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CUET · ECONOMICS · CLASS XI · CODE 309

Measures of Central Tendency

CUET unit: Statistics for Economics

By **UniDrill** · NCERT-grounded study material

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📌 Snapshot

- A whole data set can be summarised with one representative number — a **measure of central tendency**. The three most-used averages are the **Arithmetic Mean, Median and Mode**.
- Both ungrouped and grouped (discrete + continuous) calculation methods apply, including the **Direct, Assumed Mean and Step-Deviation** methods for the A.M.
- Median uses positional logic — **(N+1)/2** (for individual / discrete) and **N/2** (for continuous); quartiles and percentiles extend the same partition idea. Mode is the most frequently occurring value, with an inspection formula for continuous series.
- The empirical relation between the three averages is **Me > Mi > Mo or Me < Mi < Mo** — a heavily tested CUET point.
- CUET regularly asks: which average is suitable in a given situation, the property **$\Sigma(X - \bar{X}) = 0$**, computation of median class via N/2, and the median-lies-between-mean-and-mode rule.
- These measures feed dispersion (kest106) and correlation (kest107) — both depend on the mean and quartiles.

📖 Detailed Notes

2.1 Core concepts

- A **measure of central tendency** summarises a whole set of data into a single representative value so that comparisons (e.g., Baiju's landholding versus other farmers of Balapur) become possible (NCERT §1, pp. 58–59).
- The **three commonly used averages** are Arithmetic Mean, Median and Mode; Geometric Mean and Harmonic Mean exist but are not (NCERT §1, p. 59).
- **Arithmetic Mean (A.M.)** is defined as the sum of values of all observations divided by the number of observations — **$\bar{X} = \Sigma X \div N$** (NCERT §2, p. 59).
- For ungrouped data the A.M. can be found by the **Direct Method** ($\bar{X} = \Sigma X/N$) or, when figures are large, by the **Assumed Mean Method**: **$\bar{X} = A + \Sigma d \div N$**, where d = X – A and A is any value taken as the assumed mean (NCERT §2, pp. 60–61).

- The **Step-Deviation Method** further simplifies arithmetic by dividing each deviation by a common factor c: $\bar{X} = A + (\Sigma d' / N) \times c$, where $d' = (X - A)/c$ (NCERT §2, p. 61).
- For **grouped discrete data** the direct formula is $\bar{X} = \Sigma fX \div \Sigma f$; the assumed-mean version is $\bar{X} = A + \Sigma fd/\Sigma f$ and the step-deviation version is $\bar{X} = A + (\Sigma fd'/\Sigma f) \times c$ (NCERT §2, p. 62).
- For **continuous series**, the same formulas are used after replacing each class by its **mid-value m**; classes may be exclusive, inclusive or of unequal size and the procedure is the same (NCERT §2, p. 63).
- **Two key properties of A.M.** (NCERT §2, p. 63):
- (i) the algebraic sum of deviations of items from the A.M. is always zero: $\Sigma(X - \bar{X}) = 0$.
- (ii) the A.M. is affected by extreme values — any very large or very small value can pull it up or down.
- **Weighted Arithmetic Mean** assigns weights $W_1, W_2, \cdots$ to items by their importance: $\bar{X} = (\Sigma W_i X_i) \div \Sigma W_i$, useful when prices need to be weighted by budget shares (NCERT §2, pp. 63–64).
- **Median** is the positional middle value: it divides the ordered data into two equal halves and is unaffected by the size of extreme values, only by their position (NCERT §3, p. 64).
- For **individual series** the position of the median is the **$[(N+1)/2]^{th}$ item** after arranging the data in order; if N is even, the median is the mean of the two middle observations (NCERT §3, pp. 64–65).
- In a **discrete series** the $(N+1)/2^{th}$ item is located through the cumulative frequency column; the corresponding variable value is the median (NCERT §3, p. 65).
- In a **continuous series** the median class is located by the **$N/2^{th}$ item** (not $(N+1)/2$), and the median is interpolated by **Median = $L + [(N/2 - c.f.)/f] \times h$**, where L = lower limit of median class, c.f. = cumulative frequency of the class preceding it, f = frequency of the median class, h = class width (NCERT §3, p. 66).
- **Quartiles** divide the data into four equal parts: Q_1 has 25% items below it, Q_2 is the median, Q_3 has 75% below it. For ordered series $Q_1 = [(N+1)/4]^{th}$ item and $Q_3 = [3(N+1)/4]^{th}$ item (NCERT §4, pp. 67–68).
- **Percentiles** divide the data into 100 equal parts ($P_1 \cdots P_{99}$); P_{50} is the median. Scoring "82 percentile" means 18% of candidates are above you (NCERT §4, p. 67).
- **Mode** is the value occurring most frequently in the data, denoted Mo. A series can be unimodal, bimodal, multimodal, or have no mode if every value appears the same number of times (NCERT §5, p. 68).
- For **continuous series**, the **modal class** is the class with the largest frequency, and **Mode = $L + [D_1/(D_1 + D_2)] \times h$**, where $D_1 = |f_1 - f_0|$ (modal – preceding) and $D_2 = |$

