In [1]:
```python
import pandas as pd
import numpy as np
import scipy.stats as stats
import os
import random
import statsmodels.api as sm
import statsmodels.stats.multicomp
from statsmodels.formula.api import ols
from statsmodels.stats.anova import anova_lm
import matplotlib.pyplot as plt
from scipy import stats
import seaborn as sns
```

In [2]:
```python
#Read CSV
LabTAT=pd.read_csv("C:/Users/rjas/Downloads/ds assignments/3a/LabTAT.csv")
```

In [4]:
```python
LabTAT
```

Out[4]:

	Laboratory 1	Laboratory 2	Laboratory 3	Laboratory 4
0	185.35	165.53	176.70	166.13
1	170.49	185.91	198.45	160.79
2	192.77	194.92	201.23	185.18
3	177.33	183.00	199.61	176.42
4	193.41	169.57	204.63	152.60
...	...	...	...	...
115	178.49	170.66	193.80	172.68
116	176.08	183.98	215.25	177.64
117	202.48	174.54	203.99	170.27
118	182.40	197.18	194.52	150.87
119	182.09	215.17	221.49	162.21

120 rows × 4 columns

In [5]:
```python
LabTAT.dtypes
```

Out[5]:
```
Laboratory 1    float64
Laboratory 2    float64
Laboratory 3    float64
Laboratory 4    float64
dtype: object
```

In [6]:
```python
LabTAT.size
```

Out[6]: 480

In [7]:
```python
LabTAT.shape
```

Out[7]: (120, 4)

In [8]:
```python
LabTAT.columns
```

Out[8]: Index(['Laboratory 1', 'Laboratory 2', 'Laboratory 3', 'Laboratory 4'], dtype='object')

In [9]:
```python
LabTAT.axes
```

Out[9]:
```
[RangeIndex(start=0, stop=120, step=1),
 Index(['Laboratory 1', 'Laboratory 2', 'Laboratory 3', 'Laboratory 4'], dtype='object')]
```

