Two-Mean Hypothesis Testing (Data Science Applications)

Here are **5 application-based questions** related to **two-mean hypothesis testing** (both one-tailed and two-tailed) in **data science**, with **given summary statistics** (or data) and **test values (t or z)**. Your students will be required to:

1. Write the null and alternative hypotheses,
2. Use the **given test statistic** to draw conclusions.

Question 1: Two-Tailed t-Test (A/B Testing of Click-Through Rates)

A company compares the average click-through rate (CTR) for two versions of an email campaign.

- Sample A: Mean = 3.8%, SD = 0.5%, n = 30
- Sample B: Mean = 3.5%, SD = 0.6%, n = 28
- Test statistic (t) = 1.96
- Significance level (α) = 0.05

State if the difference in CTR is statistically significant.

Question 2: One-Tailed t-Test (Model Accuracy Comparison)

You are comparing the accuracy of two machine learning models:

- Model X Accuracy: Mean = 91%, SD = 1.2%, n = 20
- Model Y Accuracy: Mean = 89.5%, SD = 1.5%, n = 22
- Test statistic (t) = 2.25
- **α** = 0.05

Is Model X performing better than Model Y?

Question 3: One-Tailed z-Test (User Engagement on Platforms)

A data scientist wants to test if users on Platform A spend **more** time (in minutes) than users on Platform B:

- Platform A: Mean = 52 min, $\sigma = 10$, $n = 50$
- Platform B: Mean = 49 min, $\sigma = 12$, $n = 60$
- Test statistic (z) = 1.85
- $\alpha = 0.05$

Use z-value to conclude if Platform A shows significantly higher engagement.

Question 4: Two-Tailed z-Test (Website Load Time Comparison)

Two website versions are tested for load time:

- Site A: Mean = 2.5 sec, $\sigma = 0.3$, $n = 100$
- Site B: Mean = 2.6 sec, $\sigma = 0.35$, $n = 100$
- $z = -2.12$
- $\alpha = 0.05$

Are the mean load times significantly different?

Question 5: One-Tailed t-Test (Effect of Data Preprocessing)

A team evaluates whether data preprocessing improves model F1 score:

- Without preprocessing: Mean = 0.74, SD = 0.02, $n = 15$
- With preprocessing: Mean = 0.76, SD = 0.015, $n = 15$
- t-statistic = -2.10
- $\alpha = 0.05$

Hypothesis: Preprocessing increases the F1 score.

Variance and 2-Variance Hypothesis Testing (Data Science Applications)

Here are **5 additional questions** related to **tests for 1 variance and 2 variances**, commonly used in **data science and analytics**, complete with summary statistics and **test statistics (chi-square or F values)**:

- Write null and alternative hypotheses,
- Determine the correct test,
- Use the given test statistic to draw conclusions.

Question 6: One-Variance Chi-Square Test (Model Residual Variance)

You are evaluating whether the residuals of a regression model have a variance of 0.05^2.

- Sample variance = 0.006
- Sample size (n) = 20
- Chi-square statistic = 22.8
- Significance level (α) = 0.05

Hypothesis: Residual variance = 0.0025
Test if model variance differs from the theoretical target.

Question 7: One-Variance Chi-Square Test (Sensor Measurement Precision)

A temperature sensor is expected to have a variance of $1°C^2$. After testing:

- Sample variance = 1.4
- Sample size = 25
- Chi-square statistic = 33.6
- α = 0.05

🔷 **Test if the sensor variability is consistent with the specification.**

Question 8: Two-Variance F-Test (Traffic Volume Variability)

Compare daily traffic volume variance on two highways:

- Highway A: n = 20, variance = 2500
- Highway B: n = 25, variance = 1800
- F-statistic = 1.39
- α = 0.05

Test the hypothesis that the traffic variances are equal.

Question 9: Two-Variance F-Test (Model Training Time Variability)

Two ML algorithms are tested for consistency in training time (in seconds):

- Algo X: n = 10, variance = 0.25
- Algo Y: n = 12, variance = 0.10
- F-statistic = 2.5
- α = 0.05

Test if training time variability is significantly different.

Question 10: Two-Variance F-Test (Website Conversion Rate Variability)

You are analyzing the weekly conversion rate for two websites.

- Site A: Variance = 1.2, n = 15
- Site B: Variance = 0.8, n = 20
- F-statistic = 1.5
- α = 0.05

Test if the variability in conversion rates differs significantly.