$f_1 - f_2|$ (modal − succeeding), h = class width; class intervals must be equal and exclusive (NCERT §5, p. 69).

- **Relative position**: the three averages obey **Me > Mi > Mo** or **Me < Mi < Mo** (suffixes in alphabetical order); the median always lies between the arithmetic mean and the mode (NCERT §6, p. 70). For a symmetric distribution, Me = Mi = Mo.
- **Conclusion**: A.M. is simple and uses all observations but is distorted by extremes; median is better for such data and for open-ended distributions; mode is best for qualitative data and is easily found graphically (NCERT §7, p. 70).
- **Baiju's-landholding example**: whether Baiju with 7 acres is a "small", "medium" or "large" farmer of Balapur depends on comparison with an **average** landholding of the village (NCERT §1, p. 58). A one-number summary is needed before any qualitative judgement.
- **Why three averages, not one**: each captures a different facet of "centre" — A.M. measures arithmetic balance, median the positional middle, mode the most typical value. NCERT explicitly says "no one measure is ideal in all situations", which is the basis of the "suitability" CUET MCQs (NCERT §1, p. 59).
- **Direct method illustration (NCERT p. 60)**: marks of 5 students 40, 50, 55, 78, 58. $\bar{X}$ = (40+50+55+78+58)/5 = 281/5 = 56.2. The mean of 56.2 is not itself an observation — a typical feature of arithmetic means.
- **Assumed-mean rationale**: when raw values are large or unwieldy (incomes in thousands, prices in lakhs), subtracting an assumed mean A reduces the arithmetic burden. The crucial identity is $\bar{X}$ = A + (mean of deviations) — true for any choice of A, with computational ease maximised when A lies near the centre (NCERT §2, p. 61).
- **Step-deviation rationale**: when all deviations share a common factor c (typical when class widths are equal), dividing by c shrinks the numbers further. The end formula $\bar{X} = A + (\Sigma fd'/\Sigma f) \times c$ must therefore be **re-multiplied** by c — a step students frequently forget, giving the wrong answer (NCERT §2, p. 61).
- **Continuous-series A.M. example (Table 5.3)**: marks-classes 0–10, 10–20, ⋯, 60–70 with class-marks 5, 15, ⋯, 65 and frequencies summing to 100; using direct method $\Sigma fm = 3014$, so $\bar{X}$ = 3014/100 = 30.14. The same answer emerges from the step-deviation method with A = 35, c = 10 (NCERT §2, p. 63) — a useful cross-check for CUET MCQs.
- **Property $\Sigma(X - \bar{X}) = 0$ — quick proof**: $\Sigma(X - \bar{X}) = \Sigma X - N\bar{X} = \Sigma X - N(\Sigma X/N) = 0$. This identity is why **deviations from the mean cannot be summed to get a measure of dispersion**; one must square them or take absolutes (motivating kest106) (NCERT §2, p. 63).
- **Weighted A.M. example**: a student scores 60, 70, 80 in three subjects with weights 1, 2, 3 (credit hours). Weighted mean = (60×1 + 70×2 + 80×3)/(1+2+3) = (60+140+240)/6 = 440/6 ≈ 73.3, whereas simple mean is 70. The two differ whenever items have unequal importance (NCERT §2, pp. 63–64).