In [10]:
```python
LabTAT.ndim
```

Out[10]: 2

In [11]:
```python
LabTAT.values
```

Out[11]:
```
array([[185.35, 165.53, 176.7 , 166.13],
       [170.49, 185.91, 198.45, 160.79],
       [192.77, 194.92, 201.23, 185.18],
       [177.33, 183.  , 199.61, 176.42],
       [193.41, 169.57, 204.63, 152.6 ],
       [179.45, 197.  , 181.51, 161.12],
       [191.37, 166.36, 214.21, 154.02],
       [166.81, 169.6 , 183.43, 163.25],
       [158.81, 175.36, 191.6 , 152.79],
       [165.88, 198.68, 208.43, 161.98],
       [174.75, 189.12, 231.  , 171.22],
       [193.37, 140.55, 198.37, 183.67],
       [184.75, 160.44, 226.62, 142.95],
       [178.54, 167.03, 214.44, 152.37],
       [180.19, 182.67, 159.69, 163.81],
       [172.17, 155.73, 214.14, 156.06],
       [172.  , 183.07, 212.29, 176.44],
       [184.92, 177.7 , 209.25, 173.68],
       [187.38, 191.62, 198.54, 161.49],
       [194.17, 186.85, 229.02, 175.05],
       [192.03, 161.09, 214.71, 150.22],
       [193.77, 173.01, 172.27, 148.17],
       [178.24, 199.43, 205.31, 166.21],
       [171.41, 185.67, 180.35, 145.4 ],
       [178.3 , 182.69, 214.58, 166.42],
       [176.13, 180.45, 231.76, 132.21],
       [180.67, 182.37, 215.78, 143.26],
       [177.38, 189.99, 201.78, 154.06],
       [190.36, 167.55, 191.64, 179.08],
       [199.99, 190.09, 217.56, 144.82],
       [181.36, 168.01, 193.04, 184.64],
       [187.37, 176.5 , 217.66, 188.49],
       [172.93, 173.54, 198.68, 198.69],
       [187.18, 153.75, 206.49, 142.43],
       [179.03, 212.8 , 198.81, 169.68],
       [181.69, 179.32, 200.58, 174.79],
       [185.28, 173.56, 199.91, 133.31],
       [157.14, 217.86, 190.34, 176.42],
       [184.42, 187.57, 181.87, 176.67],
       [183.45, 163.69, 214.39, 158.2 ],
       [175.5 , 186.49, 189.61, 157.02],
       [169.55, 171.31, 203.58, 154.55],
       [166.86, 202.29, 196.64, 157.58],
       [166.33, 197.68, 225.42, 161.96],
       [173.88, 156.89, 175.13, 168.14],
       [189.84, 168.03, 228.21, 180.14],
       [184.88, 173.09, 229.33, 170.28],
       [188.63, 187.52, 170.58, 166.68],
       [216.39, 193.28, 177.76, 161.42],
       [180.57, 178.04, 207.34, 153.97],
       [177.54, 197.45, 178.07, 167.5 ],
       [182.34, 172.35, 188.32, 165.43],
       [187.35, 167.63, 193.26, 150.83],
       [185.87, 194.24, 201.17, 149.96],
       [188.01, 179.43, 192.75, 161.94],
       [182.62, 183.62, 192.81, 146.46],
       [179.08, 157.92, 183.1 , 174.83],
       [189.96, 173.55, 181.92, 181.66],
       [169.15, 180.86, 209.43, 164.82],
       [169.83, 161.02, 180.11, 181.35],
       [181.45, 178.42, 172.92, 176.21],
       [196.13, 165.12, 205.01, 152.4 ],
       [172.02, 183.75, 206.46, 159.63],
       [181.83, 186.77, 192.48, 156.56],
       [170.41, 177.59, 237.49, 168.11],
       [161.99, 202.78, 173.08, 145.07],
       [138.3 , 176.63, 193.08, 128.93],
       [170.61, 169.11, 203.24, 165.95],
       [201.27, 148.7 , 215.17, 181.76],
       [202.12, 154.19, 186.83, 168.17],
       [172.62, 189.65, 199.7 , 162.11],
       [159.13, 186.93, 225.14, 177.03],
       [143.52, 168.2 , 213.18, 124.06],
       [195.85, 159.14, 237.23, 138.48],
       [186.22, 182.17, 189.98, 167.83],
       [168.62, 198.69, 193.63, 165.07],
       [164.88, 167.9 , 184.7 , 153.74],
       [155.29, 178.21, 175.87, 172.72],
       [168.39, 170.73, 180.94, 159.97],
       [190.02, 199.62, 211.19, 167.26],
       [188.99, 186.03, 205.54, 164.98],
       [175.49, 156.23, 219.55, 154.06],
       [190.88, 158.08, 197.33, 168.92],
       [178.08, 163.74, 205.62, 168.9 ],
       [210.38, 161.45, 238.7 , 157.48],
       [164.27, 163.45, 192.5 , 164.03],
       [166.97, 178.17, 208.35, 162.76],
       [176.16, 194.1 , 208.04, 173.37],
       [199.72, 182.6 , 222.47, 152.13],
       [176.93, 168.51, 207.6 , 187.08],
       [185.16, 191.89, 194.59, 162.84],
       [161.05, 180.53, 184.28, 162.67],
       [186.32, 165.45, 174.55, 157.21],
       [149.24, 168.8 , 188.53, 156.79],
       [168.62, 159.92, 204.28, 172.38],
       [171.64, 188.49, 202.95, 167.62],
       [185.42, 205.27, 177.62, 172.72],
       [162.43, 185.63, 201.99, 167.55],
       [178.81, 197.38, 195.6 , 132.49],
       [172.65, 186.71, 178.86, 166.18],
       [164.65, 194.81, 211.23, 176.79],
       [178.52, 198.09, 213.29, 197.98],
       [170.11, 164.07, 199.12, 184.78],
       [167.15, 170.48, 187.97, 180.51],
       [190.32, 184.86, 180.93, 167.27],
       [167.25, 189.11, 213.22, 159.34],
       [179.2 , 179.68, 175.36, 142.35],
       [171.65, 142.38, 187.6 , 167.07],
       [166.35, 167.72, 208.33, 126.94],
       [175.41, 199.9 , 172.86, 205.18],
       [172.05, 174.43, 211.64, 152.31],
       [181.88, 168.2 , 183.19, 191.26],
       [201.11, 195.07, 203.05, 160.98],
       [154.21, 193.79, 197.88, 192.23],
       [145.89, 175.16, 203.39, 139.34],
       [178.49, 170.66, 193.8 , 172.68],
       [176.08, 183.98, 215.25, 177.64],
       [202.48, 174.54, 203.99, 170.27],
       [182.4 , 197.18, 194.52, 150.87],
       [182.09, 215.17, 221.49, 162.21]])
```

