ACME INSURANCE

Exploratory Data Analysis

In [1]:
```
import pandas as pd
```

In [2]:
```
df = pd.read_csv('insurance.csv')
```

In [3]:
```
df
```

Out[3]:

	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
...	...	...	...	...	...	...	...
1333	50	male	30.970	3	no	northwest	10600.54830
1334	18	female	31.920	0	no	northeast	2205.98080
1335	18	female	36.850	0	no	southeast	1629.83350
1336	21	female	25.800	0	no	southwest	2007.94500
1337	61	female	29.070	0	yes	northwest	29141.36030

1338 rows × 7 columns

In [4]:
```
df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 1338 entries, 0 to 1337
Data columns (total 7 columns):
 #   Column    Non-Null Count  Dtype  
---  ------    --------------  -----  
 0   age       1338 non-null   int64  
 1   sex       1338 non-null   object 
 2   bmi       1338 non-null   float64
 3   children  1338 non-null   int64  
 4   smoker    1338 non-null   object 
 5   region    1338 non-null   object 
 6   charges   1338 non-null   float64
dtypes: float64(2), int64(2), object(3)
memory usage: 73.3+ KB
```

In [5]:
```
df.describe()
```

Out[5]:

	age	bmi	children	charges
count	1338.000000	1338.000000	1338.000000	1338.000000
mean	39.207025	30.663397	1.094918	13270.422265
std	14.049960	6.098187	1.205493	12110.011237
min	18.000000	15.960000	0.000000	1121.873900
25%	27.000000	26.296250	0.000000	4740.287150
50%	39.000000	30.400000	1.000000	9382.033000
75%	51.000000	34.693750	2.000000	16639.912515
max	64.000000	53.130000	5.000000	63770.428010

Exploratory Analysis and Visualization

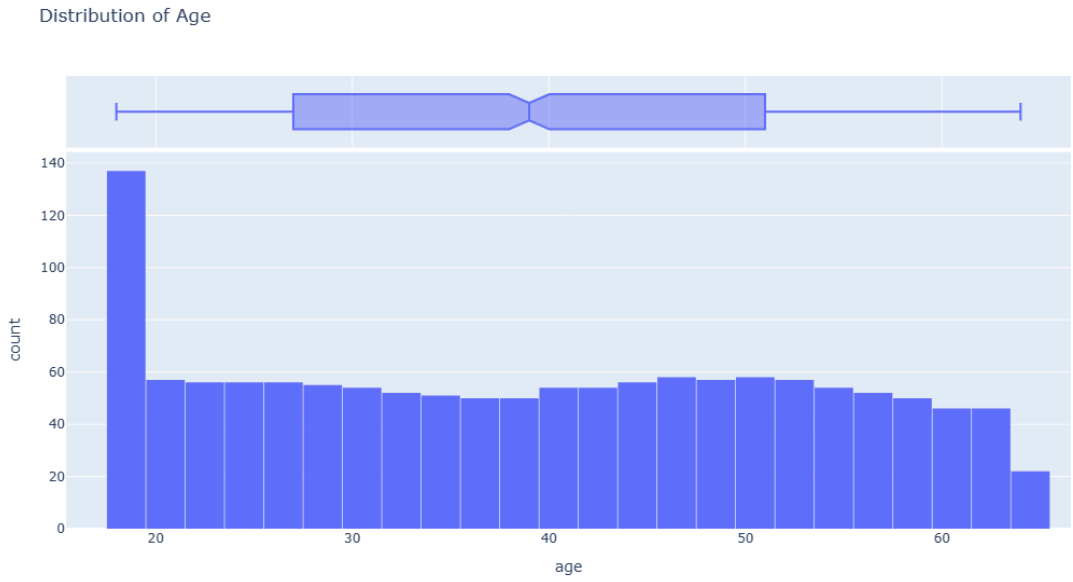
In [6]:
```
import plotly.express as px
import matplotlib as ml
import matplotlib.pyplot as plt
import seaborn as sns
%matplotlib inline
#shows chart in this notebook only
```

In [7]:
```
sns.set_style('whitegrid')
ml.rcParams['font.size'] = 14 #rcParams is a dictionary that controls default se
ml.rcParams['figure.figsize'] = (10,6)
ml.rcParams['figure.facecolor'] = 'white'
```

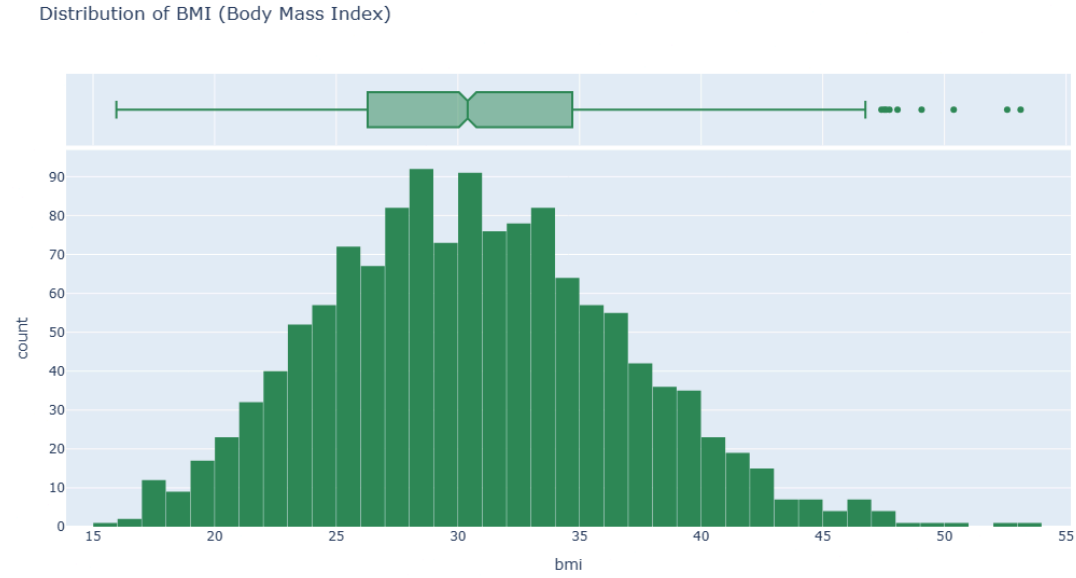
In [8]:
```
df.age.describe()
```

Out[8]:
```
count    1338.000000
mean       39.207025
std        14.049960
min        18.000000
25%        27.000000
50%        39.000000
75%        51.000000
max        64.000000
Name: age, dtype: float64
```

In [9]:
```
figure = px.histogram(df,
                      x = 'age',
                      marginal = 'box' ,
                      nbins=40,
                       title = 'Distribution of Age')
figure.update_layout(
                       bargap = 0.02,
                       width = 1000,
                       height = 600)
figure.show()
figure.write_html("age_distribution.html")
```



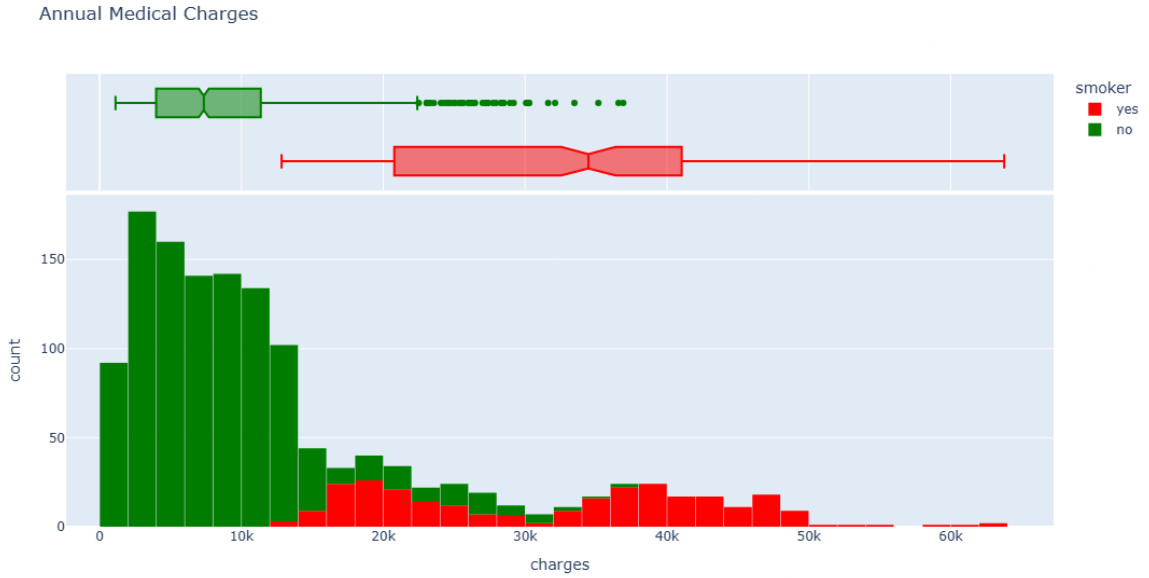
In [10]:
```
fig = px.histogram(df,
                   x = 'bmi' ,
                   marginal = 'box',
                   color_discrete_sequence = ['seagreen'],
                   title = 'Distribution of BMI (Body Mass Index)'
                   )
fig.update_layout(
                  bargap=0.02,
                  width = 1000,
                  height = 600)
fig.show()
fig.write_html("bmi_distribution.html")
```



