```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
from scipy.stats import ttest_1samp, ttest_ind, f_oneway
```

1. One-sample t-test

The mass of a sample of N = 20 acorns from a forest subjected to acid rain from a coal power plant are m = [8.8, 6.6, 9.5, 11.2, 10.2, 7.4, 8.0, 9.6, 9.9, 9.0, 7.6, 7.4, 10.4, 11.1, 8.5, 10.0, 11.6, 10.7, 10.3, and 7.0 g]

Does this sample provide enough evidence (alpha = 0.05) to say that the average mass of all acorns is different from 10 g?

```
# 1. One-sample t-test
acorn_sample = [
    18.8, 6.6, 9.5, 11.2, 10.2, 7.4, 8.0, 9.6, 9.9, 9.0,
    7.6, 7.4, 10.4, 11.1, 8.5, 10.0, 11.6, 10.7, 10.3, 7.0
]
population_mean = 10
alpha = 0.05


# Perform one-sample t-test
t_stat_1, p_value_1 = ttest_1samp(acorn_sample, population_mean)
```

```
print("1. One-sample t-test:")
print(f"T-statistic: {t_stat_1:.3f}, P-value: {p_value_1:.3f}")
if p_value_1 < alpha:
    print("Reject the null hypothesis: The average mass of all acorns is different from 10 g.")
else:
    print("Fail to reject the null hypothesis: No sufficient evidence to say the average mass is different from 10 g.")
```

```
1. One-sample t-test:
T-statistic: -0.445, P-value: 0.661
Fail to reject the null hypothesis: No sufficient evidence to say the average mass is different from 10 g.
```

2. Independent (unpaired) two-sample t-test

The mass of N_1 = 20 acorns from oak trees up wind from a coal power plant and N_2 = 30 acorns from oak trees down wind from the same coal power plant are measured. Is the mass of acorns from trees down wind different from the ones from up wind at a significance level of 0.05? The sample sizes are not equal but we will assume that the population variance for sample 1 and sample 2 are equal.

sample up wind:

x1 = [10.8, 10.0, 8.2, 9.9, 11.6, 10.1, 11.3, 10.3, 10.7, 9.7, 7.8, 9.6, 9.7, 11.6, 10.3, 9.8, 12.3, 11.0, 10.4, 10.4]

sample down wind:

x2 = [7.8, 7.5, 9.5, 11.7, 8.1, 8.8, 8.8, 7.7, 9.7, 7.0, 9.0, 9.7, 11.3, 8.7, 8.8, 10.9, 10.3, 9.6, 8.4, 6.6, 7.2, 7.6, 11.5, 6.6, 8.6, 10.5, 8.4, 8.5, 10.2, 9.2]

```
# 2. Independent (unpaired) two-sample t-test
up_wind_sample = [
    10.8, 10.0, 8.2, 9.9, 11.6, 10.1, 11.3, 10.3, 10.7, 9.7,
    7.8, 9.6, 9.7, 11.6, 10.3, 9.8, 12.3, 11.0, 10.4, 10.4
]
down_wind_sample = [
    7.8, 7.5, 9.5, 11.7, 8.1, 8.8, 8.8, 7.7, 9.7, 7.0, 9.0,
    9.7, 11.3, 8.7, 8.8, 10.9, 10.3, 9.6, 8.4, 6.6, 7.2, 7.6,
    11.5, 6.6, 8.6, 10.5, 8.4, 8.5, 10.2, 9.2
]


# Perform independent two-sample t-test
t_stat_2, p_value_2 = ttest_ind(up_wind_sample, down_wind_sample, equal_var=True)


print("\n2. Independent two-sample t-test:")
print(f"T-statistic: {t_stat_2:.3f}, P-value: {p_value_2:.3f}")
if p_value_2 < alpha:
    print("Reject the null hypothesis: The mass of acorns from down-wind trees is different from up-wind trees.")
else:
    print("Fail to reject the null hypothesis: No sufficient evidence to say the masses are different.")
```

```

2. Independent two-sample t-test:
T-statistic: 3.598, P-value: 0.001
```

```
Reject the null hypothesis: The mass of acorns from down-wind trees is different from up-wind trees.
```

3. ANOVA test

The marks obtained by 5 randomly picked students in Mathematics exam from three sections A, B, and C are as follows:

Marks of 5 randomly picked students from Section A

A = [51, 45, 33, 45, 67]

Marks of 5 randomly picked students from Section B

B = [23, 43, 23, 43, 45]

Marks of 5 randomly picked students from Section C

C = [56, 76, 74, 87, 56]

Does the sample provide enough evidence to say that the mean marks of students in the three sections are different?

```
# 3. ANOVA test
section_A = [51, 45, 33, 45, 67]
section_B = [23, 43, 23, 43, 45]
section_C = [56, 76, 74, 87, 56]


# Perform ANOVA test
f_stat, p_value_3 = f_oneway(section_A, section_B, section_C)


print("\n3. ANOVA test:")
print(f"F-statistic: {f_stat:.3f}, P-value: {p_value_3:.3f}")
if p_value_3 < alpha:
    print("Reject the null hypothesis: The mean marks of students in the three sections are different.")
else:
    print("Fail to reject the null hypothesis: No sufficient evidence to say the mean marks are different.")
```

```
3. ANOVA test:
F-statistic: 9.747, P-value: 0.003
Reject the null hypothesis: The mean marks of students in the three sections are different.
```

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