In [12]:
```python
LabTAT['Laboratory 1'].value_counts()
```

Out[12]:
```
168.62    2
176.16    1
181.69    1
185.87    1
188.99    1
         ..
192.03    1
180.19    1
193.41    1
169.83    1
199.72    1
Name: Laboratory 1, Length: 119, dtype: int64
```

In [13]:
```python
LabTAT.describe()
```

Out[13]:

	Laboratory 1	Laboratory 2	Laboratory 3	Laboratory 4
count	120.000000	120.000000	120.000000	120.00000
mean	178.361583	178.902917	199.913250	163.68275
std	13.173594	14.957114	16.539033	15.08508
min	138.300000	140.550000	159.690000	124.06000
25%	170.335000	168.025000	188.232500	154.05000
50%	178.530000	178.870000	199.805000	164.42500
75%	186.535000	189.112500	211.332500	172.88250
max	216.390000	217.860000	238.700000	205.18000

In [14]:
```python
LabTAT.mean()
```

Out[14]:
```
Laboratory 1    178.361583
Laboratory 2    178.902917
Laboratory 3    199.913250
Laboratory 4    163.682750
dtype: float64
```

In [16]:
```python
LabTAT.std()
```

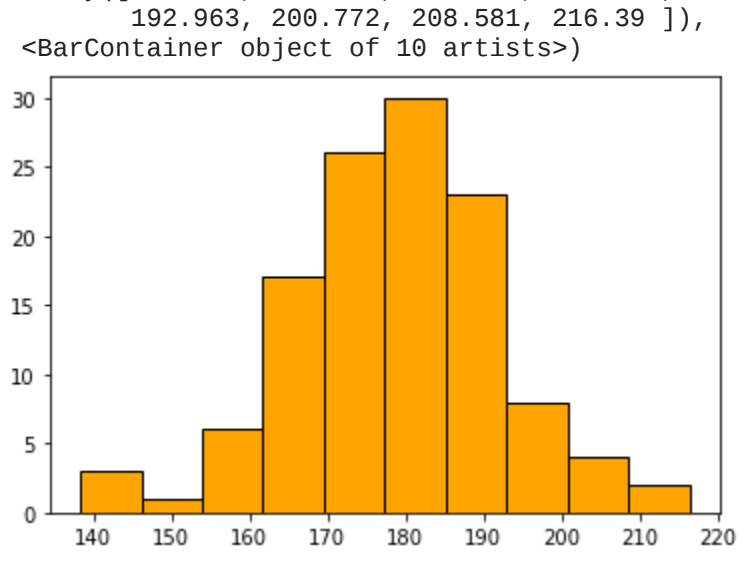
Out[16]:
```
Laboratory 1    13.173594
Laboratory 2    14.957114
Laboratory 3    16.539033
Laboratory 4    15.085080
dtype: float64
```

In [17]:
```python
LabTAT.median()
```

Out[17]:
```
Laboratory 1    178.530
Laboratory 2    178.870
Laboratory 3    199.805
Laboratory 4    164.425
dtype: float64
```

In [18]:
```python
plt.hist(LabTAT["Laboratory 1"],facecolor="orange",edgecolor="black",bins=10)
```

