In [1]:
```
import numpy as np
from scipy import linalg
import pandas as pd
import matplotlib.pyplot as plt

# the commonly used alias for seaborn is sns
import seaborn as sns

# set a seaborn style of your taste
sns.set_style("whitegrid")
```

In [2]:
```
df = pd.read_excel('Demo_DataSets.xlsx')
```

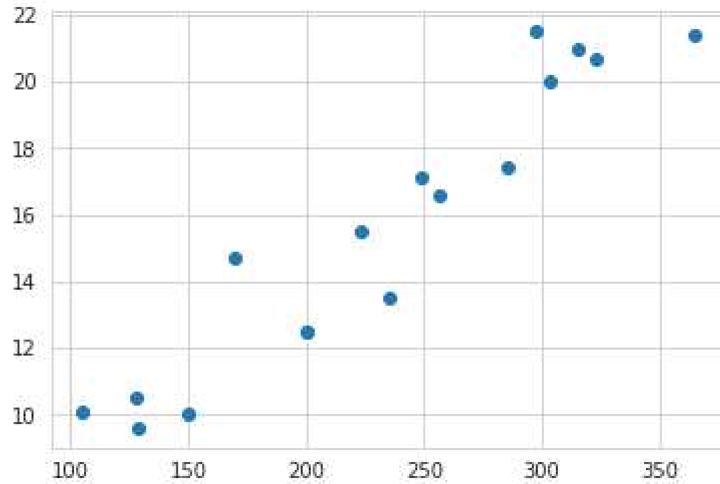
In [3]:
```
df
```

Out[3]:

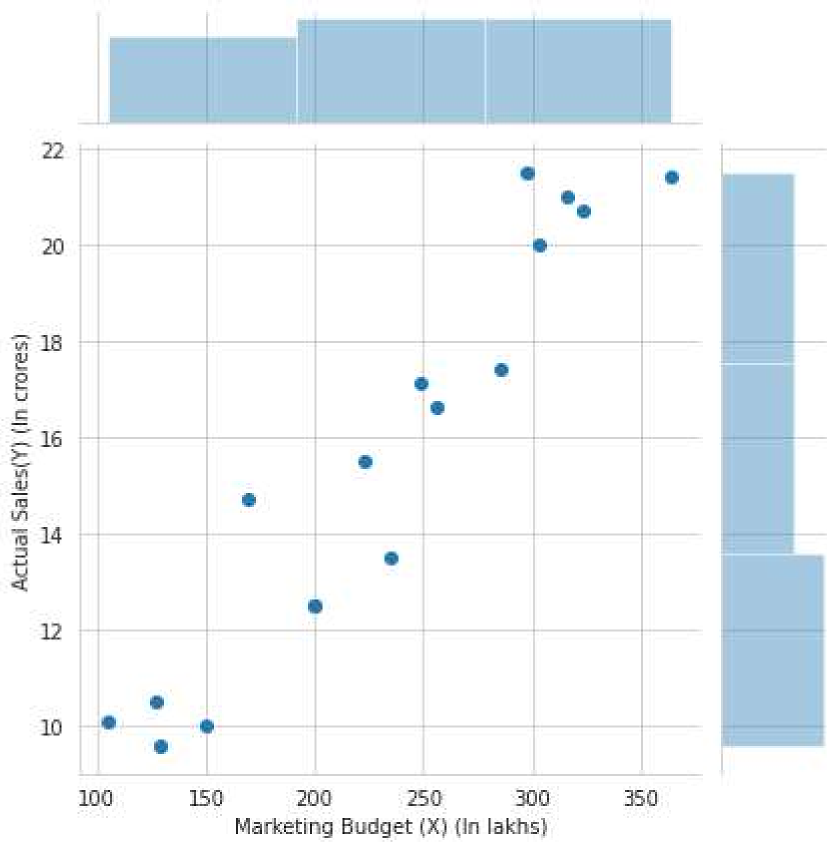
	Marketing Budget (X) (In lakhs)	Actual Sales(Y) (In crores)
0	127.4	10.5
1	364.4	21.4
2	150.0	10.0
3	128.7	9.6
4	285.9	17.4
5	200.0	12.5
6	303.3	20.0
7	315.7	21.0
8	169.8	14.7
9	104.9	10.1
10	297.7	21.5
11	256.4	16.6
12	249.1	17.1
13	323.1	20.7
14	223.0	15.5
15	235.0	13.5
16	200.0	12.5

In [4]:
```
print(df.shape)

plt.scatter(df['Marketing Budget (X) (In lakhs)'], df['Actual Sales(Y) (In cro
res)'])
plt.show();
```

```
(17, 2)
```

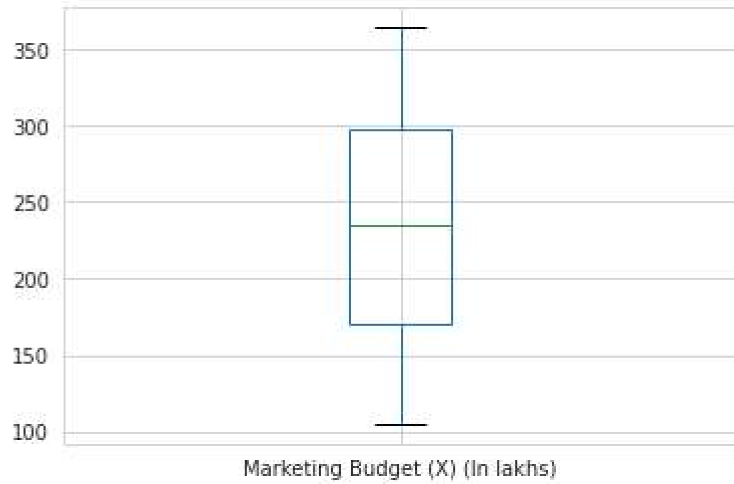


In [5]:
```
# joint plots of Profit and Sales

sns.jointplot('Marketing Budget (X) (In lakhs)', 'Actual Sales(Y) (In crores)'
, df)
plt.show()
```



