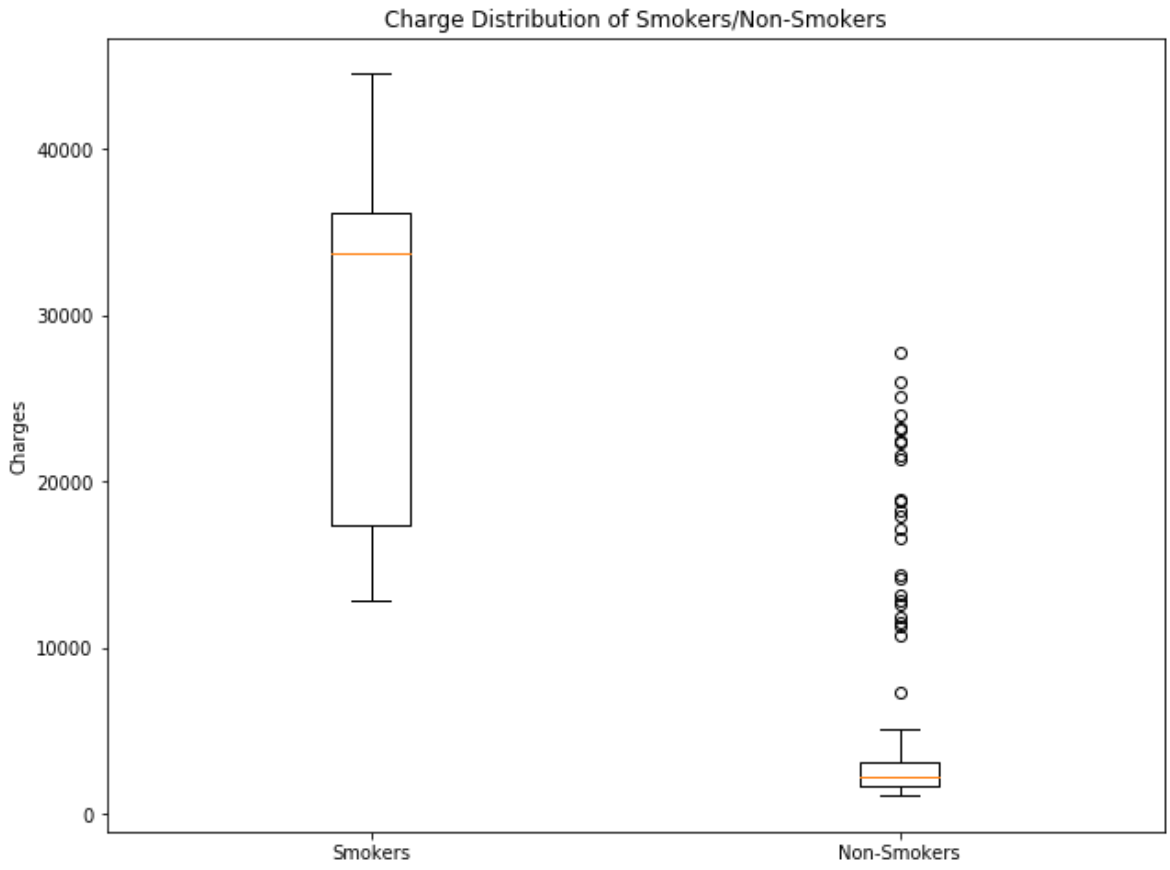
Question: Just for younger persons, make two boxplots in one plot to show the charges for smokers and non-smokers.

In [5]:

```
fig = plt.figure(figsize=(8, 6))
ax1 = fig.add_axes([0,0,1,1])
ax1.boxplot([insurance.loc[(younger == 1) & (insurance.smoker == "yes")]["charges"],
             insurance.loc[(younger == 1) & (insurance.smoker == "no")]["charges"]])
ax1.set_ylabel("Charges")
ax1.set_xticklabels(["Smokers","Non-Smokers"])
ax1.set_title("Charge Distribution of Smokers/Non-Smokers")
```

Out[5]:

Text(0.5,1,'Charge Distribution of Smokers/Non-Smokers')



age v.s. charges for non-smokers

Question: For non-smokers, make a scatterplot to show the correlation between `age` and `charges`, add a linear line to represent the relationship (hint: using `stats.linregress`)

In [6]:

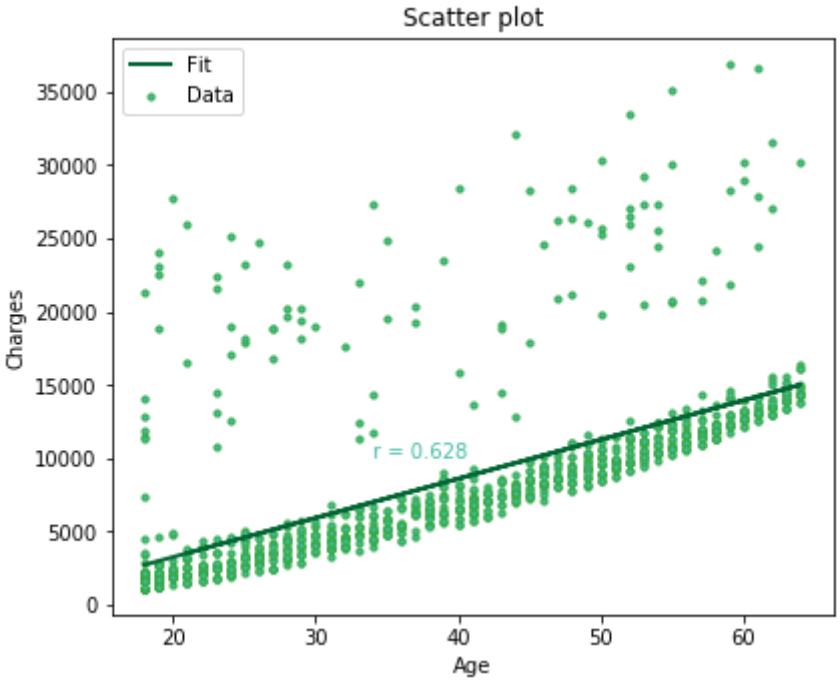
```
fig = plt.figure(figsize=(5, 4))
axes = fig.add_axes([0, 0, 1, 1])

x = insurance.loc[insurance.smoker == "no"]["age"]
y = insurance.loc[insurance.smoker == "no"]["charges"]
slope, intercept, r_value, _, _ = stats.linregress(x, y)
line = slope * x + intercept

axes.scatter(x, y, label='Data', edgecolors="#34AA43", color = "#45BEAA",s = 10)
axes.plot(x, line, linewidth = 2, color = "#016633", label='Fit')
axes.text(34, 10000, "r = " + str(round(r_value, 3)), color = "#45BEAA")
axes.legend(loc='upper left')
axes.set_xlabel('Age')
axes.set_ylabel('Charges')
axes.set_title('Scatter plot')
```

Out[6]:

Text(0.5, 1, 'Scatter plot')



Question: For smokers, make a scatterplot to show the correlation between `age` and `charges`, add a linear line to represent the relationship (hint: using `stats.linregress`)

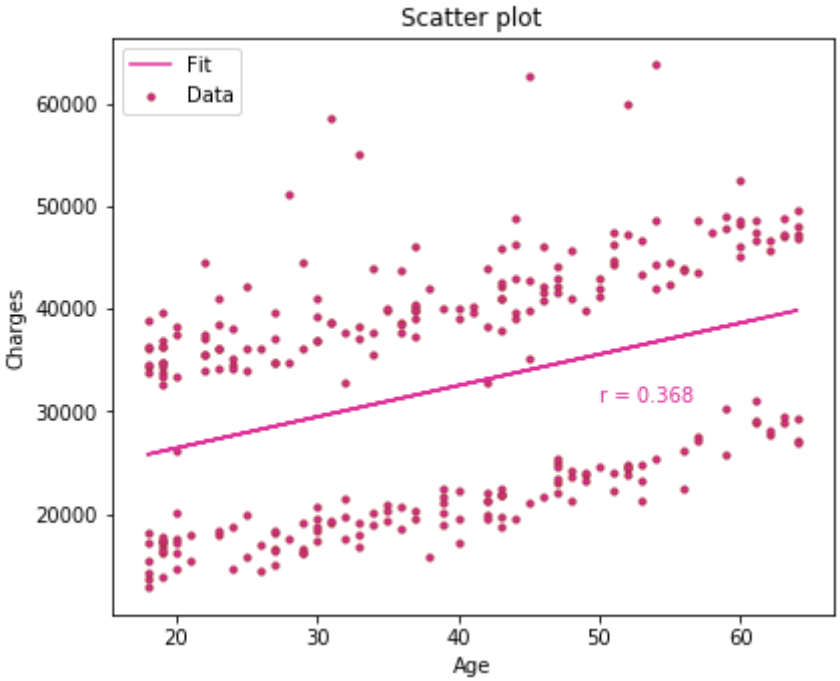
In [7]:

```
fig = plt.figure(figsize=(5, 4))
axes = fig.add_axes([0, 0, 1, 1])

x = insurance.loc[insurance.smoker == "yes"]["age"]
y = insurance.loc[insurance.smoker == "yes"]["charges"]
slope, intercept, r_value, _, _ = stats.linregress(x, y)
line = slope * x + intercept
axes.plot(x, line, linewidth=1.5, label='Fit',color = "#DD3399")
axes.scatter(x, y, label='Data', edgecolors="#AA3443", color = "#EB23AA",s = 10)
axes.text(50, 31000, "r = " + str(round(r_value, 3)), color = "#DD3399")
axes.legend(loc='upper left')
axes.set_xlabel('Age')
axes.set_ylabel('Charges')
axes.set_title('Scatter plot')
```

