Two-way ANOVA is used to estimate how the mean of a quantitative variable changes according to the levels of two categorical variables.

In [ ]:
```
# import libraries
import numpy as np
import pandas as pd
import seaborn as sns
import matplotlib.pyplot as plt
```

In [ ]:
```
# creat a dataset

df = pd.DataFrame({'water': np.repeat(['daily','weakly'],15),
                   'sun': np.tile(np.repeat(['low','medium','high'], 5), 2),
                   'height': [6,6,6,5,6,5,5,6,4,5,
                              6,6,7,8,7,3,4,4,4,5,
                              4,4,4,4,4,5,6,6,7,8]})
#Look into data
df.sample(10)
```

Out[ ]:

	water	sun	height
7	daily	medium	6
4	daily	low	6
19	weakly	low	5
3	daily	low	5
13	daily	high	8
8	daily	medium	4
14	daily	high	7
16	weakly	low	4
9	daily	medium	5
2	daily	low	6

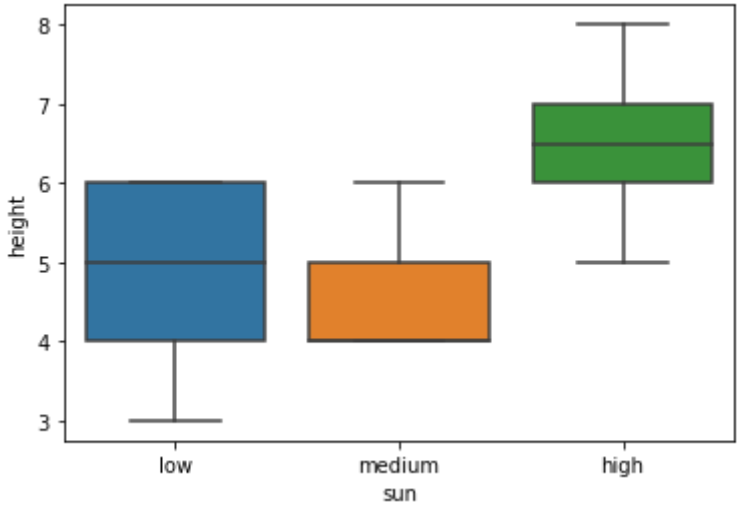
There are 2 catagorical column having 5 catagories ,

1. if 2 catagories in one column : t-test
2. if more than 2 in one column : ANOVA
3. if more than 2 in two columns : two-way-ANOVA

In [ ]:
```
sns.boxplot(df['sun'],df['height']) #one way ANOVA date
```

```
C:\Users\Azka\anaconda3\lib\site-packages\seaborn\_decorators.py:36: FutureWarning:
Pass the following variables as keyword args: x, y. From version 0.12, the only vali
d positional argument will be `data`, and passing other arguments without an explici
t keyword will result in an error or misinterpretation.
  warnings.warn(
```

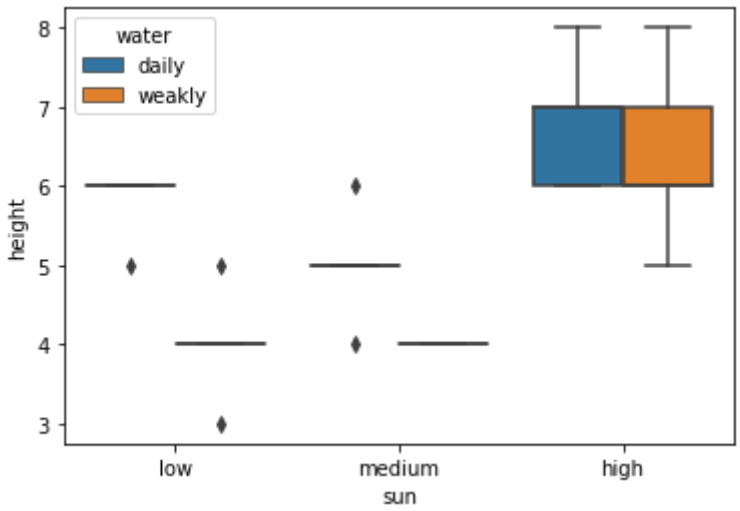
Out[ ]:
```
<AxesSubplot:xlabel='sun', ylabel='height'>
```



In [ ]:
```
sns.boxplot(df['sun'],df['height'], hue=df['water']) # two way ANOVA data
```

```
C:\Users\Azka\anaconda3\lib\site-packages\seaborn\_decorators.py:36: FutureWarning:
Pass the following variables as keyword args: x, y. From version 0.12, the only vali
d positional argument will be `data`, and passing other arguments without an explici
t keyword will result in an error or misinterpretation.
  warnings.warn(
```

Out[ ]:
```
<AxesSubplot:xlabel='sun', ylabel='height'>
```



1. ANOVA METHOD through statsmodels

In [ ]:
```
#import libararies
import statsmodels.api as sm
from statsmodels.formula.api import ols
```

In [ ]:
```
# ANOVA oneway
model=ols('height~sun',data=df).fit()
sm.stats.anova_lm(model,type=2)
```

Out[ ]:

	df	sum_sq	mean_sq	F	PR(>F)
sun	2.0	24.866667	12.433333	14.105042	0.000064
Residual	27.0	23.800000	0.881481	NaN	NaN

- Sun effect on plant height = significant because PR<0.05

In [ ]:
```
# ANOVA Two-Way
model=ols('height~ C(sun) + C(water) + C(sun) : C(water)',data=df).fit()
sm.stats.anova_lm(model,type=2)
```