Now lets also check the distribution of marketing and sales

In [6]:
```
df['Marketing Budget (X) (In lakhs)'].plot(kind='box');
```



In [7]:
```
df['Marketing Budget (X) (In lakhs)'].mean()
```

Out[7]: 231.43529411764703

In [8]:
```
df['Marketing Budget (X) (In lakhs)'].median()
```

Out[8]: 235.0

In [9]:
```
df['Actual Sales(Y) (In crores)'].plot(kind='box');
```

from the above distribution we see that the x variable is normally distributed, since it's mean and median are same, so we do not need to standardize the x variable

we know that the Equation of a straight line is:
y = mx + b

So, The Equation of a Tangent line at any point x will be:
f(x) = mx + b

We already know y and x, therefore in order to solve the above equation we need m which is:
m = y2 - y1 / x2 - x1

Also, we need to calculate the cost function a simple MSE:

$$f(MSE) = \frac{1}{n}\sum_{i=1}^{n}(y_i - (m * x_i + b))^2$$

Now, in order to find out the optimal value of M and B, we need to find the Slope of the above equation with respect of M:

$$\frac{d(MSE)}{dm} = \frac{2}{n}\sum_{i=1}^{n} -x_i(y_i - (m * x_i + b))$$

and with respect to B:

$$\frac{d(MSE)}{db} = \frac{2}{n}\sum_{i=1}^{n}(y_i - (m * x_i + b))$$

Now, we need to iterate through the initial value of M and B which we found in the first stage
and on each iteration we need to check the value of slope of MSE with respect to M and B, and
if it is very very small we are done with our gredient descent

But, in order to find out the optimal value of M and B, we need to keep guessing.. and in order to do so we need to add or suptract M and B by certain number. That certain number is called Learning Rate "LR", which means how much do we need to adjust M or B to reach optimal MSE or slope close to 0

so we take the learning rate as 0.02 and multiply with the slope to get the adjustment needed for M or B

LR = 0.02

Adjustment In M can be defind as below:

$$\triangle_{M_n} = \frac{d(MSE)}{dm_n} * LR$$

Adjustment In B can be defind as below:

$$\triangle_{B_n} = \frac{d(MSE)}{db_n} * LR$$

after we found out the adjustment in M and B, we need to again recalculate the MSE by subtracting the M and B from the previous value of M and B

Suppose the Initial value of:

$$M_1 = 0; B_1 = 0$$

therefore the nth value of M and B:

$$M_n = M_{n-1} - \triangle_{M_{n-1}}$$

$$B_n = B_{n-1} - \triangle_{B_{n-1}}$$

Now, the question is when is to stop the iteration, we will use RELU activation which is MAX(0, f(x))

which means the f(x) of the tanget line at any point in x cannot be less than 0

Now lets calculate the initial value of M and B using matrix multiplication

In [10]:
```
# so first we need to convert our data sets into matrix form
# but first we need to introduce a new column with only 1 for matrix multiplic
ation
```

In [11]:
```
df["X_prime"] = pd.DataFrame([1 for item in range(len(df['Marketing Budget (X)
(In lakhs)']))])
```

In [12]:
```
X = df[["X_prime", "Marketing Budget (X) (In lakhs)"]].to_numpy()
```

In [13]:
```
X.shape
```

Out[13]:
```
(17, 2)
```

In [14]:
```
X
```

Out[14]:
```
array([[  1. , 127.4],
       [  1. , 364.4],
       [  1. , 150. ],
       [  1. , 128.7],
       [  1. , 285.9],
       [  1. , 200. ],
       [  1. , 303.3],
       [  1. , 315.7],
       [  1. , 169.8],
       [  1. , 104.9],
       [  1. , 297.7],
       [  1. , 256.4],
       [  1. , 249.1],
       [  1. , 323.1],
       [  1. , 223. ],
       [  1. , 235. ],
       [  1. , 200. ]])
```

In [15]:
```
# Now we also need to convert y to numpy array
Y = df["Actual Sales(Y) (In crores)"].to_numpy()
```

In [16]:
```
Y
```

Out[16]:
```
array([10.5, 21.4, 10. ,  9.6, 17.4, 12.5, 20. , 21. , 14.7, 10.1, 21.5,
       16.6, 17.1, 20.7, 15.5, 13.5, 12.5])
```

Now the matrix form to calculate the M and B is:

$$\begin{bmatrix} b \\ m \end{bmatrix} = ([X]^T [X])^{-1} [X]^T Y$$

In [17]:
```
# Multiply X by its transpose
A = X.transpose().dot(X)
```

In [18]:
```
# Calculate the inverse of A
B = linalg.inv(A)
```

In [19]:
```
# Multiply the result by the transpose of X
C = B.dot(X.transpose())
```

In [20]:
```
# Multiply the result by the vector Y:
D = C.dot(Y)
```

In [21]:
```
# now we have the intercept and slope that we can use as an initial value for
 Gredient descent
D
```

Out[21]:
```
array([3.35249683, 0.05276727])
```

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