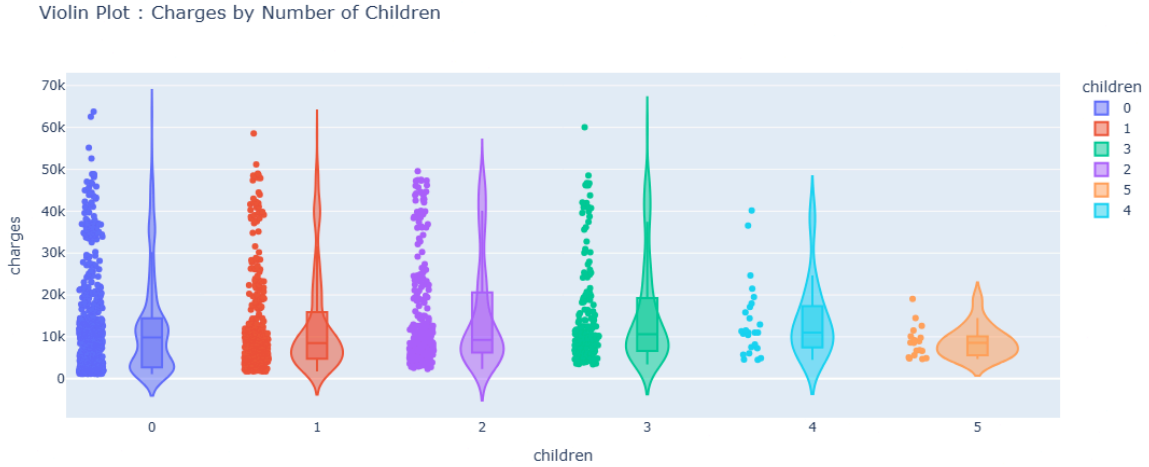
Charges

In [11]:
```
fig = px.histogram(df,
                   x = 'charges',
                   marginal = 'box',
                   color = 'smoker',
```

```
                  color_discrete_sequence = ['red', 'green'],
                  title = 'Annual Medical Charges')
fig.update_layout(
                 bargap=0.02,
                 width = 1000,
                 height = 600)
fig.show()
fig.write_html("Annual_medical_charges.html")
```

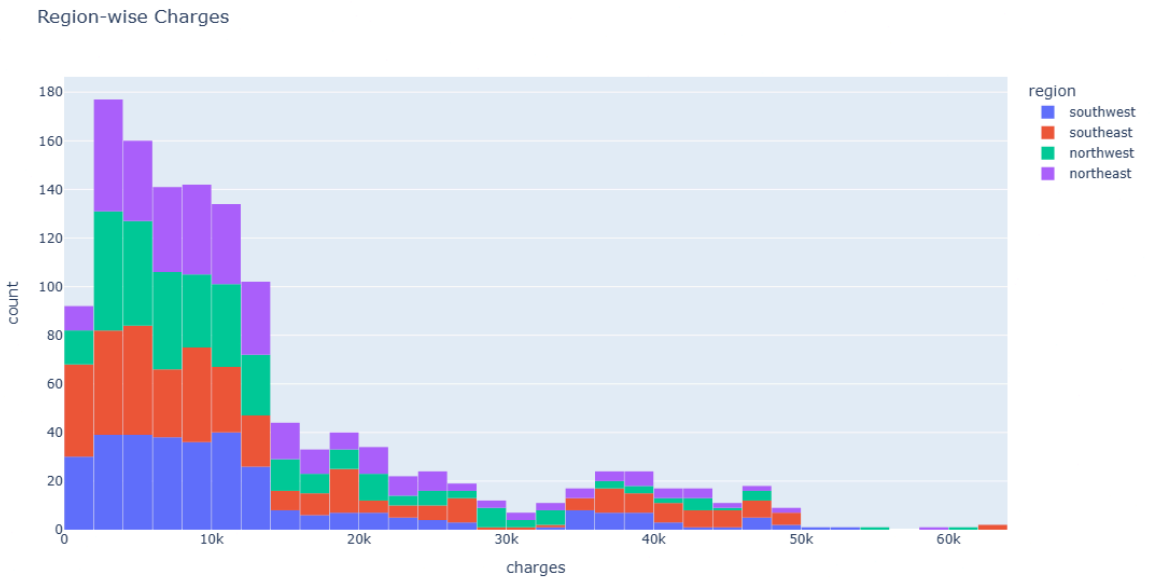


In [12]:
```
fig = px.violin(df,
                x = 'children',
                y = 'charges',
                box = True,
                points ='all',
                color = 'children',
                title = 'Violin Plot : Charges by Number of Children')

fig.update_layout(width = 900, height = 500)
fig.show()
fig.write_html("Violin_Plot.html")
```



In [13]:
```
fig = px.histogram(df,
                   x = 'charges',
```

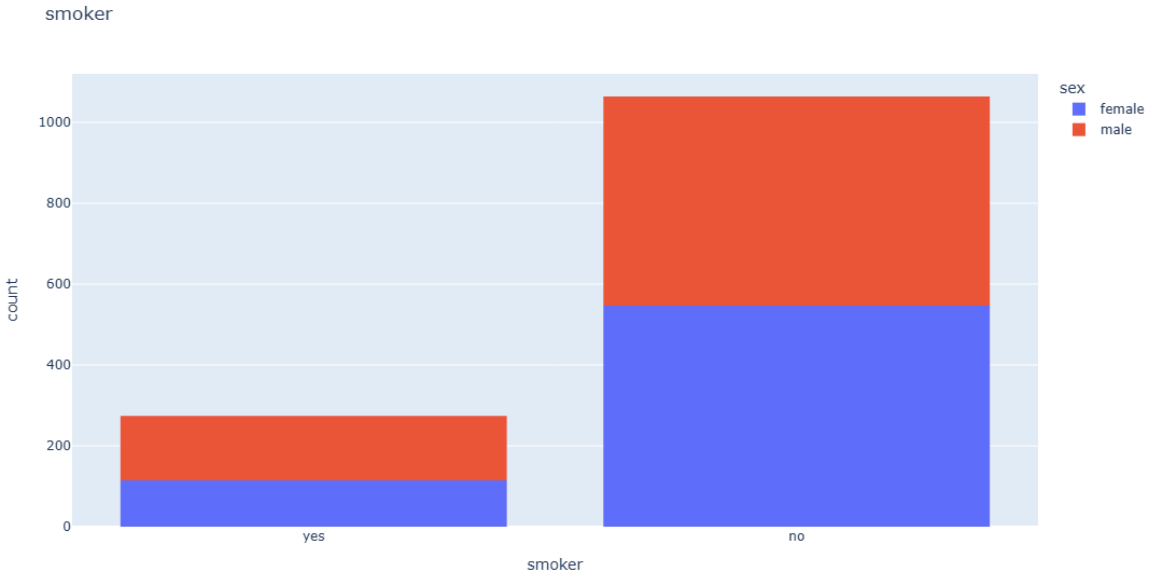
```
                  color = 'region',
                  title = 'Region-wise Charges')
fig.update_layout(
                 bargap = 0.02,
                 width = 1000,
                 height = 600
                    )
fig.show()
fig.write_html("Region_wise_charges.html")
```



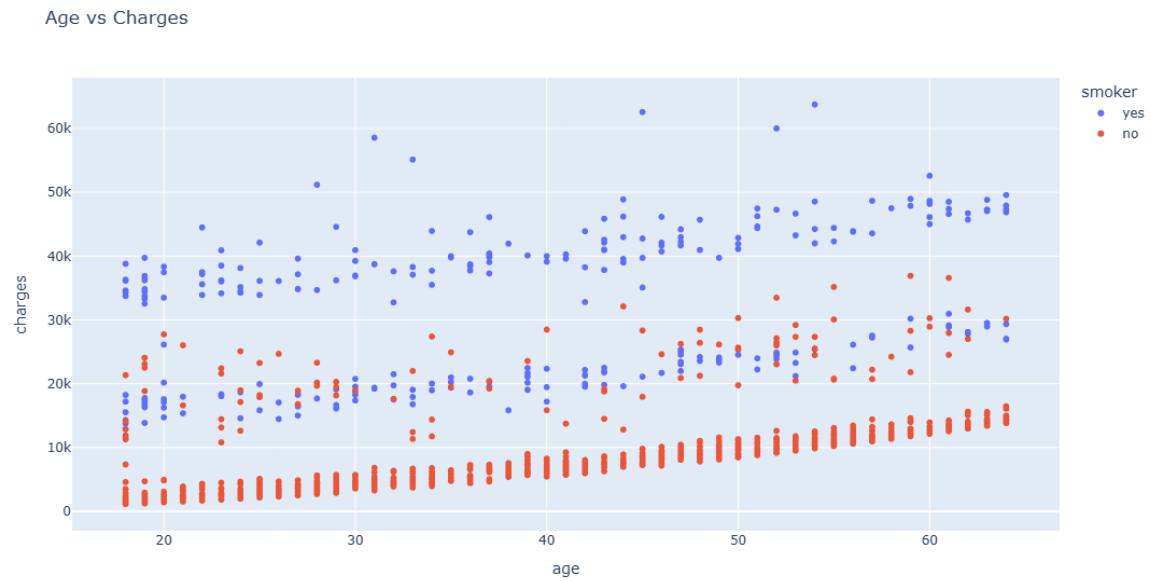
In [14]:
```
df.smoker.value_counts()
```