Out[7]:

Text(0.5,1,'Scatter plot')



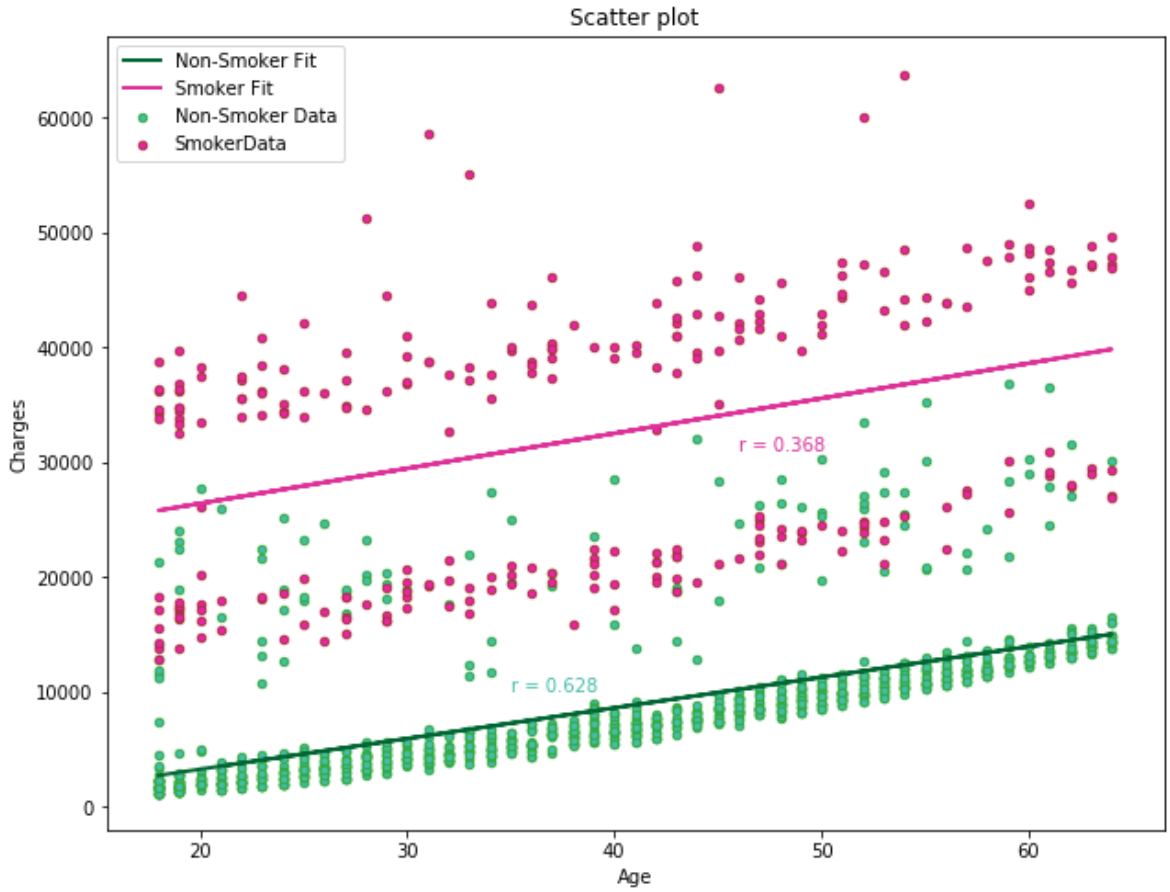
Question: Using different colors for smokers and non-smokers, make scatterplots to show the correlation between `age` and `charges`, add linear lines to represent the relationship respectively.

