Cumulative frequency

95 marks

Hints online, answers free with an account: mathswariz.uk/worksheets/a-level-statistics-cumulative-frequency/

Date

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A Do Now

Quick questions to start. Some use earlier lessons; some set a slip that costs marks.

A1 Needed today [3 marks]

The table shows the times, t minutes, of 40 phone calls. Use linear interpolation to estimate the median time.

Time, t (minutes)	Frequency
$0 < t \leq 10$	8
$10 < t \leq 20$	15
$20 < t \leq 30$	11
$30 < t \leq 40$	6

Answer .....

A2 Common slip [2 marks]

Lengths are measured to the nearest centimetre. One class is written 15 to 19. Write down the class boundaries and the class width.

Answer .....

A3 Common slip [2 marks]

In a cumulative frequency table, the row for $20 < t \leqslant 30$ has cumulative frequency 15. State the point that is plotted for this row on a cumulative frequency graph.

Answer .....

A4 Common slip [2 marks]

For 120 values, state the position of the 90th percentile, and the position of the value that 25% of the data lie below.

Answer .....

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PART 1 Drawing a cumulative frequency graph

EXAMPLE 1 · I DO

The table shows the heights, h cm, of 60 plants. Complete a cumulative frequency table, and list the points to plot for a cumulative frequency graph.

Height, h (cm)	Frequency
$140 < h \leq 150$	8
$150 < h \leq 160$	12
$160 < h \leq 170$	20
$170 < h \leq 180$	16
$180 < h \leq 190$	4

Hint Keep a running total of the frequencies. Each running total is plotted at the TOP of its class: it counts every plant up to that height.

YOUR TURN · WE DO

B1 The table shows the times, t seconds, taken by 60 students to solve a puzzle. Find the cumulative frequencies, and list the points to plot for a cumulative frequency graph. [4 marks]

Time, t (seconds)	Frequency
$0 < t \leq 5$	6
$5 < t \leq 10$	14
$10 < t \leq 15$	22
$15 < t \leq 20$	10
$20 < t \leq 30$	8

Answer .....

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C1 The table shows the reaction times, r milliseconds, of 40 drivers. Find the cumulative frequencies, and list the points to plot for a cumulative frequency graph. [3 marks]

Reaction time, r (ms)	Frequency
$200 < r \leq 250$	3
$250 < r \leq 300$	9
$300 < r \leq 350$	16
$350 < r \leq 400$	8
$400 < r \leq 450$	4

Answer .....

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C2 The table shows the times, t minutes, of 50 runners. Leo plots the cumulative frequencies at $5, 15, 25, 35$. Explain his mistake, and list the points he should plot. [3 marks]

Time, t (minutes)	Frequency
$0 < t \leq 10$	6
$10 < t \leq 20$	14
$20 < t \leq 30$	20
$30 < t \leq 40$	10

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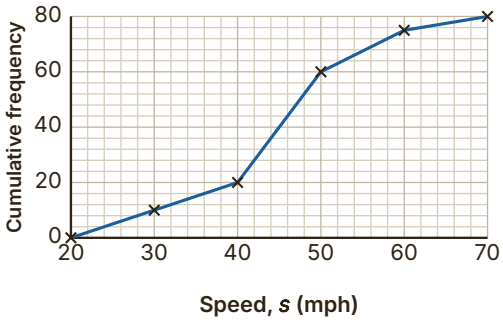
PART 2 Reading values from a cumulative frequency graph

EXAMPLE 2 · I DO

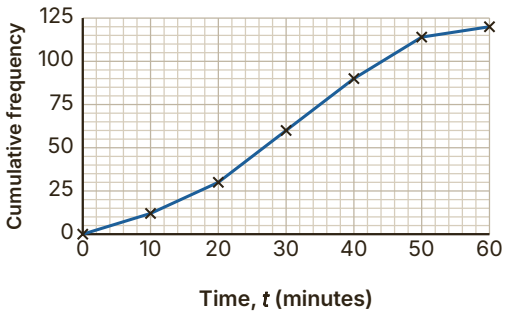
The cumulative frequency graph shows the speeds, s mph, of 80 cars. The points are joined with straight lines. Estimate the median, the quartiles, the interquartile range, and the 10th to 90th percentile range.



Hint Find the position first: $\frac{80}{4}$, $\frac{80}{2}$, $\frac{3\times80}{4}$, then $\frac{10}{100}\times 80$ and $\frac{90}{100}\times 80$. Go across from that cumulative frequency to the graph, then down.

YOUR TURN · WE DO

B2 The graph shows the times, t minutes, that 120 people waited at a clinic. The points are joined with straight lines. Estimate the median, the interquartile range, and the 10th to 90th percentile range. [5 marks]



Answer .....