Out[14]:
```
smoker
no     1064
yes     274
Name: count, dtype: int64
```

In [17]:
```
fig = px.histogram(df, x='smoker', color = 'sex', title = 'smoker')
fig.update_layout(
                 width = 600,
                 height = 600,
                    )
fig.show()
fig.write_html("smoker.html")
```



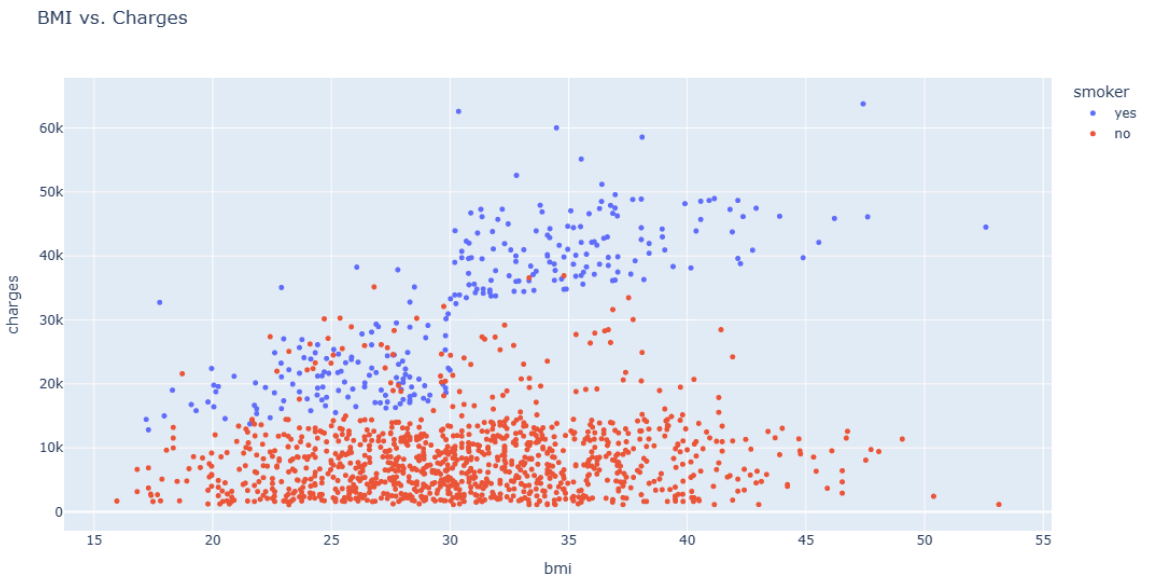
In [18]:
```
fig = px.scatter(df,
                 x = 'age',
                 y = 'charges',
                 color = 'smoker',
                 hover_data = ['sex'],
                 title = 'Age vs Charges')
fig.update_layout( width = 900,
                  height = 600)
fig.show()
fig.write_html("Age_vs_Charges.html")
```



BMI & Charges

In [19]:
```
fig = px.scatter(df,
                 x = 'bmi',
                  y = 'charges',
                 color = 'smoker',
                 hover_data = ['sex','age'],
                 title = 'BMI vs. Charges')
```

```
fig.update_traces(marker_size=5)
fig.update_layout( width = 900,
                   height = 600)
fig.show()
fig.write_html("BMI_vs_Charges.html")
```



Correlation

In [20]:
```
df.charges.corr(df.age)
```

Out[20]:
```
np.float64(0.2990081933306478)
```

In [21]:
```
df.charges.corr(df.bmi)
```

Out[21]:
```
np.float64(0.19834096883362887)
```

Encoding

In [22]:
```
smoker_values = {'no': 0, 'yes': 1}
smoker_numeric = df.smoker.map(smoker_values)
df.charges.corr(smoker_numeric)
```

Out[22]:
```
np.float64(0.7872514304984778)
```

In [23]:
```
sex_values = {'male': 0, 'female': 1}
sex_numeric = df.sex.map(sex_values)
df.charges.corr(sex_numeric)
```

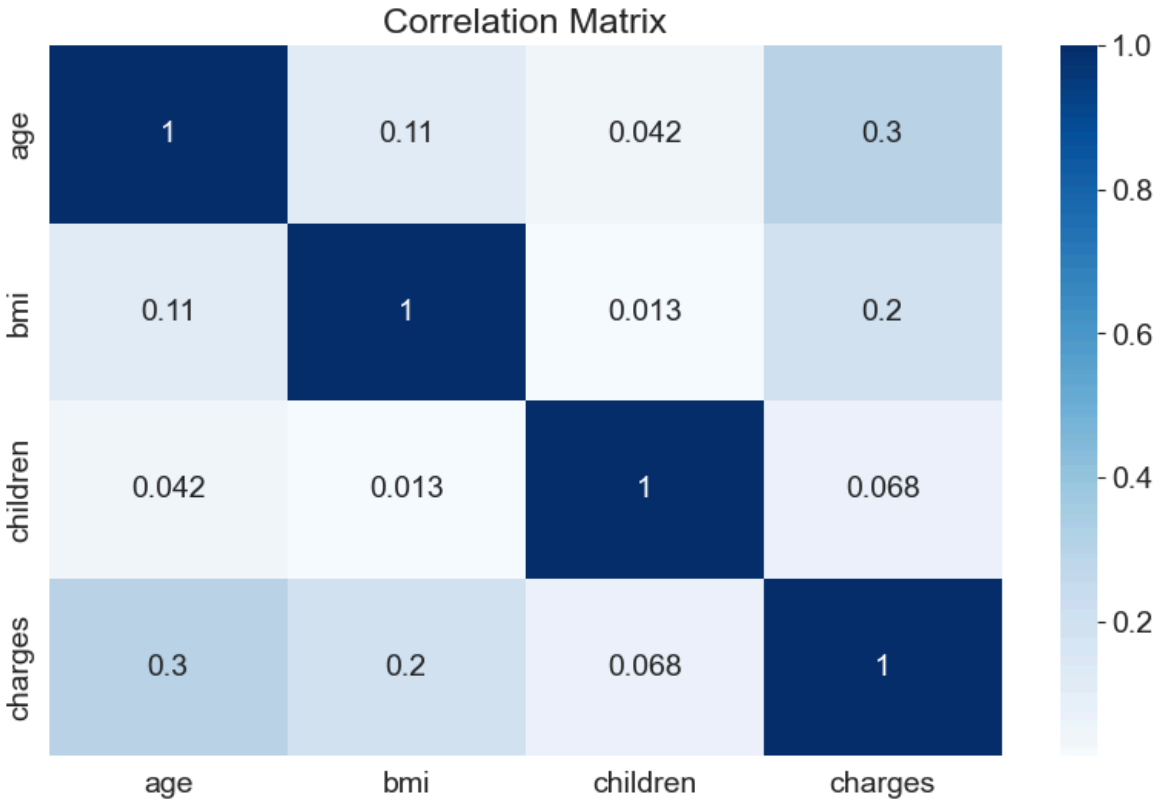
Out[23]:
```
np.float64(-0.05729206220202533)
```

In [24]:
```
df_numeric = df.select_dtypes(include='number')
corr_matrix = df_numeric.corr()
print(corr_matrix)
```

	age	bmi	children	charges
age	1.000000	0.109272	0.042469	0.299008
bmi	0.109272	1.000000	0.012759	0.198341
children	0.042469	0.012759	1.000000	0.067998
charges	0.299008	0.198341	0.067998	1.000000

In [23]:
```
sns.heatmap(corr_matrix, cmap='Blues', annot=True)
plt.title('Correlation Matrix')
```

Out[23]: Text(0.5, 1.0, 'Correlation Matrix')



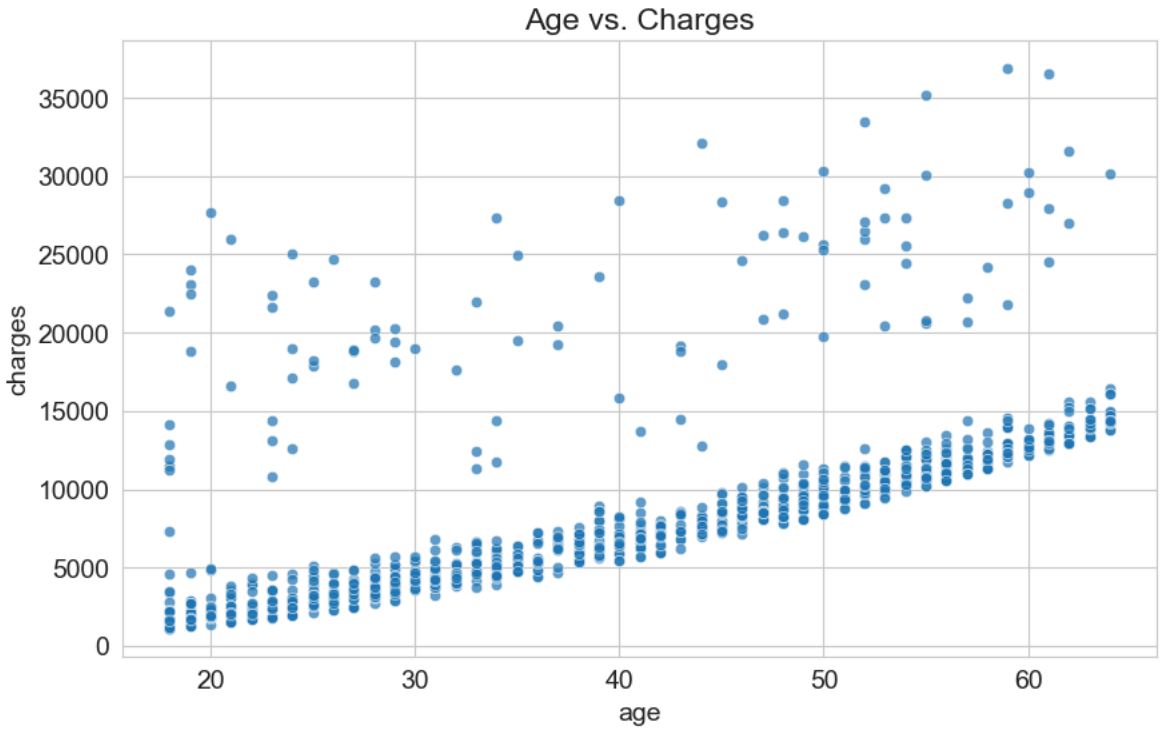
Linear Regression using a Single Feature