In [8]:

```
fig = plt.figure(figsize=(8, 6))
axes = fig.add_axes([0, 0, 1, 1])
x1 = insurance.loc[insurance.smoker == "no"]["age"]
y1 = insurance.loc[insurance.smoker == "no"]["charges"]
x2 = insurance.loc[insurance.smoker == "yes"]["age"]
y2 = insurance.loc[insurance.smoker == "yes"]["charges"]
slope1, intercept1, r_value1, _, _ = stats.linregress(x1, y1)
line1 = slope1 * x1 + intercept1
slope2, intercept2, r_value2, _, _ = stats.linregress(x2, y2)
line2 = slope2 * x2 + intercept2
axes.scatter(x1, y1, label='Non-Smoker Data', edgecolors="#34AA43", color = "#45BEAA",s = 2
axes.plot(x1, line1, linewidth = 2, color = "#016633", label = "Non-Smoker Fit")
axes.scatter(x2, y2, label='SmokerData', edgecolors="#AA3443", color = "#EB23AA",s = 20)
axes.plot(x2, line2, linewidth = 2, label = "Smoker Fit",color = "#DD3399")
axes.text(35, 10000, "r = " + str(round(r_value1, 3)), color = "#45BEAA")
axes.text(46, 31000, "r = " + str(round(r_value2, 3)), color = "#DD3399")
axes.legend(loc='upper left')
axes.set_xlabel('Age')
axes.set_ylabel('Charges')
axes.set_title('Scatter plot')
```

Out[8]:

Text(0.5,1,'Scatter plot')



Question: What you can conclude from the above analysis?

In [9]:

```
#Smokers have a tendency to expense far more money than non-smokers.
#The charge increases as the age increases.
#The smokers' charges are more fluctuated.
```

---

pandas groupby and merge

Question: Load the `state_population.csv` , `state_areas.csv` and the `state_abbrevs.csv` in the following three cells.

In [10]:

```
# load the state_population here
state_population = pd.read_csv("state_population.csv")

state_population.head()
```

Out[10]:

	state/region	ages	year	population
0	AL	under18	2012	1117489.0
1	AL	total	2012	4817528.0
2	AL	under18	2010	1130966.0
3	AL	total	2010	4785570.0
4	AL	under18	2011	1125763.0

In [11]:

```
# load the state_areas here
state_areas = pd.read_csv("state_areas.csv")

state_areas.head()
```

Out[11]:

	state	area (sq. mi)
0	Alabama	52423
1	Alaska	656425
2	Arizona	114006
3	Arkansas	53182
4	California	163707

In [12]:

```
# load the state_abbrevs here
state_abbrev = pd.read_csv("state_abbrevs.csv")

state_abbrev.head()
```

Out[12]:

	state	abbreviation
0	Alabama	AL
1	Alaska	AK
2	Arizona	AZ
3	Arkansas	AR
4	California	CA

Question: Rank US ***states with full name*** by their 2010 population density.

Note:

1. Here the population density is the total population devided by area.
2. You need to take care of missing values when merging data. In case of missing values, just drop them.
3. The total population is the population with `ages` equals to `total`.

In [13]:

```
df1 = pd.merge(state_abbrev,state_areas,left_on = "state",right_on = "state")
df1 = pd.merge(df1,state_population,left_on = "abbreviation",right_on = "state/region")
df1["population_density"] = df1["population"] / df1["area (sq. mi)"]
df2 = df1.loc[(df1.ages == "total") & (state_population.year == 2010)][["state","populatior
df2.columns = df2.columns.str.replace("population_density","2010_population_density")
df2 = df2.sort_values(by = "2010_population_density",ascending = False)
df2.reset_index(drop = True)
```

Out[13]:

	state	2010_population_density
0	District of Columbia	8898.897059
1	New Jersey	1009.253268
2	Rhode Island	681.339159
3	Connecticut	645.600649
4	Massachusetts	621.815538
5	Maryland	466.445797
6	Delaware	460.445752
7	New York	356.094135
8	Florida	286.597129
9	Pennsylvania	275.966651
10	Ohio	257.549634
11	California	228.051342
12	Illinois	221.687472
13	Virginia	187.622273
14	Indiana	178.197831
15	North Carolina	177.617157
16	Georgia	163.409902
17	Tennessee	150.825298
18	South Carolina	144.854594
19	New Hampshire	140.799273
20	Hawaii	124.746707
21	Kentucky	107.586994
22	Michigan	102.015794
23	Washington	94.557817
24	Texas	93.987655
25	Alabama	91.287603
26	Louisiana	87.676099
27	Wisconsin	86.851900
28	Missouri	86.015622

	state	2010_population_density
29	West Virginia	76.519582
30	Vermont	65.085075
31	Mississippi	61.321530
32	Minnesota	61.078373
33	Arizona	56.214497
34	Arkansas	54.948667
35	Iowa	54.202751
36	Oklahoma	53.778278
37	Colorado	48.493718
38	Oregon	39.001565
39	Maine	37.509990
40	Kansas	34.745266
41	Utah	32.677188
42	Nevada	24.448796
43	Nebraska	23.654153
44	Idaho	18.794338
45	New Mexico	16.982737
46	South Dakota	10.583512
47	North Dakota	9.537565
48	Montana	6.736171
49	Wyoming	5.768079
50	Alaska	1.087509

Question: Based on the above merged table, calculate the average and standard deviations of population density for each states.