- **Median advantage in open-ended classes**: in an income distribution with the top class "₹1,00,000 and above", the A.M. cannot be computed without assuming an upper limit for the open class, but the median is computable so long as the median class is below the open class — making median the **preferred** summary for income, wealth and other open-ended variables (NCERT §3, p. 70, conclusion).
- **Quartile coefficient and box plots (implicit)**: $Q_3 - Q_1$ is the inter-quartile range that becomes the basis of the **quartile deviation** measure in kest106; the box plot drawn around (Q_1, Q_2, Q_3) is a graphical summary that combines the median with dispersion in one picture (NCERT §4, pp. 67–68).
- **Mode practical use**: mode is the measure used in **fashion-merchandising** (which shoe size to stock most), in **public transport planning** (most common commute distance) and in **survey design** (most common response option) — all qualitative or quasi-qualitative settings where averaging numerically makes little sense (NCERT §5, p. 68).
- **Bimodal distribution diagnostic**: if a histogram shows two peaks, the population is likely a **mixture of two sub-populations** (e.g., heights of men + women plotted together) — a single mode would conceal this fact, illustrating why summary statistics must be paired with visualisation (NCERT §5, p. 68).
- **Empirical relation in words**: in a **positively skewed** distribution (long right tail, like income), mean > median > mode; in a **negatively skewed** distribution (long left tail, like age at retirement), mean < median < mode. The median is always sandwiched, which is the operational meaning of "median lies between mean and mode" (NCERT §6, p. 70).
- **Choice algorithm (NCERT §7 paraphrased)**: (i) data qualitative → mode; (ii) data has open classes or extreme values → median; (iii) data symmetric, no extremes, every observation should count → mean; (iv) items have unequal importance → weighted mean. CUET often poses this as a "which measure is suitable in situation X" item.

2.2 Definitions to memorise

Term	Definition	Page
Measure of central tendency	A single value summarising a data set, representing its centre	58
Arithmetic Mean ($\bar{X}$)	Sum of observations divided by number of observations ($\Sigma X/N$)	59
Direct Method (A.M.)	Computation $\bar{X} = \Sigma X/N$ using actual values	60
Assumed Mean Method	Computation $\bar{X} = A + \Sigma d/N$ using deviations from an assumed mean A	61
Step-Deviation Method	Computation $\bar{X} = A + (\Sigma d'/N) \times c$ using scaled deviations	61
		63

Term	Definition	Page
Weighted Arithmetic Mean	Mean computed after multiplying each item by an assigned weight	
Property of A.M. (zero deviation)	$\Sigma(X - \bar{X}) = 0$ — sum of deviations from the mean is zero	63
Property of A.M. (sensitivity)	A.M. is affected by extreme values	63
Median	Middle positional value when data are arranged in order of magnitude	64
Median class	Class containing the $N/2^{th}$ item in a continuous series	66
Median formula (continuous)	$L + [(N/2 - c.f.) \div f] \times h$	66
Quartile (Q_1, Q_3)	Values dividing ordered data into four equal parts	67
Percentile ($P_1 \cdots P_{99}$)	Values dividing ordered data into 100 equal parts	67
Mode (Mo)	Value occurring most frequently in the data	68
Modal class	Class with the highest frequency in a continuous distribution	69
Mode formula (continuous)	$L + [D_1 \div (D_1 + D_2)] \times h$	69
Unimodal / Bimodal	Distribution with one / two modes	68
Empirical relation	Me > Mi > Mo or Me < Mi < Mo; median lies between mean and mode	70
Symmetric distribution	Mean = Median = Mode	70
Assumed mean (A)	Working mean chosen to simplify arithmetic in calculation of A.M.	61
Class mid-value (m)	Average of upper and lower limits, used for grouped-data A.M.	63
Cumulative frequency (c.f.)	Running total of frequencies used to find median class	66
Class width (h)	Difference between upper and lower class limits	66
Open-ended class	Class with no specified lower or upper bound; median is preferred when present	70
Skewness	Asymmetry that produces Me ≠ Mi ≠ Mo	70

2.3 Diagrams / processes to remember

- **Direct-method worked example** for ungrouped A.M. (marks 40, 50, 55, 78, 58 → $\bar{X} = 56.2$), p. 60.