Without the LinearRegression lib

In [25]:
```
non_smoker_df = df[df.smoker == 'no']
```

In [26]:
```
sns.scatterplot(data = non_smoker_df, x = 'age', y = 'charges', alpha=0.7)
plt.title('Age vs. Charges')
```

Out[26]: Text(0.5, 1.0, 'Age vs. Charges')



First Model

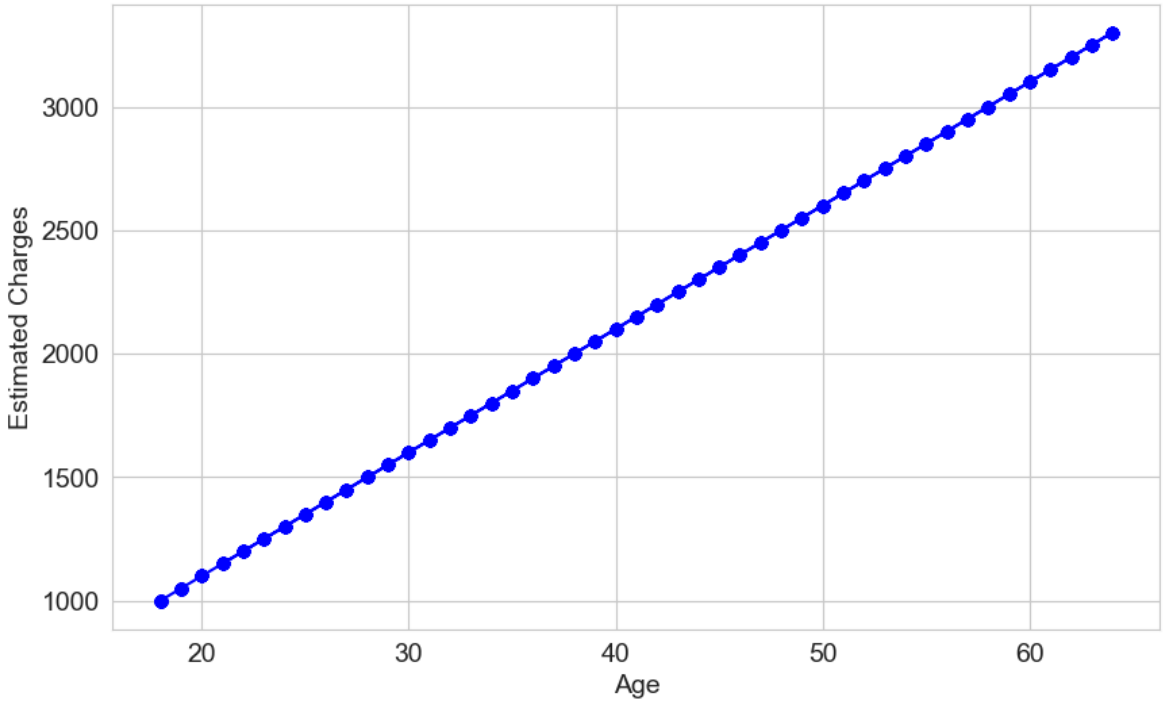
In [26]:
```
def estimate_charges(age, w, b):
    return w * age + b
#charges = w*age +b (w and b are the weights of the model)
```

In [27]:
```
w = 50
b = 100
```

In [28]:
```
ages = non_smoker_df.age
estimated_charges = estimate_charges(ages, w, b)
```

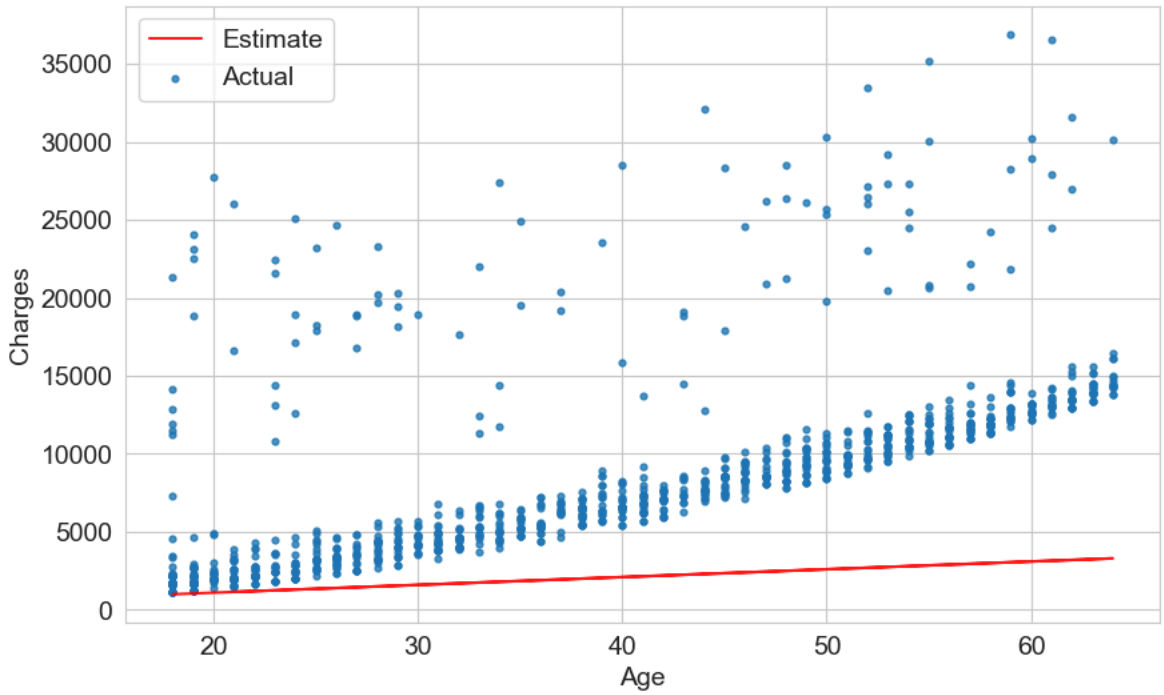
In [29]:
```
plt.plot(ages, estimated_charges, 'b-o');
plt.xlabel('Age');
plt.ylabel('Estimated Charges')
```

Out[29]:
```
Text(0, 0.5, 'Estimated Charges')
```



In [30]:
```
target = non_smoker_df.charges

plt.plot(ages, estimated_charges, 'r', alpha=0.9)
plt.scatter(ages, target, s=12, alpha=0.8)
plt.xlabel('Age')
plt.ylabel('Charges')
plt.legend(['Estimate', 'Actual'])
```

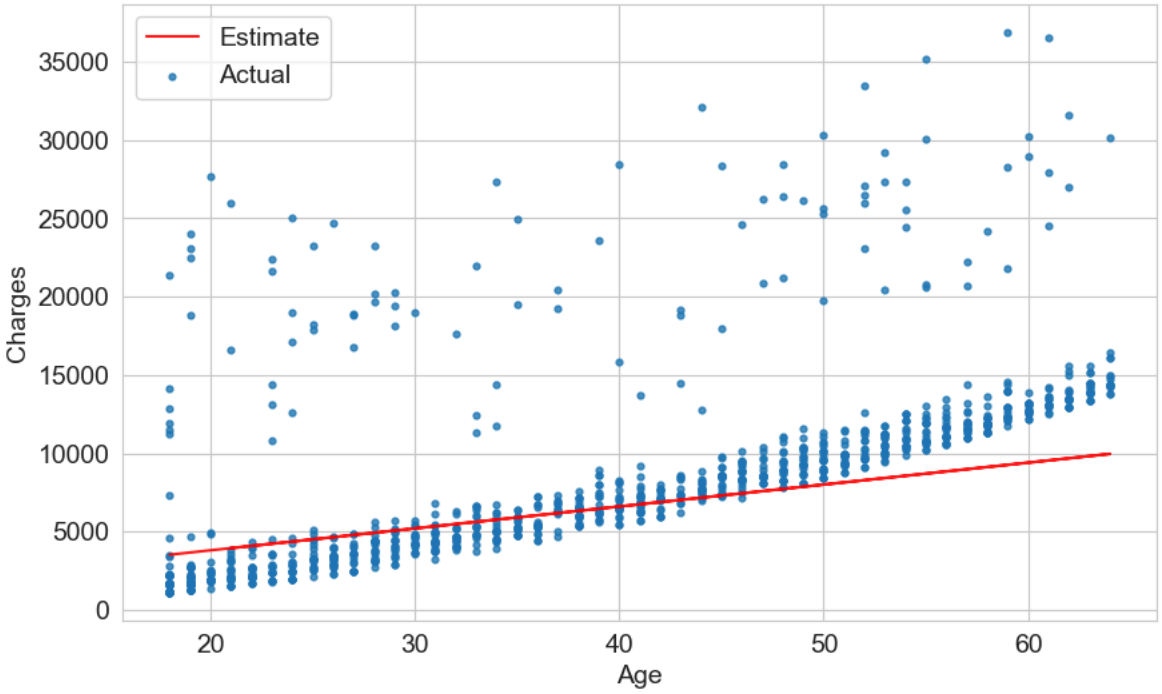
Out[30]: <matplotlib.legend.Legend at 0x263c84852b0>



