

Learn these by heart before the exam.

Exploring One-Variable Data

$\bar{x} = \frac{\sum x_i}{n}$, $s_x = \sqrt{\frac{\sum (x_i - \bar{x})^2}{n - 1}}$
Describe a distribution with SOCS: Shape, Outliers, Centre, Spread. In context, always.
Skewed right pulls the MEAN above the median. Use median and IQR for skewed data, mean and s for roughly symmetric.
outlier $\iff x < Q_1 - 1.5\text{IQR}$ or $x > Q_3 + 1.5\text{IQR}$
 $z = \frac{x - \mu}{\sigma}$ how many standard deviations from the mean; unitless
Linear transform $y = a + bx$: centre scales by b and shifts by a; spread scales by |b| only.

Exploring Two-Variable Data

$\hat{y} = a + bx$, $b = r \frac{s_y}{s_x}$, $a = \bar{y} - b\bar{x}$ the line always passes through $(\bar{x}, \bar{y})$
 $r = \frac{1}{n - 1} \sum \left(\frac{x_i - \bar{x}}{s_x} \right) \left(\frac{y_i - \bar{y}}{s_y} \right)$ $-1 \leq r \leq 1$, unitless, and NOT resistant to outliers
 r^2 is the proportion of variation in y explained by the linear model with x. Say it that way.
residual = $y - \hat{y}$ a curved residual plot means a linear model is wrong
Correlation is not causation. Only a randomised EXPERIMENT supports a causal claim.
Influentail point: far in the x direction, moves the line a lot. An outlier in y mainly inflates residuals.

Collecting Data

SRS, stratified (homogeneous groups, sample within each), cluster (sample whole groups), systematic. Say which and why.
Bias sources: voluntary response, undercoverage, nonresponse, question wording. Name the specific one.
Experiment needs: comparison, random assignment, replication, control. Random ASSIGNMENT gives causation; random SELECTION gives generalisability.
Blocking is to experiments what stratifying is to samples: group similar units, then randomise WITHIN each block.
Blind means subjects do not know the treatment. Double-blind means the assessors do not either.

Probability and Random Variables

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

$P(A \mid B) = \frac{P(A \cap B)}{P(B)}$
Independent
 $\iff P(A \mid B) = P(A) \iff P(A \cap B) = P(A)P(B)$. Mutually exclusive is NOT the same as independent.
 $\mu_X = \sum x_i p_i$, $\sigma_X^2 = \sum (x_i - \mu_X)^2 p_i$
 $\mu_{X \pm Y} = \mu_X \pm \mu_Y$, $\sigma_{X \pm Y}^2 = \sigma_X^2 + \sigma_Y^2$ variances ADD even when subtracting, and only if X and Y are independent
 $P(X = k) = \binom{n}{k} p^k (1 - p)^{n - k}$, $\mu = np$, $\sigma = \sqrt{np(1 - p)}$ BINS: Binary, Independent, fixed Number, Same p

$P(X = k) = (1 - p)^{k - 1} p$, $\mu = \frac{1}{p}$

Sampling Distributions

$\mu_{\bar{x}} = \mu$, $\sigma_{\bar{x}} = \frac{\sigma}{\sqrt{n}}$
 $\mu_{\hat{p}} = p$, $\sigma_{\hat{p}} = \sqrt{\frac{p(1 - p)}{n}}$
CLT: for $n \geq 30$ the sampling distribution of $\bar{x}$ is approximately normal WHATEVER the population shape.
10% condition: sampling without replacement needs $n \leq 0.10N$ for independence.
Large counts for proportions: $np \geq 10$ AND $n(1 - p) \geq 10$.

Inference - the common structure

estimate $\pm$ (critical value) $\times$ (standard error)
test statistic = $\frac{\text{statistic} - \text{parameter}}{\text{standard error}}$
Four steps every time: State (hypotheses + α), Plan (name the test + check conditions), Do (statistic + p-value), Conclude (in context).
Interpret a CI: 'We are 95% confident the true [parameter in context] is between A and B.' Never 'the probability is 95%'.
Interpret a p-value: 'the probability of a result at least this extreme IF H_0 were true'.
 $p < \alpha$: reject H_0 , evidence for H_a . $p \geq \alpha$: fail to reject. NEVER 'accept H_0 '.
Type I: reject a true H_0 (probability α). Type II: fail to reject a false H_0 . Power = $1 - P(\text{Type II})$; it rises with larger n, larger α , or a bigger true effect.

Which test to use

$\hat{p} \pm z^* \sqrt{\frac{\hat{p}(1 - \hat{p})}{n}}$, $z = \frac{\hat{p} - p_0}{\sqrt{p_0(1 - p_0)/n}}$ the TEST uses p_0 in the standard error; the INTERVAL uses $\hat{p}$
 $\bar{x} \pm t^* \frac{s_x}{\sqrt{n}}$, $t = \frac{\bar{x} - \mu_0}{s_x / \sqrt{n}}$, $df = n - 1$
 $(\hat{p}_1 - \hat{p}_2) \pm z^* \sqrt{\frac{\hat{p}_1(1 - \hat{p}_1)}{n_1} + \frac{\hat{p}_2(1 - \hat{p}_2)}{n_2}}$ the two-proportion TEST pools: $\hat{p}_c = \frac{X_1 + X_2}{n_1 + n_2}$
 $\chi^2 = \sum \frac{(O - E)^2}{E}$ goodness-of-fit $df = k - 1$; independence/homogeneity $df = (r - 1)(c - 1)$; need every $E \geq 5$
 $b \pm t^* SE_b$, $t = \frac{b}{SE_b}$, $df = n - 2$
Paired data (before/after on the SAME unit) is a ONE-sample t on the differences, not a two-sample test.

Exam technique

Always in context. Name the variable and the population in every conclusion; a generic sentence scores E for essentially correct only if contextual.
Check and STATE conditions: random, 10%, and normal/large counts. Listing them without checking earns nothing.
Show the setup: write the formula with numbers substituted, then the answer. Calculator output alone is not enough.