- **Table 5.1** — computation of A.M. by assumed-mean method for weekly family income; $A = 850$, $\Sigma d = 2,660$, $N = 10$, $\bar{X} =$ ₹1,116, p. 61.
- **Table 5.2** — discrete-series A.M. by direct method (plots of 100/200/300 sq m; $\bar{X} =$ 126.92 sq m), p. 62.
- **Table 5.3** — continuous-series A.M. for student marks using both direct ($\bar{X} = \Sigma fm/\Sigma f = 30.14$) and step-deviation methods ($A = 35$, $c = 10$), p. 63.
- **Table 5.5** — discrete-series median via cumulative frequency (median income = ₹30), p. 66.
- **Table 5.6** — continuous-series median, daily wages of factory workers (median = ₹35.83), p. 67.
- **Unimodal vs Bimodal distribution sketch** illustrating Mode, p. 68.
- **Table 5.7** — conversion of a "less-than" cumulative frequency table into an ordinary frequency table to find Mode (Mo = ₹27,273), p. 69.
- **Average decision flow**: identify data type (qualitative / quantitative) → check for extremes or open-ended classes → choose A.M., median or mode → compute using direct or assumed-mean method.
- **Full worked A.M. (continuous, step-deviation)** using NCERT Table 5.3-style data: classes 0–10, 10–20, 20–30, 30–40, 40–50, 50–60, 60–70 with frequencies 5, 12, 15, 25, 18, 15, 10 ($\Sigma f = 100$). Take $A = 35$, $c = 10$, so $d' = (m - 35)/10 = -3, -2, -1, 0, 1, 2, 3$. Then $fd' = -15, -24, -15, 0, 18, 30, 30 = 24$. $\bar{X} = 35 + (24/100) \times 10 = 35 + 2.4 = 37.4$. Same data via direct method: $\Sigma fm = 5\times5 + 12\times15 + 15\times25 + 25\times35 + 18\times45 + 15\times55 + 10\times65 = 25 + 180 + 375 + 875 + 810 + 825 + 650 = 3740 \rightarrow \bar{X} = 3740/100 = 37.4$ ✓.
- **Full worked median (continuous)** for the same data: cumulative frequencies are 5, 17, 32, 57, 75, 90, 100; $N/2 = 50$, which falls in the class 30–40 (since cumulative $32 < 50 \leqslant 57$). $L = 30$, c.f. = 32, $f = 25$, $h = 10$. Median $= 30 + ((50 - 32)/25) \times 10 = 30 + (18/25) \times 10 = 30 + 7.2 = 37.2$.
- **Full worked mode (continuous)** for the same data: highest frequency = 25 in class 30–40, so $L = 30$, $f_1 = 25$, $f_0 = 15$, $f_2 = 18$, $h = 10$. $D_1 = |25 - 15| = 10$, $D_2 = |25 - 18| = 7$. Mode $= 30 + (10/(10+7)) \times 10 = 30 + 5.88 = 35.88$. The three averages are $\bar{X} \approx 37.4$, Me ≈ 37.2, Mo ≈ 35.88 — consistent with the empirical ordering Mean > Median > Mode for a slightly positively-skewed distribution, and the rough rule Mode ≈ 3 Median − 2 Mean = 3(37.2) − 2(37.4) = 111.6 − 74.8 = 36.8 (close to 35.88, confirming the approximation).
- **Quartile worked example**: ordered series 12, 18, 22, 25, 28, 32, 35, 38, 41, 44, 46 ($N = 11$). Q_1 position $= (11+1)/4 = 3$, so $Q_1 = 22$ (3rd value); Q_2 position $= (11+1)/2 = 6$, so median = 32; Q_3 position $= 3(11+1)/4 = 9$, so $Q_3 = 41$. Inter-quartile range $Q_3 - Q_1 = 41 - 22 = 19$ — the dispersion summary that kest106 will build on.