In [28]:

```
df3 = df1.loc[df1.ages == "total"]
df3.columns = df3.columns.str.replace("population_density","population_density_total")
df4 = df1.loc[df1.ages == "under18"]
df4.columns = df4.columns.str.replace("population_density","population_density_under18")
df5 = pd.merge(df3.groupby("state").aggregate({"population_density_total":[np.mean,np.std]}
         df4.groupby("state").aggregate({"population_density_under18":[np.mean,np.std]}),
        left_on = "state",right_on = "state")
df5
```

Out[28]:

	population_density_total		population_density_under18	
	mean	std	mean	std
state				
Alabama	85.545045	4.486721	21.196746	0.428319
Alaska	0.984431	0.077983	0.284378	0.004783
Arizona	46.441414	8.385203	12.109489	1.921445
Arkansas	50.640774	3.535277	12.788206	0.503227
California	209.729195	15.818095	55.489504	2.386844
Colorado	41.876976	5.717944	10.530384	1.108403
Connecticut	620.653454	19.639446	147.182825	4.986739
Delaware	410.937777	41.135916	98.704090	6.433301
District of Columbia	8633.371936	326.750704	1650.549020	100.300087
Florida	250.867464	31.573966	55.806337	5.319649
Georgia	140.920964	18.821500	36.916585	4.339109
Hawaii	114.886930	7.601503	27.470179	0.673177
Idaho	15.995962	2.261960	4.527766	0.452179
Illinois	213.591570	7.520677	54.294150	1.527044
Indiana	168.100295	8.537198	42.683893	1.526957
Iowa	52.205844	1.577351	12.894327	0.072796
Kansas	32.837619	1.487910	8.570441	0.205481
Kentucky	100.871657	5.421288	24.658394	0.538272
Louisiana	85.661046	2.179238	22.803814	1.114799
Maine	36.366939	1.071710	8.320952	0.442807
Maryland	434.173551	27.844340	107.053575	4.566635
Massachusetts	600.473899	19.232888	136.842436	4.206235
Michigan	101.504344	2.227849	25.707900	1.129610
Minnesota	56.966751	3.650695	14.540441	0.372595
Mississippi	58.425931	2.658533	15.665941	0.248247
Missouri	80.900599	4.182787	20.157587	0.472174

	population_density_total		population_density_under18	
	mean	std	mean	std
state				
Montana	6.229075	0.420720	1.545438	0.035660
Nebraska	22.322478	1.078849	5.804968	0.110176
Nevada	18.964557	4.773182	4.736527	1.138033
New Hampshire	132.460971	8.361290	31.712058	1.378807
New Jersey	965.454149	41.076515	233.136384	9.914328
New Mexico	15.205630	1.416905	4.125599	0.137269
New York	347.421846	8.449770	82.603704	2.881882
North Carolina	153.856481	18.851882	37.173959	4.242560
North Dakota	9.249240	0.307584	2.254393	0.137986
Ohio	253.019954	4.520812	62.821864	1.667378
Oklahoma	49.924540	2.961290	12.791580	0.382758
Oregon	35.189296	3.281423	8.453505	0.382446
Pennsylvania	268.565664	5.493992	62.137599	1.478207
Rhode Island	674.655852	14.028931	152.581769	6.855788
South Carolina	128.769307	12.440464	31.802008	1.536369
South Dakota	9.925185	0.525973	2.627246	0.050755
Tennessee	136.682968	11.777783	33.162597	2.097976
Texas	80.439992	10.818130	22.445521	2.482439
Utah	27.337324	4.198260	8.844919	1.000464
Vermont	63.048596	2.130267	14.655374	0.948759
Virginia	169.475551	14.824785	40.684314	2.515829
Washington	84.184271	8.580093	20.937127	1.174463
West Virginia	75.251790	0.788185	16.710691	0.790687
Wisconsin	82.409353	3.905823	20.524166	0.296021
Wyoming	5.217118	0.388820	1.351950	0.051537

The end