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STATISTICS ULTIMATE CHEAT SHEET

1. Descriptive Statistics

Measures of Central Tendency

- **Mean (Population/Sample):**

$$\mu = \frac{\sum X}{N}, \quad \bar{x} = \frac{\sum x}{n}$$

- **Median:** Middle value of sorted data.

$$\text{Pos} = \frac{n+1}{2}$$

- **Mode:** Most frequently occurring value.

Measures of Dispersion

- **Variance:**

$$\sigma^2 = \frac{\sum(X-\mu)^2}{N}, \quad s^2 = \frac{\sum(x-\bar{x})^2}{n-1}$$

- **Standard Deviation:**

$$\sigma = \sqrt{\sigma^2}, \quad s = \sqrt{s^2}$$

- **Interquartile Range (IQR):**

$$\text{IQR} = Q_3 - Q_1$$

- **Coefficient of Variation (CV):**

$$\text{CV} = (\frac{s}{\bar{x}}) \times 100\%$$

2. Probability Rules & Formulas

- **Axioms:** $0 \le P(A) \le 1$, $P(S) = 1$
- **Complement:** $P(A') = 1 - P(A)$
- **Addition Rule (General):**

$$P(A \cup B) = P(A) + P(B) - P(A \cap B)$$

- **Mutually Exclusive:** $P(A \cap B) = 0$
- **Conditional Probability:**

$$P(A \mid B) = \frac{P(A \cap B)}{P(B)}, \quad P(B) > 0$$

- **Independence Test:** $P(A \cap B) = P(A)P(B)$
- **Bayes' Theorem:**

$$P(A_i \mid B) = \frac{P(B \mid A_i)P(A_i)}{\sum_j P(B \mid A_j)P(A_j)}$$

3. Discrete Probability Distributions

Binomial Distribution: $X \sim \text{Bin}(n, p)$

$$P(X = k) = \binom{n}{k} p^k (1-p)^{n-k}$$

$$\text{E}[X] = np, \quad \text{Var}(X) = np(1-p)$$

Poisson Distribution: $X \sim \text{Poisson}(\lambda)$

$$P(X = k) = \frac{\lambda^k e^{-\lambda}}{k!}$$

$$\text{E}[X] = \lambda, \quad \text{Var}(X) = \lambda$$

Geometric Distribution: $X \sim \text{Geo}(p)$

$$P(X = k) = (1-p)^{k-1} p$$

$$\text{E}[X] = \frac{1}{p}, \quad \text{Var}(X) = \frac{1-p}{p^2}$$

4. Continuous Probability Distributions

Normal Distribution: $X \sim \mathcal{N}(\mu, \sigma^2)$

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{1}{2}(\frac{x-\mu}{\sigma})^2}$$

Standard Normal Score (Z-Score):

$$Z = \frac{X-\mu}{\sigma} \sim \mathcal{N}(0,1)$$

Exponential Distribution: $X \sim \text{Exp}(\lambda)$

$$f(x) = \lambda e^{-\lambda x} \quad (x \geq 0)$$

$$\text{E}[X] = \frac{1}{\lambda}, \quad \text{Var}(X) = \frac{1}{\lambda^2}$$

5. Sampling & Central Limit Theorem

Central Limit Theorem (CLT): For a sample size $n \geq 30$, the sampling distribution of $\bar{X}$ approaches normal regardless of population shape:

$$\bar{X} \sim \mathcal{N}(\mu, \frac{\sigma^2}{n})$$

Standard Error (SE):

$$\text{SE}_{\bar{x}} = \frac{\sigma}{\sqrt{n}} \approx \frac{s}{\sqrt{n}}, \quad \text{SE}_p = \sqrt{\frac{\hat{p}(1-\hat{p})}{n}}$$

6. Confidence Intervals (CI)

CI for Mean (Known σ or Large n):

$$\bar{x} \pm z_{\alpha/2}(\frac{\sigma}{\sqrt{n}})$$

CI for Mean (Unknown σ, Small n):

$$\bar{x} \pm t_{\alpha/2, df=n-1}(\frac{s}{\sqrt{n}})$$

CI for Population Proportion (p):

$$\hat{p} \pm z_{\alpha/2}\sqrt{\frac{\hat{p}(1-\hat{p})}{n}}$$

7. Hypothesis Testing

General Steps:

1. State H_0 (Null) and H_1 (Alternative).
2. Select significance level α (e.g., 0.05).
3. Compute Test Statistic.
4. Determine Critical Value or p-value.
5. Decision: Reject H_0 if p-value $\leq \alpha$.

Common Test Statistics:

- **1-Sample Z-Test:**

$$Z = \frac{\bar{x}-\mu_0}{\sigma/\sqrt{n}}$$

- **1-Sample t-Test:**

$$t = \frac{\bar{x}-\mu_0}{s/\sqrt{n}}, \quad df = n-1$$

- **2-Sample t-Test (Equal Var):**

$$t = \frac{\bar{x}_1 - \bar{x}_2}{s_p\sqrt{\frac{1}{n_1}+\frac{1}{n_2}}}$$

8. Error Types & Power

	H_0 **True**	H_0 **False**
Reject H_0	Type I Error (α)	Correct ($1-\beta$)
Fail to Reject	Correct ($1-\alpha$)	Type II Error (β)

$$\text{Power} = 1-\beta = P(\text{Reject } H_0 \mid H_0 \text{ is False})$$

9. Linear Regression & Correlation

Pearson Correlation Coefficient (r):

$$r = \frac{\sum(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum(x_i - \bar{x})^2 \sum(y_i - \bar{y})^2}}$$

Simple Linear Regression Model:

$$\hat{Y} = b_0 + b_1 X$$

$$b_1 = \frac{Cov(X,Y)}{Var(X)} = r\frac{s_y}{s_x}, \quad b_0 = \bar{Y} - b_1\bar{X}$$

Coefficient of Determination (R^2):

$$R^2 = \frac{\text{SSR}}{\text{SST}} = 1 - \frac{\text{SSE}}{\text{SST}}$$

10. Chi-Square Test (χ^2)

Goodness of Fit & Independence:

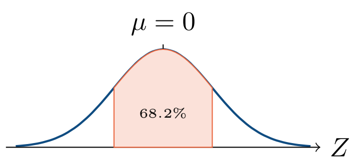
$$\chi^2 = \sum \frac{(O-E)^2}{E}$$

Where O = Observed Frequency, E = Expected Frequency.

Expected (Contingency): $E_{i,j} = \dfrac{\text{Row}_i \text{ Total} \times \text{Col}_j \text{ Total}}{\text{Grand Total}}$

$$df = (r-1)(c-1)$$

11. Key Visual Distributions



Empirical Rule: $\pm 1\sigma = 68.2\%$, $\pm 2\sigma = 95.4\%$, $\pm 3\sigma = 99.7\%$