Out[18]:
```
(array([ 3.,  1.,  6., 17., 26., 30., 23.,  8.,  4.,  2.]),
 array([138.3  , 146.109, 153.918, 161.727, 169.536, 177.345, 185.154,
        192.963, 200.772, 208.581, 216.39 ]),
 <BarContainer object of 10 artists>)
```



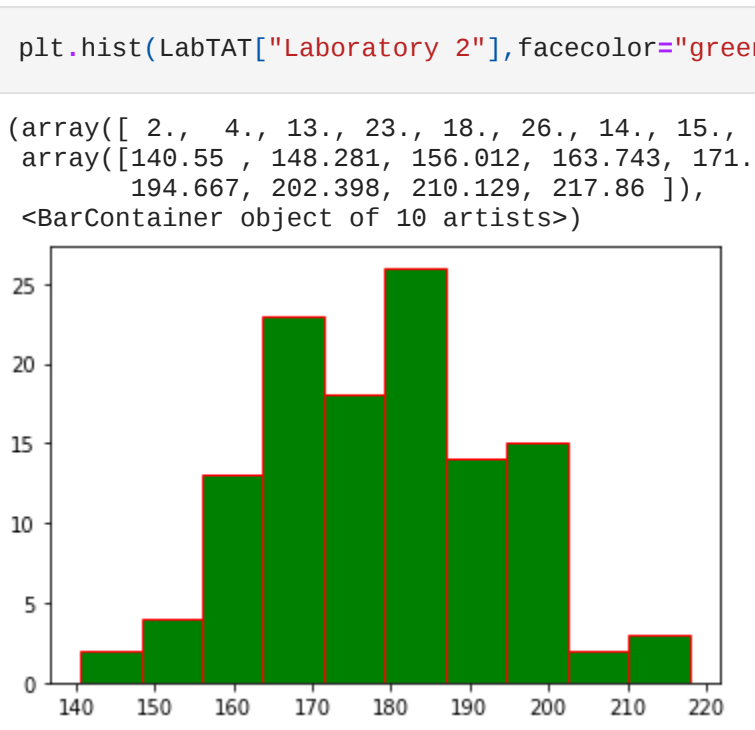
In [29]:
```python
LabTAT_CI_1=stats.norm.interval(0.975,loc= 178.361583,scale=13.173594)
```

In [30]:
```python
LabTAT_CI_1
```

Out[30]: (148.83425347603986, 207.88891252396016)

In [23]:
```python
plt.hist(LabTAT["Laboratory 2"],facecolor="green",edgecolor="red",bins=10)
```

Out[23]:
```
(array([ 2.,  4., 13., 23., 18., 26., 14., 15.,  2.,  3.]),
 array([140.55 , 148.281, 156.012, 163.743, 171.474, 179.205, 186.936,
        194.667, 202.398, 210.129, 217.86 ]),
 <BarContainer object of 10 artists>)
```



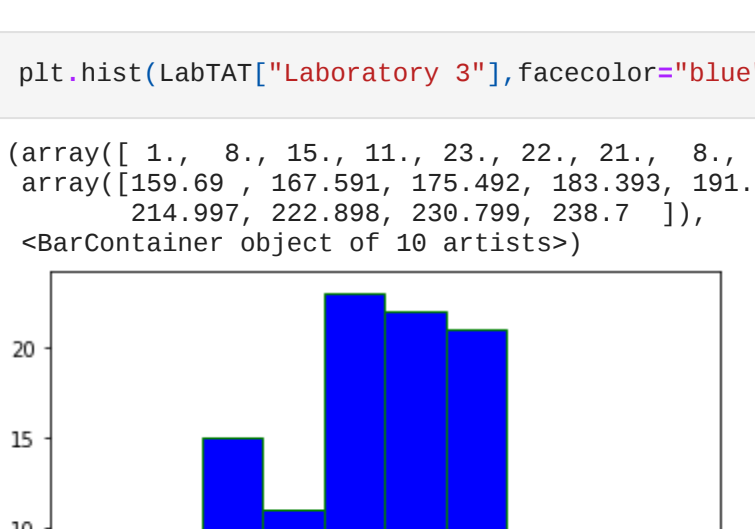
In [27]:
```python
LabTAT_CI_2=stats.norm.interval(0.975,loc=178.902917,scale=14.957114)
```