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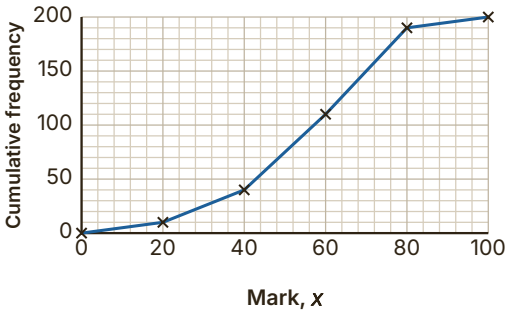
EXAMPLE 3 · I DO

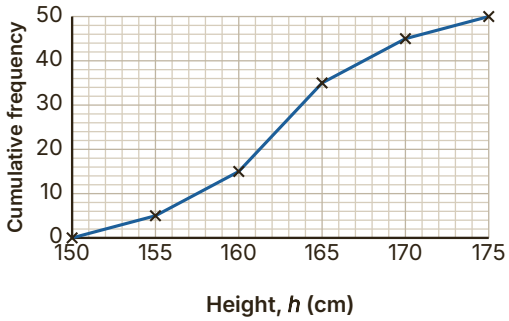
The graph shows the marks of 200 students in an exam, joined with straight lines. (a) Estimate how many students scored more than 70. (b) The top 20% of students get a distinction. Estimate the lowest mark for a distinction. (c) 80% of students pass. Estimate the pass mark.



Hint "More than 70" is the total take away the number up to 70. The top 20% are the 40 highest marks, so the cut-off is the 160th value.

YOUR TURN · WE DO

B3 The graph shows the heights, h cm, of 50 students, joined with straight lines. Estimate (i) the number taller than 162 cm, (ii) the number with heights between 158 cm and 168 cm, (iii) the height above which the tallest 30% lie. [5 marks]



Answer .....

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C3 The table shows the times, t minutes, of 50 runners. A cumulative frequency graph is drawn, with the points joined by straight lines. Nia is asked to estimate how many took more than 34 minutes. She reads 44 from the graph and writes "44 runners". Explain her mistake and give the correct estimate. [4 marks]

Time, t (minutes)	Frequency
$0 < t \leq 10$	6
$10 < t \leq 20$	14
$20 < t \leq 30$	20
$30 < t \leq 40$	10

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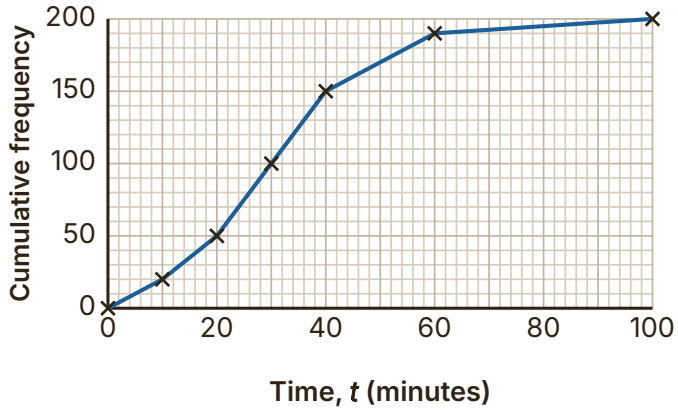
C4 The graph shows the journey times, t minutes, of 200 workers. The points are joined with straight lines.



(a) Estimate the median and the interquartile range. [3 marks]

Answer .....

(b) The 20 workers with the longest journeys are given a parking space. Estimate the shortest journey time that gets a parking space. [2 marks]

Answer .....

Total for C4: 5 marks

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PART 3 Linear interpolation from a table

EXAMPLE 4 · I DO

The ages, in whole years, of the 100 members of a club are shown in the table. The youngest member is 21 and the oldest is 68. Use linear interpolation to estimate the median and the quartiles, and give the five values needed for a box plot.

Age (years)	Frequency
20 to 29	15
30 to 39	25
40 to 49	30
50 to 59	20
60 to 69	10

Hint Age is counted in completed years, so 20 to 29 means $20 \leqslant a < 30$. The boundaries are $20, 30, 40, \ldots$. Find positions 25, 50 and 75 and interpolate.

YOUR TURN · WE DO

B4 The lengths of 60 leaves were measured to the nearest centimetre. Use linear interpolation to estimate the median and the interquartile range. [5 marks]

Length (cm)	Frequency
10 to 14	6
15 to 19	14
20 to 24	24
25 to 29	12
30 to 34	4

Answer .....

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C5 The table shows the times, t minutes, of 120 runners in a race. The fastest 10% receive a medal. Ava says the time needed for a medal is the 90th percentile, 43.3 minutes. Explain her mistake, and estimate the time needed for a medal. [4 marks]

Time, t (minutes)	Frequency
$20 < t \leq 25$	6
$25 < t \leq 30$	18
$30 < t \leq 35$	42
$35 < t \leq 40$	36
$40 < t \leq 50$	18

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C6 For the data in the table, Josh estimates the upper quartile as $15 + \dfrac{37.5 - 20}{24} \times 10 = 22.3$. Explain his mistake, and estimate the upper quartile correctly. [4 marks]

Distance, d (km)	Frequency
$0 < d \leq 5$	4
$5 < d \leq 15$	16
$15 < d \leq 30$	24
$30 < d \leq 50$	6

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PART 4 Finding an unknown frequency

EXAMPLE 5 · I DO

The table shows the times, t minutes, that 60 people spent in a shop. The median time is 17 minutes. Find x and y.

