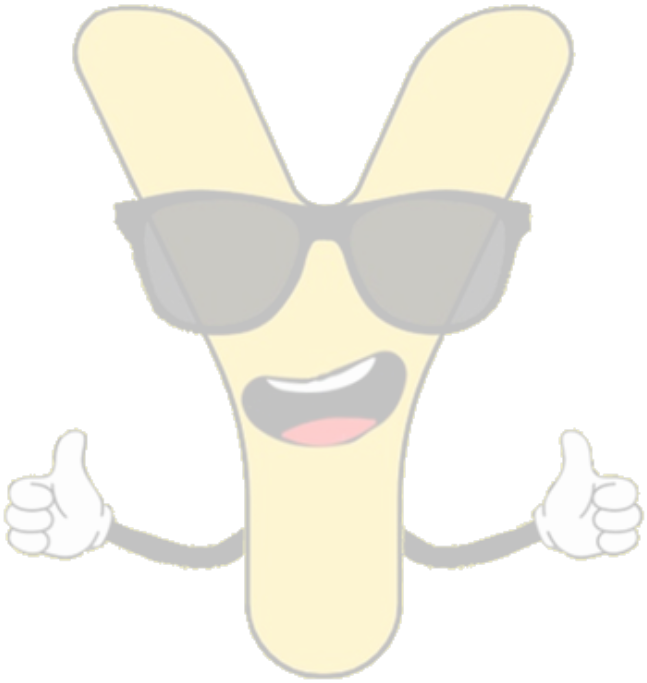
UNIT–4 : Empirical Research and Statistical Analysis (PYQ Solution)

PART–A Answers (≈70 Words Each)

Q1. Define ANOVA. / What is ANOVA principle? (2024, Feb 2024)

ANOVA (analysis of variance) is a statistical test that decides whether the means of three or more groups differ significantly. Principle: compare the variance between group means with the variance within groups; if the ratio $F = MS_B / MS_W$ is larger than the critical value, the group means are not all equal.



PART–B Answers (≈250 Words Each)

Q1. Explain Empirical Research methods for Human-Computer Interaction with suitable example. (2022)

Empirical research collects observed data from real users to test claims about a design, instead of relying on opinion.

Motivation: designer intuition can be wrong, so evidence is needed to show that one design is better, and to find real problems.

Steps:

1. State the **research question**
2. Form hypotheses (H0: no difference; H1: there is a difference)
3. Design the experiment (variables, participants, tasks)
4. Run it and collect data
5. Analyse statistically
6. Draw conclusions and report

Methods:

Method	Use
Controlled experiment	Cause and effect between design and performance
Survey, questionnaire	Opinions and satisfaction from many users
Observation, field study	Behaviour in the real setting
Interview, focus group	Deep understanding of needs
Log analysis	Actual usage data

Example: *Does a larger button reduce selection time?* Independent variable: button size (small, large). Dependent variable: time to select. Twenty participants perform 10 selections for each size. A t-test on the mean times shows whether the difference is significant ($p < 0.05$). If significant, H0 is rejected and large buttons are recommended.

PART–C Answers (≈500 Words Each)

Q1. Discuss in detail about experimental design and data analysis with explanation of one-way ANOVA. (2022)

Experimental design

Variables

- **Independent variable (IV):** manipulated factor with levels (interface design A, B, C)
- **Dependent variable (DV):** measured outcome (task time, errors, satisfaction)
- **Controlled variables:** kept equal (task, screen, instructions)

Hypotheses: H0, all means equal; H1, at least one mean differs.

Designs

Design	Idea	Pros and cons
Between-subjects	Each participant uses one condition	No carry-over, needs more participants
Within-subjects	Each participant uses all conditions	Fewer participants; needs counterbalancing for order effects
Mixed	A combination	Flexible

Other points: random assignment, adequate sample size, a pilot test and ethics (informed consent).