In [28]:
```python
LabTAT_CI_2
```

Out[28]: (145.3780008833019, 212.42783311669814)

In [31]:
```python
plt.hist(LabTAT["Laboratory 3"],facecolor="blue",edgecolor="green",bins=10)
```

Out[31]:
```
(array([ 1.,  8., 15., 11., 23., 22., 21.,  8.,  6.,  5.]),
 array([159.69 , 167.591, 175.492, 183.393, 191.294, 199.195, 207.096,
        214.997, 222.898, 230.799, 238.7  ]),
 <BarContainer object of 10 artists>)
```



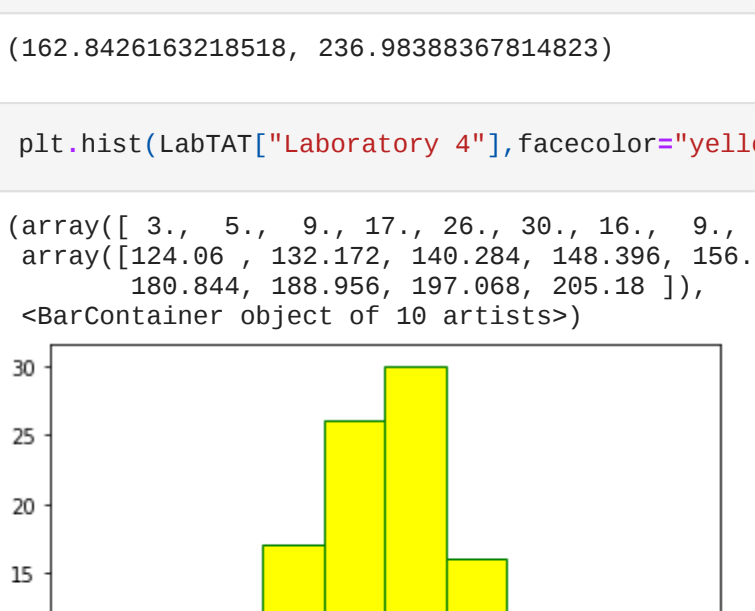
In [32]:
```python
LabTAT_CI_3=stats.norm.interval(0.975,loc=199.913250,scale=16.539033)
```

In [33]:
```python
LabTAT_CI_3
```

Out[33]: (162.8426163218518, 236.98388367814823)

In [34]:
```python
plt.hist(LabTAT["Laboratory 4"],facecolor="yellow",edgecolor="green",bins=10)
```

Out[34]:
```
(array([ 3.,  5.,  9., 17., 26., 30., 16.,  9.,  2.,  3.]),
 array([124.06 , 132.172, 140.284, 148.396, 156.508, 164.62 , 172.732,
        180.844, 188.956, 197.068, 205.18 ]),
 <BarContainer object of 10 artists>)
```



In [35]:
```python
LabTAT_CI_4=stats.norm.interval(0.975,loc=163.682750,scale=15.085080)
```

In [36]:
```python
LabTAT_CI_4
```

Out[36]: (129.8710105418612, 197.49448945813884)