Time, t (minutes)	Frequency
$0 < t \leq 10$	9
$10 < t \leq 20$	x
$20 < t \leq 30$	y
$30 < t \leq 40$	12

Hint The median is the 30th value. 17 is in $10 < t \leqslant 20$, so write the interpolation with x as the frequency of that class.

YOUR TURN · WE DO

B5 The table shows the masses, m kg, of 80 parcels. The lower quartile is 7.5 kg. Find a and b, and estimate the median. [4 marks]

Mass, m (kg)	Frequency
$0 < m \leq 5$	10
$5 < m \leq 10$	a
$10 < m \leq 15$	b
$15 < m \leq 20$	20

Answer .....

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C7 The table shows the distances, d km, cycled by 80 riders. The median, estimated by linear interpolation, is 36 km. Find p and q. [4 marks]

Distance, d (km)	Frequency
$0 < d \leq 20$	12
$20 < d \leq 40$	p
$40 < d \leq 60$	q
$60 < d \leq 80$	16

Answer .....

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C8 The table shows the ages, a years, of 50 people at an event. The median age, estimated by linear interpolation, is 35 years. Find the values of x and y, and estimate the upper quartile. [7 marks]

Age, a (years)	Frequency
$20 < a \leq 30$	12
$30 < a \leq 40$	x
$40 < a \leq 50$	y
$50 < a \leq 60$	8

Answer .....

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D1 The lengths, l cm, of 120 fish caught in a lake are summarised in the table.

Length, l (cm)	Frequency
$10 < l \leq 20$	8
$20 < l \leq 30$	22
$30 < l \leq 40$	40
$40 < l \leq 50$	30
$50 < l \leq 60$	14
$60 < l \leq 80$	6

(a) Find the cumulative frequencies. [2 marks]

Answer .....

(b) Use linear interpolation to estimate the median and the interquartile range. [4 marks]

Answer .....

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(c) Estimate the number of fish longer than 55 cm. [2 marks]

Answer .....

(d) The shortest fish is 12 cm and the longest is 76 cm. An outlier is a value more than $1.5 \times \mathrm{IQR}$ below Q_1 or above Q_3. Show that the longest fish is an outlier and the shortest is not. [3 marks]

Answer .....

Total for D1: 11 marks

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D2

> The table shows the masses, m grams, of 40 apples. Kemi estimates the median: "The median is the 20th value. It is in $40 < m \leqslant 60$, so the median is $40 + \dfrac{20 - 16}{30} \times 10 = 41.3$ g."

Kemi is wrong.

Mass, m (g)	Frequency
$0 < m \leq 20$	6
$20 < m \leq 40$	10
$40 < m \leq 60$	14
$60 < m \leq 100$	10

(a) Identify Kemi's two mistakes, and estimate the median correctly. [4 marks]

(b) Estimate the interquartile range. [3 marks]

Answer .....

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(c) The actual masses were later found to give a median of 47 g. [2 marks]
Give a reason why the estimate in (a) is different.

Total for D2: 9 marks

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E Extension

Stretch

No route is given. The hints are at the end of the sheet. Use one at a time.

E1 The table shows the distances, d km, that some people travel to work. The median, estimated by linear interpolation, is 20 km, and the lower quartile is 12.5 km. Find a, b and the total number of people. Estimate the interquartile range and the 90th percentile. [9 marks]

Distance, d (km)	Frequency
$0 < d \leq 10$	a
$10 < d \leq 20$	20
$20 < d \leq 30$	b
$30 < d \leq 40$	10

Answer .....

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Extension hints

Cover these with paper. Uncover one at a time.

E1

Hint 1 Let $n = a + 30 + b$. The median is the $\frac{n}{2}$th value, and it is exactly 20, the top of the second class.

Hint 2 So the number up to 20 km, $a + 20$, is equal to $\frac{n}{2}$. That gives one equation in a and b.

Hint 3 $Q_1 = 12.5$ is in $10 < d \leqslant 20$: $10 + \frac{\frac{n}{4} - a}{20} \times 10 = 12.5$. Write n in terms of a and solve.

How did it go?

Colour one circle on each line: not yet, nearly, yes.

I can draw a cumulative frequency graph, plotting each point at the upper class boundary. ○ ○ ○

I can read the median, the quartiles and percentiles from a cumulative frequency graph and find them by linear interpolation. ○ ○ ○

I can estimate how many values lie above, below or between given values, and find a cut-off for a given percentage. ○ ○ ○

I can find unknown frequencies from a given median or quartile. ○ ○ ○

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