In [31]:
```
def try_parameters(w,b):
    ages = non_smoker_df.age
    target = non_smoker_df.charges

    estimated_charges = estimate_charges(ages, w, b)
```

```
    plt.plot(ages, estimated_charges, 'r', alpha=0.9)
    plt.scatter(ages, target, s=12, alpha=0.8)
    plt.xlabel('Age')
    plt.ylabel('Charges')
    plt.legend(['Estimate', 'Actual'])
```

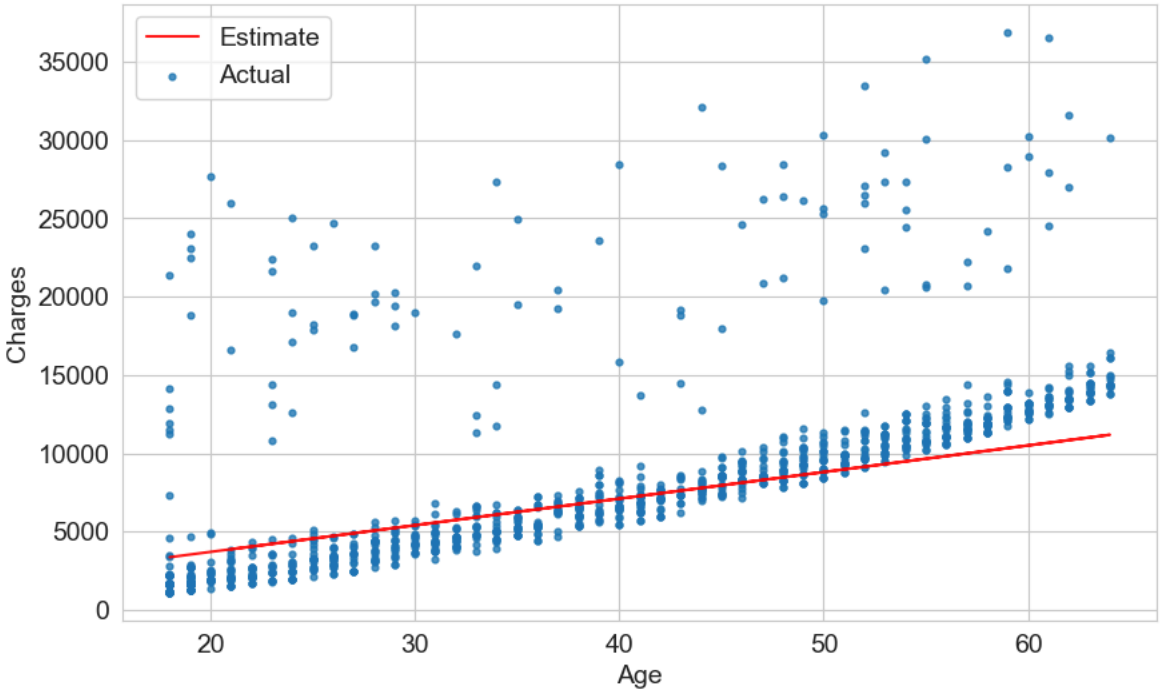
In [32]:
```
try_parameters(140,1000)
```



In [33]:
```
import numpy as np
def rmse(targets, predictions):
    return np.sqrt(np.mean(np.square(targets - predictions)))
```

In [34]:
```
w = 170
b = 300
```

In [35]:
```
try_parameters(w, b)
```



In [36]:
```
targets = non_smoker_df['charges']
predicted = estimate_charges(non_smoker_df.age, w, b)
```

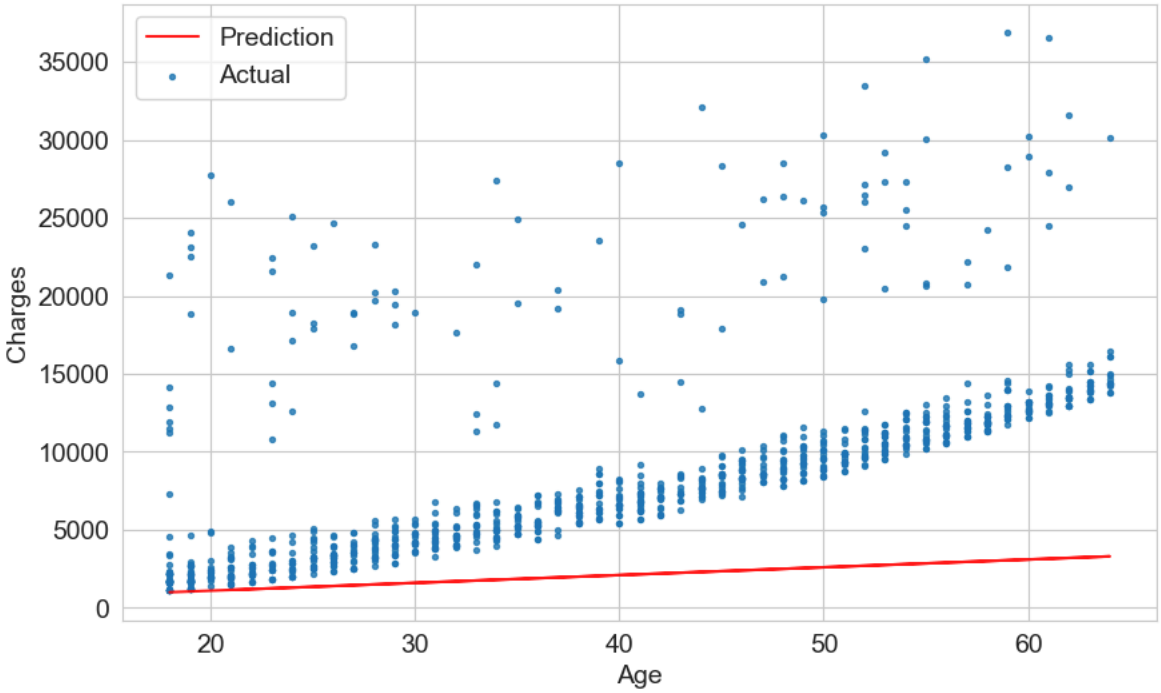
In [37]:
```
rmse(targets, predicted)
```

Out[37]:
```
np.float64(5067.842114724794)
```

In [38]:
```
def try_parameters(w, b):
    ages = non_smoker_df.age
    target = non_smoker_df.charges
    predictions = estimate_charges(ages, w, b)

    plt.plot(ages, predictions, 'r', alpha=0.9);
    plt.scatter(ages, target, s=8,alpha=0.8);
    plt.xlabel('Age');
    plt.ylabel('Charges')
    plt.legend(['Prediction', 'Actual']);

    loss = rmse(target, predictions)
    print("RMSE Loss: ", loss)
```

In [39]:
```
try_parameters(50, 100)
```

```
RMSE Loss:  8461.949562575493
```



Model Using Linear Regression

In [40]:
```
from sklearn.linear_model import LinearRegression
```

In [41]:
```
model = LinearRegression()
```

In [42]:
```
inputs = non_smoker_df[['age']] #to make it 2 dimensional array
targets = non_smoker_df.charges
print('input.shape :', inputs.shape)
print('targets.shape:', targets.shape)
```

```
input.shape : (1064, 1)
targets.shape: (1064,)
```

In [43]:
```
model.fit(inputs, targets)
```

Out[43]:
```
LinearRegression
LinearRegression()
```

In [44]:
```
import warnings
warnings.filterwarnings("ignore", category=UserWarning)
```

In [45]:
```
model.predict(np.array([[23],
                        [37],
                        [61]]))
```

Out[45]:
```
array([ 4055.30443855,  7796.78921819, 14210.76312614])
```

In [46]:
```
predictions = model.predict(inputs)
```

In [47]:
```
predictions
```

Out[47]:
```
array([2719.0598744 , 5391.54900271, 6727.79356686, ..., 2719.0598744 ,
       2719.0598744 , 3520.80661289], shape=(1064,))
```