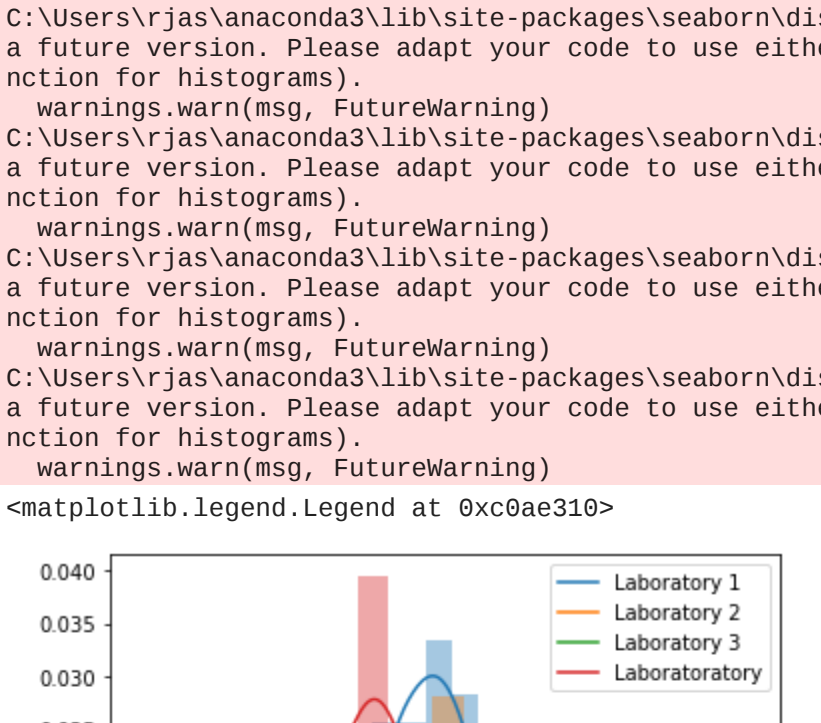
In [38]:
```python
Laboratory_1=LabTAT['Laboratory 1'].mean()
Laboratory_2=LabTAT['Laboratory 2'].mean()
Laboratory_3=LabTAT['Laboratory 3'].mean()
Laboratory_4=LabTAT['Laboratory 4'].mean()

print('Laboratory 1 Mean = ',Laboratory_1, '\nLaboratory 2 Mean = ',Laboratory_2, '\nLaboratory 3 Mean = ',Laboratory_3, '\nLaboratory 4 Mean = ',L
print('Laboratory 1 Mean < Laboratory 2 Mean < Laboratory 3 Mean > Laboratory 4 Mean = ',Laboratory_1<Laboratory_2<Laboratory_3>Laboratory_4)
```

```
Laboratory 1 Mean =  178.36158333333339
Laboratory 2 Mean =  178.9029166666668
Laboratory 3 Mean =  199.91325000000003
Laboratory 4 Mean =  163.6827499999999
Laboratory 1 Mean < Laboratory 2 Mean < Laboratory 3 Mean > Laboratory 4 Mean =  True
```

In [39]:
```python
sns.distplot(LabTAT['Laboratory 1'])
sns.distplot(LabTAT['Laboratory 2'])
sns.distplot(LabTAT['Laboratory 3'])
sns.distplot(LabTAT['Laboratory 4'])
plt.legend(['Laboratory 1','Laboratory 2','Laboratory 3','Laboratoratory'])
```