Out[ ]:

	df	sum_sq	mean_sq	F	PR(>F)
C(sun)	2.0	24.866667	12.433333	23.3125	0.000002
C(water)	1.0	8.533333	8.533333	16.0000	0.000527
C(sun):C(water)	2.0	2.466667	1.233333	2.3125	0.120667
Residual	24.0	12.800000	0.533333	NaN	NaN

- sun effect on plant height = significant because PR<0.05
- water effect on plant height = significant because PR<0.05
- sun+water interactive effect on plant height is not significant because PR > 0.05

2. ANOVA METHOD through pingouin

In [ ]:
```
# example of one way anova
import pingouin as pg
aov = pg.anova(data=df, dv='height', between='sun', detailed=True)
print(aov)
```

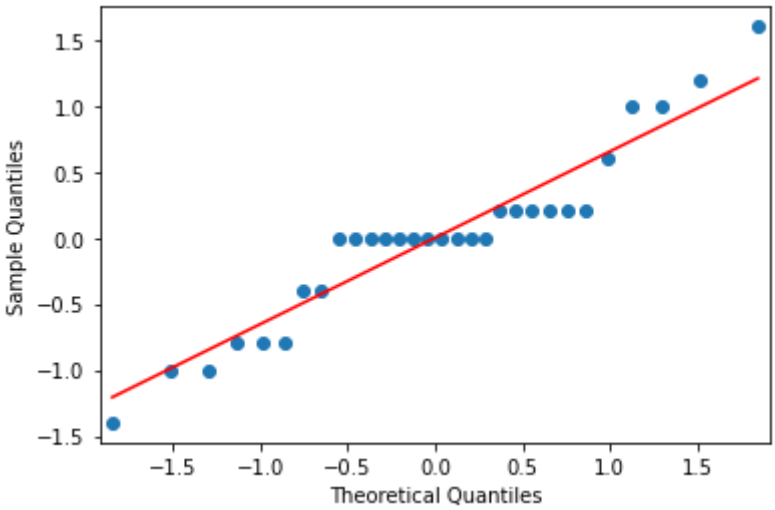
```
   Source          SS  DF         MS          F     p-unc       np2
0     sun   24.866667   2  12.433333  14.105042  0.000064  0.510959
1  Within   23.800000  27   0.881481        NaN       NaN       NaN
```

In [ ]:
```
# example of one way anova
import pingouin as pg
aov = pg.anova(data=df, dv='height', between=['sun','water'], detailed=True)
print(aov)
```

```
        Source          SS  DF         MS        F     p-unc       np2
0          sun   24.866667   2  12.433333  23.3125  0.000002  0.660177
1        water    8.533333   1   8.533333  16.0000  0.000527  0.400000
2  sun * water    2.466667   2   1.233333   2.3125  0.120667  0.161572
3     Residual   12.800000  24   0.533333      NaN       NaN       NaN
```

- Through both methods results are same

In [ ]:
```
# qq norms plot
res = model.resid
fig =sm.qqplot(res,line='s')
plt.show()
```



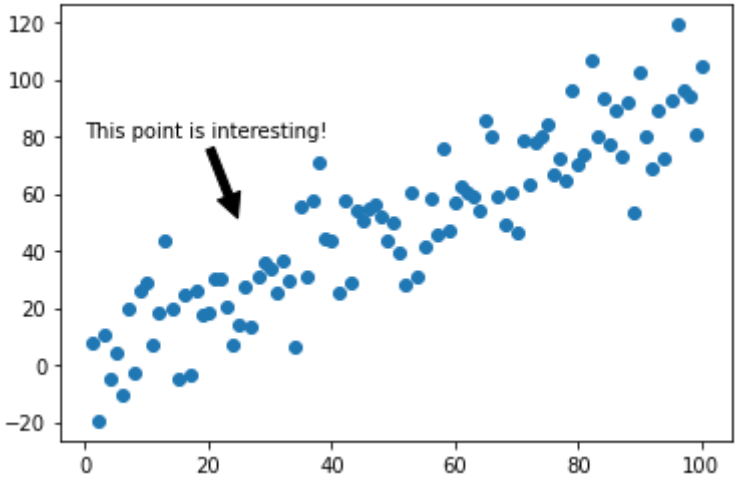
In [ ]:
```
# tukey test kaisy lagana ha 2-way anova py?

from statsmodels.stats.multicomp import pairwise_tukeyhsd

# perform multiple pairwise comparison (Tukey HSD)
tukey= pairwise_tukeyhsd(endog=df['height'], groups=df['water'], alpha=0.05)
print(tukey.summary)
```

```
<bound method TukeyHSDResults.summary of <statsmodels.sandbox.stats.multicomp.TukeyH
SDResults object at 0x00000197881E24C0>>
```

In [ ]:
```
# perform multiple pairwise comparison (Tukey HSD)
tukey= pairwise_tukeyhsd(endog=df['height'], groups=df['sun'], alpha=0.05)
print(tukey.summary)
```

```
<bound method TukeyHSDResults.summary of <statsmodels.sandbox.stats.multicomp.TukeyH
SDResults object at 0x000001978831D520>>
```

In [ ]:
```
#annotation kesy krni h graph me?

# Libraries
import matplotlib.pyplot as plt
import numpy as np
import pandas as pd

#Data
df=pd.DataFrame({'x_pos': range(1,101), 'y_pos': np.random.randn(100)*15+range(1,101

# Basic chart
plt.plot('x_pos', 'y_pos', data=df,  linestyle='none', marker='o')

# Annotate with text + Arrow
plt.annotate(
# Label and coordinate
'This point is interesting!', xy=(25, 50), xytext=(0, 80),

# Custom arrow
arrowprops=dict(facecolor='black', shrink=0.05))

# Show the graph
plt.show()
```


This point is interesting!
120
100
80
60
40
20
0
−20
0
20
40
60
80
100