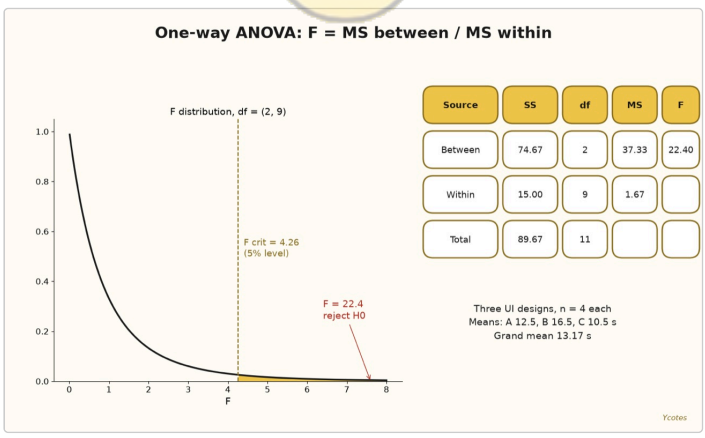
Data analysis

1. **Descriptive statistics:** mean, median, standard deviation, graphs
2. **Inferential tests:** t-test for two groups, **one-way ANOVA** for three or more groups, chi-square for categorical data
3. Report p-value and effect size

One-way ANOVA

It tests H0: $\mu_A = \mu_B = \mu_C$ using one factor. It compares between-group and within-group variance:

$$F = \frac{MS_B}{MS_W} = \frac{SS_B/(k-1)}{SS_W/(N-k)}$$



Example: task times (s) of 4 users on three designs: A: 12, 14, 11, 13; B: 15, 17, 16, 18; C: 10, 9, 11, 12. Means: 12.5, 16.5, 10.5; grand mean 13.17; $N = 12$, $k = 3$.

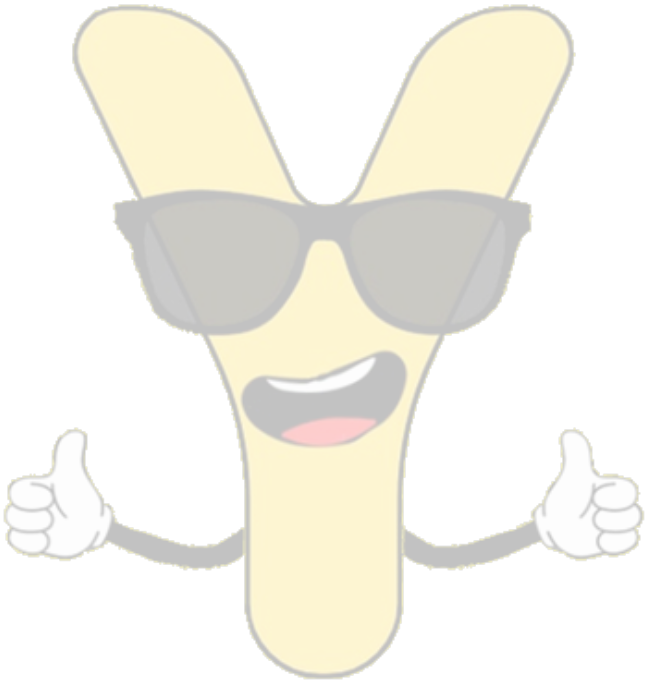
$$SS_B = 4(12.5 - 13.17)^2 + 4(16.5 - 13.17)^2 + 4(10.5 - 13.17)^2 = 1.78 + 44.44 + 28.44 = 74.67$$

$$SS_W = 5 + 5 + 5 = 15$$

Source	SS	df	MS	F
Between	74.67	2	37.33	22.40
Within	15.00	9	1.67	
Total	89.67	11		

The critical value is $F_{0.05}(2, 9) = 4.26$. Because $22.4 > 4.26$ (p < 0.05), **H0 is rejected**: the design affects task time. The effect size is $\eta^2 = 74.67/89.67 = 0.83$. A post-hoc test (Tukey) shows which designs differ; here C is the fastest and B the slowest.

Assumptions: independent observations, approximately normal data, equal variances.



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