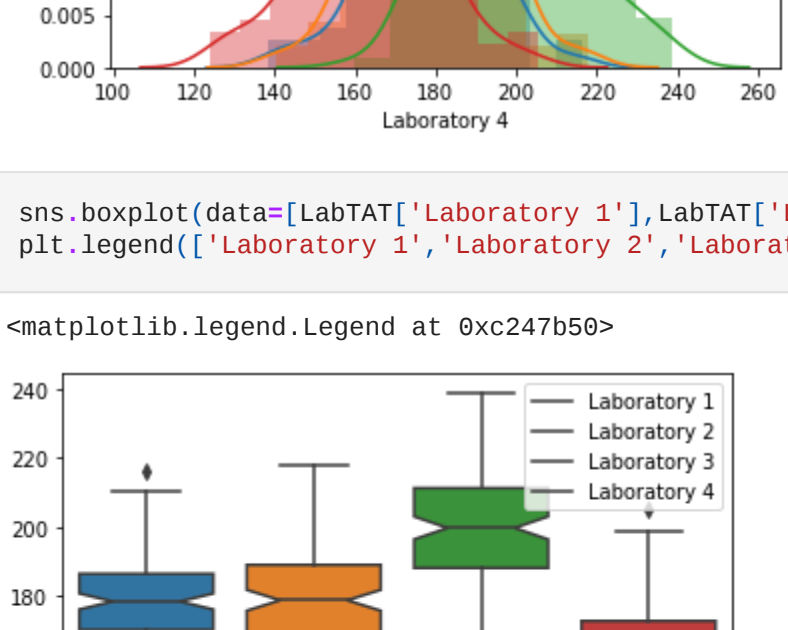
```
C:\Users\rjas\anaconda3\lib\site-packages\seaborn\distributions.py:2557: FutureWarning: `distplot` is a deprecated function and will be removed in
a future version. Please adapt your code to use either `displot` (a figure-level function with similar flexibility) or `histplot` (an axes-level fu
nction for histograms).
  warnings.warn(msg, FutureWarning)
C:\Users\rjas\anaconda3\lib\site-packages\seaborn\distributions.py:2557: FutureWarning: `distplot` is a deprecated function and will be removed in
a future version. Please adapt your code to use either `displot` (a figure-level function with similar flexibility) or `histplot` (an axes-level fu
nction for histograms).
  warnings.warn(msg, FutureWarning)
C:\Users\rjas\anaconda3\lib\site-packages\seaborn\distributions.py:2557: FutureWarning: `distplot` is a deprecated function and will be removed in
a future version. Please adapt your code to use either `displot` (a figure-level function with similar flexibility) or `histplot` (an axes-level fu
nction for histograms).
  warnings.warn(msg, FutureWarning)
C:\Users\rjas\anaconda3\lib\site-packages\seaborn\distributions.py:2557: FutureWarning: `distplot` is a deprecated function and will be removed in
a future version. Please adapt your code to use either `displot` (a figure-level function with similar flexibility) or `histplot` (an axes-level fu
nction for histograms).
  warnings.warn(msg, FutureWarning)
```

Out[39]: <matplotlib.legend.Legend at 0xc0ae310>



In [40]:
```python
sns.boxplot(data=[LabTAT['Laboratory 1'],LabTAT['Laboratory 2'],LabTAT['Laboratory 3'],LabTAT['Laboratory 4']],notch=True)
plt.legend(['Laboratory 1','Laboratory 2','Laboratory 3','Laboratory 4'])
```

Out[40]: <matplotlib.legend.Legend at 0xc247b50>



In [14]:
```python
alpha=0.05
Laboratory1=pd.DataFrame(LabTAT['Laboratory 1'])
Laboratory2=pd.DataFrame(LabTAT['Laboratory 2'])
Laboratory3=pd.DataFrame(LabTAT['Laboratory 3'])
Laboratory4=pd.DataFrame(LabTAT['Laboratory 4'])
print(Laboratory1,Laboratory2,Laboratory3,Laboratory4)
```

```
     Laboratory 1
0          185.35
1          170.49
2          192.77
3          177.33
4          193.41
..            ...
115        178.49
116        176.08
117        202.48
118        182.40
119        182.09

[120 rows x 1 columns]      Laboratory 2
0          165.53
1          185.91
2          194.92
3          183.00
4          169.57
..            ...
115        170.66
116        183.98
117        174.54
118        197.18
119        215.17

[120 rows x 1 columns]      Laboratory 3
0          176.70
1          198.45
2          201.23
3          199.61
4          204.63
..            ...
115        193.80
116        215.25
117        203.99
118        194.52
119        221.49

[120 rows x 1 columns]      Laboratory 4
0          166.13
1          160.79
2          185.18
3          176.42
4          152.60
..            ...
115        172.68
116        177.64
117        170.27
118        150.87
119        162.21

[120 rows x 1 columns]
```

In [6]:
```python
df = LabTAT
```

In [8]:
```python
stats.f_oneway(df.iloc[:,0],df.iloc[:,1],df.iloc[:,2],df.iloc[:,3])
```

Out[8]: F_onewayResult(statistic=118.70421654401437, pvalue=2.1156708949992414e-57)

Anova Test-One way H0:Average of all laboratory are same Ha:Average of atleast 1 laboratory are different # P-value is 0.00 < 0.05= Accept Ha, hence Average of atleast 1 laboratory are different As per results we can say that these are not equal i.e Average of atleast 1 laboratory are different