2.5 Key formulas

Formula	Meaning	NCERT page
$\bar{X} = \Sigma X \div N$	Direct A.M. for ungrouped data	60
$\bar{X} = A + \Sigma d \div N$	Assumed Mean Method (ungrouped)	61
$\bar{X} = A + (\Sigma d'/N) \times c$	Step-Deviation Method	61
$\bar{X} = \Sigma fX \div \Sigma f$	A.M. for discrete grouped data	62
$\bar{X} = \Sigma fm \div \Sigma f$	A.M. for continuous grouped data	63
$\bar{X} = (\Sigma W_i X_i) \div \Sigma W_i$	Weighted A.M.	63
Median position (individual/discrete) = (N+1)/2	Locate middle item	64
Median position (continuous) = N/2	Locate median class	66
Median = L + [(N/2 − c.f.) ÷ f] × h	Continuous-series interpolation	66
Q_1 position = (N+1)/4; Q_3 position = 3(N+1)/4	Quartile locators	67
Mode = L + [D_1 ÷ (D_1 + D_2)] × h	Continuous-series mode	69
Empirical relation	Median lies between mean and mode	70
$\Sigma(X - \bar{X}) = 0$	Sum of deviations from A.M. is zero	63

2.4 Common confusions / NTA trap points

- For continuous-series median use **N/2**; for individual/discrete series use **(N+1)/2**. NTA loves swapping these.
- **Σ of deviations from A.M. is zero** — but this is NOT true for deviations taken from the median.
- A.M. is affected by extreme values; **median and mode are not** — the median depends only on position, not magnitude of extremes.
- For Mode in continuous series, class intervals must be **equal and exclusive**; convert if given inclusive/unequal.
- The empirical relation is **Me > Mi > Mo or Me < Mi < Mo** — the median is the middle one of the three. "Median equals mean" holds only for symmetric data.
- Mode in a "less than" cumulative frequency table cannot be read directly — convert to an ordinary frequency distribution first.
- **Weighted A.M.** is different from the simple A.M.; do not interchange the formulas.
- **Q_2 is the median**, not Q_1 or Q_3.

- **P_{50} is the median**; "82 percentile" means 82% are below, 18% above.
- Geometric and harmonic means are **not** developed in this chapter — distractors that ask "best average for ratios" should be flagged as outside-syllabus for kest105.
- The **mode formula has D_1 in the numerator**, not D_2.
- The **step-deviation correction** multiplies the deviation sum by c, the common divisor — forgetting c is a frequent error.

🎯 Practice MCQs

Q1. Which of the following is the most suitable measure of central tendency for qualitative data such as the most popular shoe size or shirt style?

A. Arithmetic Mean

B. Median

C. Mode

D. Weighted Arithmetic Mean

Q2. The algebraic sum of the deviations of a set of n values from their arithmetic mean is:

A. n

B. 0

C. 1

D. Equal to the mean itself

Q3. In a continuous frequency distribution, the median class is located by the value of which item?

A. $(N + 1)/2^{th}$ item

B. $N/2^{th}$ item

C. $(N - 1)/2^{th}$ item

D. $3N/4^{th}$ item

📊 PYQ Alignment

This chapter is among the highest-yielding for CUET (UG) Statistics for Economics — roughly 6–8 MCQs appear every year across 2023–25, typically a mix of (a) "which average is suitable" applied questions (qualitative data → mode, open-ended series → median, ratios → geometric mean), (b) property-based factual questions ($\Sigma(X - \bar{X}) = 0$; mean affected by extremes), (c) formula/positional questions (median class via N/2 in continuous series, $Q_1 = (N+1)/4^{th}$ item) and (d) the empirical relation Me–Mi–Mo. Direct numerical plug-in MCQs using small datasets (5–10 observations) are also common. See previous CUET PYQs on this chapter.