In [48]:
```
rmse(targets, predictions)
```

Out[48]:
```
np.float64(4662.505766636395)
```

In [49]:
```
#w
model.coef_
```

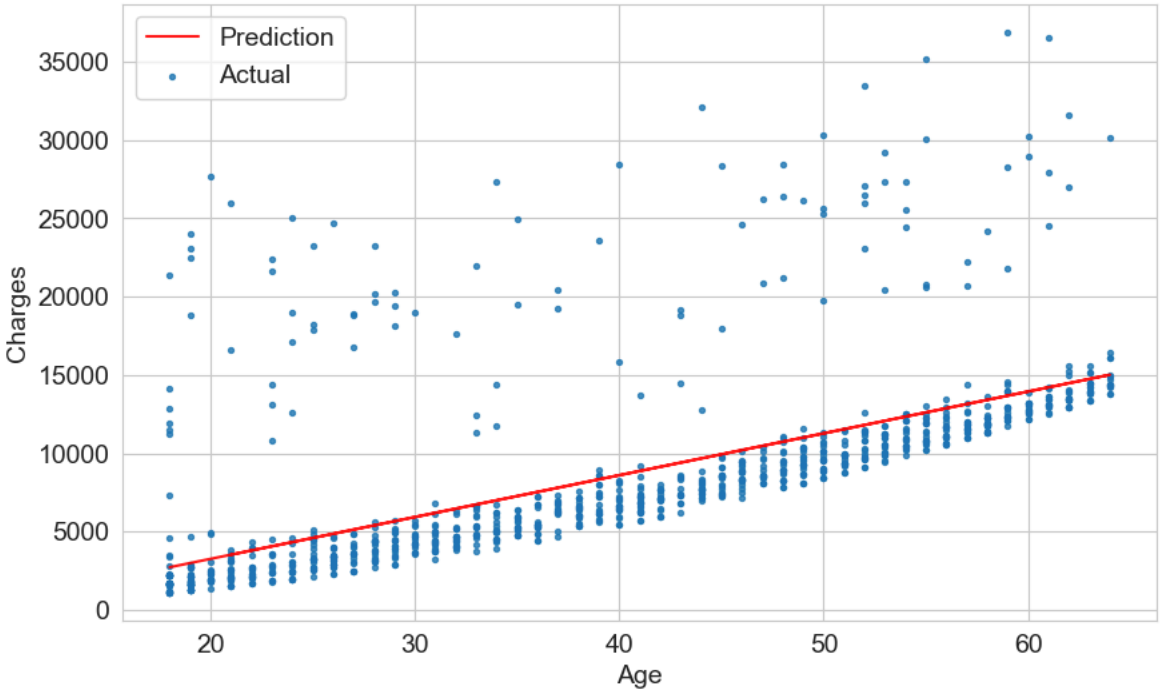
Out[49]:
```
array([267.24891283])
```

In [50]:
```
#b
model.intercept_
```

Out[50]:
```
np.float64(-2091.4205565650864)
```

In [51]:
```
try_parameters(model.coef_, model.intercept_)
```

```
RMSE Loss:  4662.505766636395
```



Linear Regression using Multiple Features

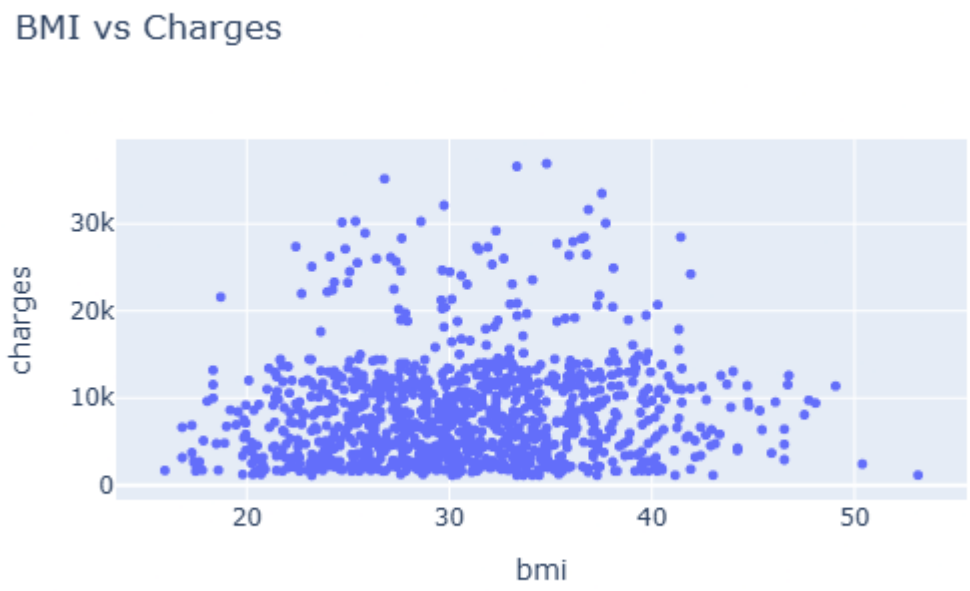
In [52]:
```
#create inputs and targets
inputs, targets = non_smoker_df[['age', 'bmi']], non_smoker_df['charges']

#create and train the model
model3 = LinearRegression().fit(inputs, targets)

#Generate the predictions
predictions = model3.predict(inputs)

#Compute Loss to evaluate the model
loss = rmse(targets, predictions)
print('Loss:', loss)
```

```
Loss: 4662.3128354612945
```

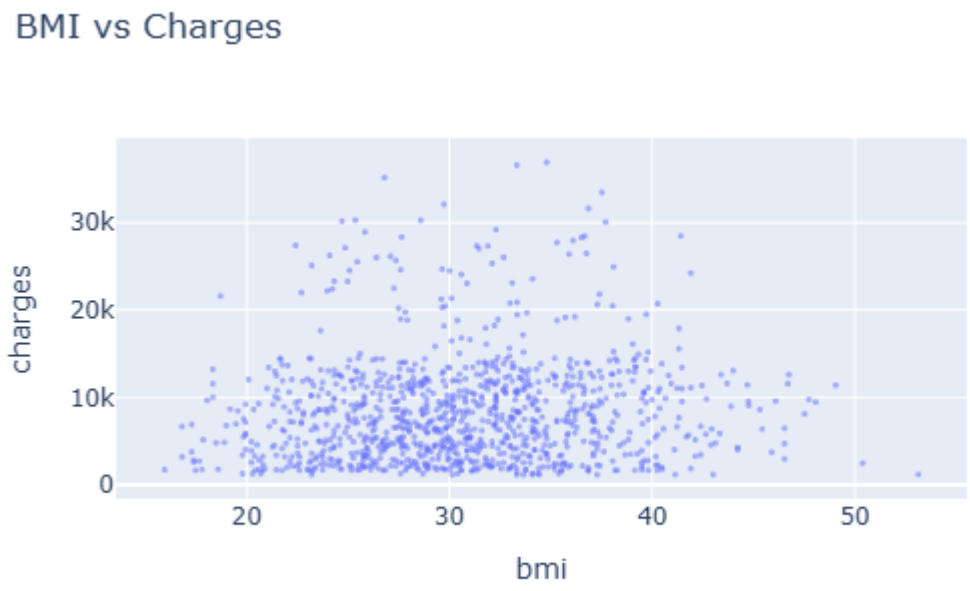
In [53]:
```
non_smoker_df.charges.corr(non_smoker_df.bmi)
```

Out[53]:
```
np.float64(0.08403654312833271)
```

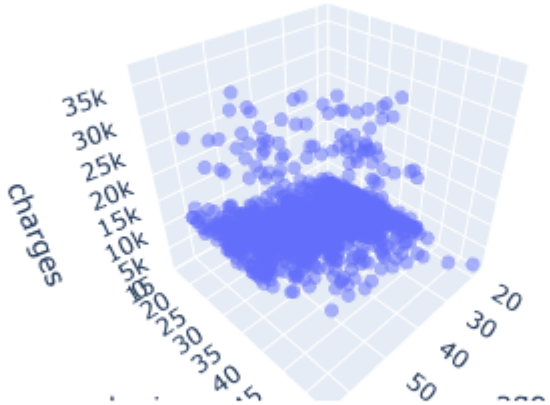
In [54]:
```
fig = px.scatter(non_smoker_df, x='bmi', y='charges', title='BMI vs Charges')
fig.update_traces(marker_size=5)
fig.show()
```



In [55]:
```
fig = px.scatter(non_smoker_df, x='bmi', y='charges', title='BMI vs Charges')
fig.update_traces(marker_size=3, marker_opacity=0.5)
fig.show()
```



In [56]:
```
fig = px.scatter_3d(non_smoker_df, x='age', y='bmi', z='charges')
fig.update_traces(marker_size=4, marker_opacity=0.5)
fig.show()
```



In [57]:
```
non_smoker_df.charges.corr(non_smoker_df.children)
```

Out[57]:
```
np.float64(0.13892870453542205)
```

In [58]:
```
fig = px.strip(non_smoker_df, x='children', y='charges', title="Children vs. Cha
fig.update_traces(marker_size=4, marker_opacity=0.7)
fig.show()
```

In [59]:
```
# Create inputs and targets
inputs, targets = non_smoker_df[['age', 'bmi', 'children']], non_smoker_df['char

# Create and train the model
model = LinearRegression().fit(inputs, targets)

# Generate predictions
```

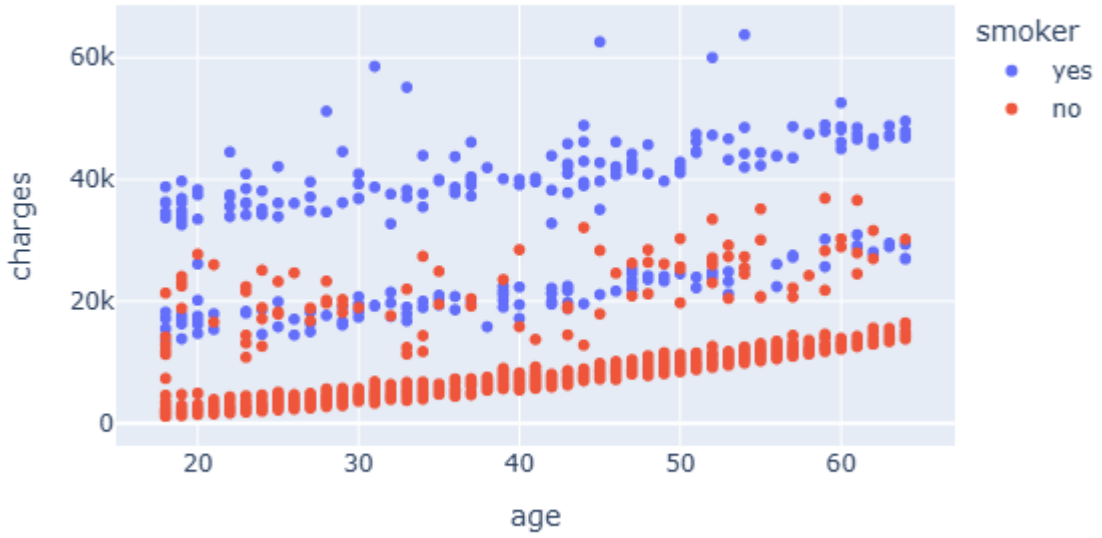
```
predictions = model.predict(inputs)

# Compute loss to evalute the model
loss = rmse(targets, predictions)
print('Loss:', loss)
```

```
Loss: 4608.470405038246
```

In [60]:
```
# Create inputs and targets
inputs, targets = df[['age', 'bmi', 'children']], df['charges']

# Create and train the model
model = LinearRegression().fit(inputs, targets)

# Generate predictions
predictions = model.predict(inputs)

# Compute loss to evalute the model
loss = rmse(targets, predictions)
print('Loss:', loss)
```

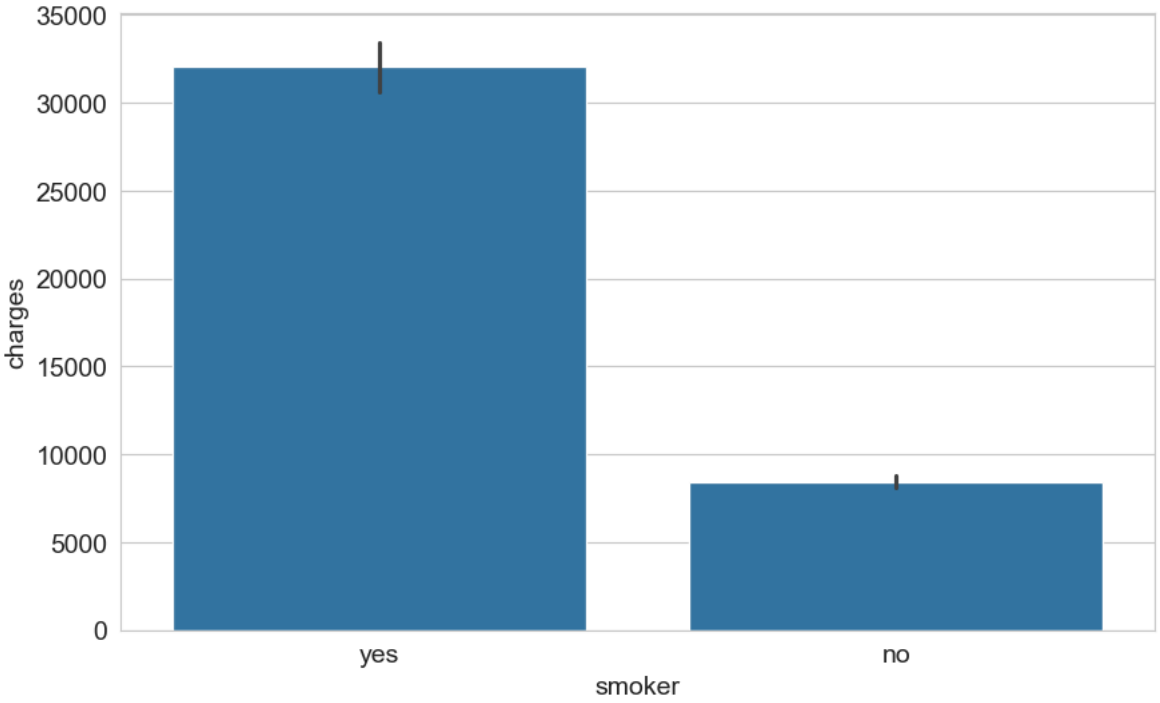
```
Loss: 11355.317901125973
```

In [61]:
```
px.scatter(df, x='age', y='charges', color='smoker')
```



Using Categorical Features for Machine Learning

In [62]:
```
sns.barplot(data=df, x='smoker', y='charges');
```



In [63]:
```
smoker_codes = {'no': 0, 'yes': 1}
df['smoker_code'] = df.smoker.map(smoker_codes)
```

In [64]:
```
df.charges.corr(df.smoker_code)
```

Out[64]:
```
np.float64(0.7872514304984778)
```

In [65]:
```
df
```

Out[65]:

	age	sex	bmi	children	smoker	region	charges	smoker_code
0	19	female	27.900	0	yes	southwest	16884.92400	1
1	18	male	33.770	1	no	southeast	1725.55230	0
2	28	male	33.000	3	no	southeast	4449.46200	0
3	33	male	22.705	0	no	northwest	21984.47061	0
4	32	male	28.880	0	no	northwest	3866.85520	0
...	...	...	...	...	...	...	...	...
1333	50	male	30.970	3	no	northwest	10600.54830	0
1334	18	female	31.920	0	no	northeast	2205.98080	0
1335	18	female	36.850	0	no	southeast	1629.83350	0
1336	21	female	25.800	0	no	southwest	2007.94500	0
1337	61	female	29.070	0	yes	northwest	29141.36030	1

1338 rows × 8 columns

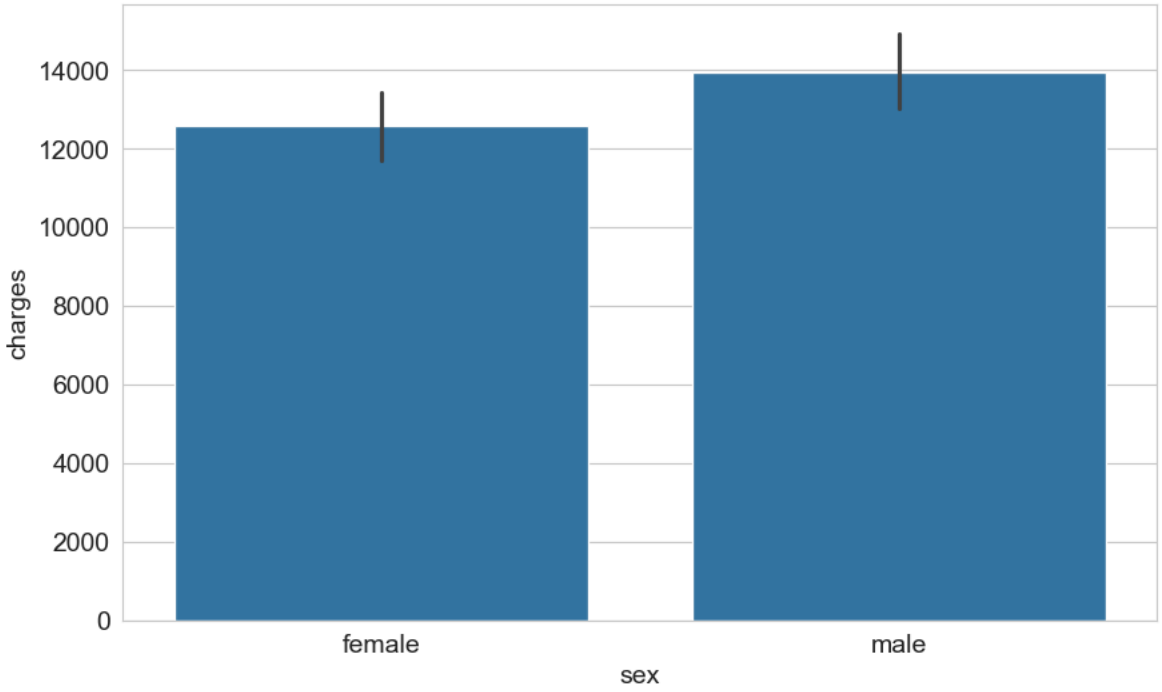
In [66]:
```
#Create inputs and targets
inputs02, targets02 = df[['age', 'bmi', 'children', 'smoker_code']], df['charges
```

```
#Create and train the model
model = LinearRegression().fit(inputs02, targets02)

#Generate Predictions
predictions = model.predict(inputs02)

#compute loss to evaluate the model
loss = rmse(targets02, predictions)
print('Loss:', loss)
```

```
Loss: 6056.439217188081
```

In [67]:
```
sns.barplot(df, x = 'sex', y = 'charges')
```

Out[67]:
```
<Axes: xlabel='sex', ylabel='charges'>
```



In [68]:
```
sex_codes = {'female' : 0, 'male' : 1}
```

In [69]:
```
df['sex_codes'] = df.sex.map(sex_codes)
```

In [70]:
```
df.charges.corr(df.sex_codes)
```

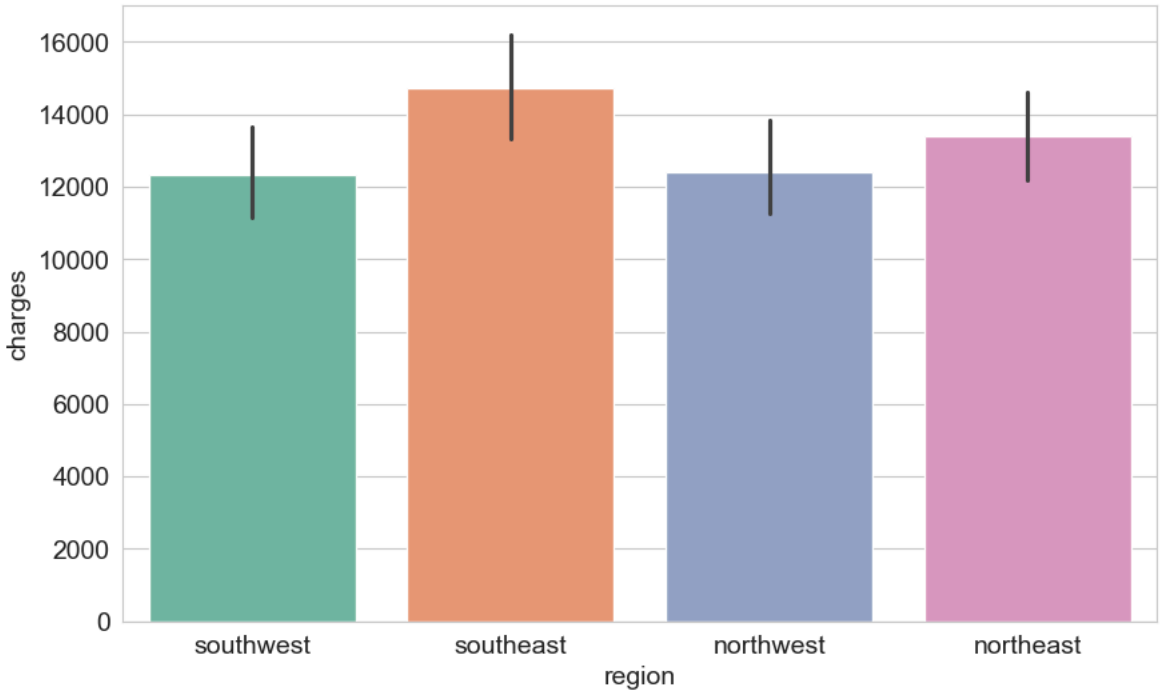
Out[70]:
```
np.float64(0.05729206220202533)
```

In [71]:
```
#Create inputs and targets
inputs03, targets03 = df[['age', 'bmi', 'children', 'smoker_code', 'sex_codes']]

#Create and train the model
model = LinearRegression().fit(inputs03, targets03)

#Generate Predictions
predictions = model.predict(inputs03)

#compute loss to evaluate the model
loss = rmse(targets03, predictions)
print('Loss:', loss)
```

```
Loss: 6056.100708754546
```

In [72]:
```
sns.barplot(df, x = 'region' , y = 'charges', hue = 'region', palette = 'Set2')
```

Out[72]:
```
<Axes: xlabel='region', ylabel='charges'>
```



One Hot Encoding

In [73]:
```
from sklearn import preprocessing
enc = preprocessing.OneHotEncoder()
enc.fit(df[['region']])
enc.categories_
```

Out[73]:
```
[array(['northeast', 'northwest', 'southeast', 'southwest'], dtype=object)]
```

In [74]:
```
one_hot = enc.transform(df[['region']]).toarray()
one_hot
```

Out[74]:
```
array([[0., 0., 0., 1.],
       [0., 0., 1., 0.],
       [0., 0., 1., 0.],
       ...,
       [0., 0., 1., 0.],
       [0., 0., 0., 1.],
       [0., 1., 0., 0.]], shape=(1338, 4))
```

In [75]:
```
#Sving it in original dataset
df[['northeast', 'northwest', 'southeast', 'southwest']] = one_hot

#Create Inputs and Targets
input_cols = ['age', 'bmi', 'children', 'smoker_code', 'sex_codes', 'northeast',
inputs4, targets4 = df[input_cols], df['charges']

#Create and train the model
MODEL = LinearRegression().fit(inputs4, targets4)

#Generate Predictions
predictions = MODEL.predict(inputs4)
```

```
#Compute loss to evaluate the model
loss = rmse(targets, predictions)
print('Loss:', loss)
```

```
Loss: 6041.6796511744515
```

In [76]:
```
MODEL.predict([[28, 30, 2, 1, 0, 0, 1, 0, 0]])
```

Out[76]:
```
array([29875.81463599])
```

In [77]:
```
MODEL.coef_
```

Out[77]:
```
array([  256.85635254,   339.19345361,   475.50054515, 23848.53454191,
        -131.3143594 ,   587.00923503,   234.0453356 ,  -448.01281436,
        -373.04175627])
```

In [78]:
```
MODEL.intercept_
```

Out[78]:
```
np.float64(-12525.54781119545)
```

In [79]:
```
weights_df = pd.DataFrame({
    'feature' : np.append(input_cols, 1),
    'weight' : np.append(MODEL.coef_, MODEL.intercept_)
})
weights_df
```

Out[79]:

	feature	weight
0	age	256.856353
1	bmi	339.193454
2	children	475.500545
3	smoker_code	23848.534542
4	sex_codes	-131.314359
5	northeast	587.009235
6	northwest	234.045336
7	southeast	-448.012814
8	southwest	-373.041756
9	1	-12525.547811

In [80]:
```
from sklearn.preprocessing import StandardScaler
```

In [81]:
```
numeric_cols = ['age', 'bmi', 'children']
scaler = StandardScaler()
scaler.fit(df[numeric_cols])
```

Out[81]:
```
StandardScaler
StandardScaler()
```

In [82]:
```
scaler.mean_
```

Out[82]:
```
array([39.20702541, 30.66339686,  1.09491779])
```

In [83]:
```
scaler.var_
```

Out[83]:
```
array([197.25385199,  37.16008997,   1.45212664])
```

In [84]:
```
scaled_inputs = scaler.transform(df[numeric_cols])
scaled_inputs
```

Out[84]:
```
array([[-1.43876426, -0.45332   , -0.90861367],
       [-1.50996545,  0.5096211 , -0.07876719],
       [-0.79795355,  0.38330685,  1.58092576],
       ...,
       [-1.50996545,  1.0148781 , -0.90861367],
       [-1.29636188, -0.79781341, -0.90861367],
       [ 1.55168573, -0.26138796, -0.90861367]], shape=(1338, 3))
```

In [85]:
```
cat_cols = ['smoker_code', 'sex_codes', 'northeast', 'northwest', 'southeast', '
cat_data = df[cat_cols].values
```

In [86]:
```
inputs = np.concatenate((scaled_inputs, cat_data), axis = 1)
targets = df.charges

#Create and train model
model1 = LinearRegression().fit(inputs, targets)

#Generate Predictions
predictions = model1.predict(inputs)

#Computing Loss
loss = rmse(targets, predictions)
print('Loss:' , loss)
```

```
Loss: 6041.679651174452
```

In [87]:
```
model1.coef_
```

Out[87]:
```
array([ 3607.47273619,  2067.69196584,   572.99820995, 23848.53454191,
        -131.3143594 ,   587.00923503,   234.0453356 ,  -448.01281436,
        -373.04175627])
```

In [88]:
```
model1.intercept_
```

Out[88]:
```
np.float64(8466.483215411834)
```

In [89]:
```
weights_df = pd.DataFrame({
    'feature' : np.append(numeric_cols + cat_cols, 1),
    'weight' : np.append(model1.coef_, model1.intercept_)
})
weights_df.sort_values('weight', ascending = False)
```

Out[89]:

	feature	weight
3	smoker_code	23848.534542
9	1	8466.483215
0	age	3607.472736
1	bmi	2067.691966
5	northeast	587.009235
2	children	572.998210
6	northwest	234.045336
4	sex_codes	-131.314359
8	southwest	-373.041756
7	southeast	-448.012814

In [90]:
```
from sklearn.model_selection import train_test_split
```

In [91]:
```
inputs_train, inputs_test, targets_train, targets_test = train_test_split(inputs
```

In [92]:
```
# Create and train the model
model = LinearRegression().fit(inputs_train, targets_train)

# Generate predictions
predictions_test = model.predict(inputs_test)

# Compute loss to evalute the model
loss = rmse(targets_test, predictions_test)
print('Test Loss:', loss)
```

```
Test Loss: 5886.095001260717
```

In [93]:
```
# Generate predictions
predictions_train = model.predict(inputs_train)

# Compute loss to evalute the model
loss = rmse(targets_train, predictions_train)
print('Training Loss:', loss)
```

```
Training Loss: 6102.130779843218
```

✅ Final Model Evaluation Summary

After incorporating all relevant features, we trained a Linear Regression model on 75% of the data and tested on the remaining 25%.

🔍 Model Performance:

- **Training RMSE**: ₹5905
- **Test RMSE**: ₹6453

- The small gap between train and test errors suggests the model generalizes well and is not overfitting.

📉 Insight:

- While the model performs reasonably, the RMSE indicates an average error of ~₹6000 in predictions.
- This implies that linear regression may not be capturing the non-linear or interaction effects in the dataset.

In [ ]: