NUMERICAL REASONING FORMULA SHEET

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Averages

The average, or 'mean', is found by adding up all the values in the dataset and dividing the total by the number of values.

$$\text{Average} = \frac{Sum\ of\ Values}{Number\ of\ Values}$$

Let's go through a quick practice question…

Q: What is the average of the following data set?

Data set: 4, 27, 60, 90, 133

$$\text{Average} = \frac{4,27,60,90,133}{5}$$

$$\text{Average} = \mathbf{62.8}$$

There are also **weighted averages**, do not be fooled into thinking the question is asking for a standard average – these are different.

$$\text{Weighted Average} = \frac{Sum\ of\ Weighted\ Values}{Number\ of\ Values}$$

We will go through an example question which will highlight the importance of being able to identify a weighted value question.

Q: 15 school children take a test and score an average of 70% between them. The next day 5 more children take the same test and score an average of 80%. What is the combined average score for all these children?

Now it may seem tempting to say the average is 75% because the two averages are 70 and 80, and 75 is in the middle right?

However, this doesn't consider the weight of the two averages…

There are 15 children who make up the 70% average, compared with 5 children generating the 80% average.

As the 70% average score contains a larger number of values, **we must weight our new average accordingly.**

$$\text{Sum of weighted values} = (15 \times 70) + (5 \times 80)$$

$$= 1450$$

$$\text{Weighted Average} = \frac{1450}{20}$$

$$= \mathbf{72.5\%}$$

Percentages

Percent literally means 'per 100'. When we work out percentages, we are presenting a number as parts per hundred.

$$\text{Percent} = \frac{Value}{Total} \times 100$$

The difficulty with percentages arises when we must work out **percentage changes** and **increases/decreases.**

Percentage Change

Here are the two formulas you will need discovering the percentage changes:

$$\% \text{ Increase} = \frac{New\ Number - Original\ Number}{Original\ Number} \text{ x } 100$$

$$\% \text{ Decrease} = \frac{Original\ Number - New\ Number}{Original\ Number} \text{ x } 100$$

As you can see the two formulas are similar – Interestingly, if we use the increase percentage change formula above and the answer is a negative number, then this tells us that it is in fact a percentage decrease!

So, if you are unsure about anything, use the first formula and it will help tell you whether the change is an increase or a decrease.

Let's look at two example questions and you can see both formulas in action (and hopefully you can see which one we would need from the question title).

Q: Sales have risen from 130 to 160 in 6 months. What is the percentage change in sales over the 6 months?

We can see that the change is an increase so we will use the first formula…

$$\% \text{ Increase} = \frac{160-130}{130} \text{ x } 100$$

$$= 0.2307... \text{ x } 100 = \mathbf{23.1\%}$$

To **double check your answer**, take the original number and multiple it by 1 + the percentage increase e.g. 1.231.

130 x 1.231 = 160.0… as this is the new sales number, we know we are correct.

If we reverse the previous question, we can try the decrease percentage change formula…

Q: Sales have fallen from 160 to 130 in 6 months. What is the percentage change?

$$\% \text{ Decrease} = \frac{130-160}{160} \text{ x } 100$$

$$= -0.1875... \text{ x } 100 = \mathbf{-18.75\%}$$

Percentage Increase and Decrease

To work out the new value of something after a percentage increase/decrease there is a simple calculation to follow.

For a Percentage Increase:

$$\text{New Value} = (1 + \text{Increase}) \text{ x Original Amount}$$

And for a Percentage Decrease:

$$\text{New Value} = (1 - \text{Decrease}) \text{ x Original Amount}$$

The increase and decrease values are worked out where 1 is 100%. Therefore, with a 30% change, the value we would use is 0.3.

You can see this in the following example:

Q: This month's sales increased 25% from last month's 400 sales. How many sales were there this month?

As the increase is 25%, this will become 0.25 in our formula.

$$\text{New Value} = (1 + 0.25) \text{ x } 400$$

Following this calculation, we can see the new value, and this month's sales figures, is **500.**

Reverse Percentages

These can commonly be the ones that catch people out. Many people know how to calculate the new value after a percentage increase or decrease, but don't know how to calculate the original value after a percentage increase or decrease has occurred.

For when there has been a percentage increase:

$$\text{Original Value} = \frac{New\ Value}{(1 + Increase)}$$

For when there has been a percentage decrease (e.g. a sale):

$$\text{Original Value} = \frac{New\ Value}{(1 - Decrease)}$$

Q: A shirt is on sale at £40 after a 20% reduction. What was the original sale price?

You can see how you can easily be perplexed by this question, trying to work out how to use a standard percentage change formula.

One might think you can multiply £40 by 1.2 however this would result in an incorrect answer, so it's important to know your formulas well.

As there has been a percentage decrease we must use the decrease formula:

$$\text{Original Value} = \frac{40}{(1 - 0.2)}$$

After we plug in our numbers, we will get the answer of 50.

The shirt was priced at £50 before the sale.

Ratios

A ratio tells us how many of one thing there is compared to another.

To work out the values of either thing when all we are given is the total and the ratio, we use the following formula:

P.S. The ratio used in the formula is Y:Z, replace your values for these.

$$\text{Number of Y} = \frac{Y}{(Y+Z)} \text{ x Total Number of Items}$$

Q: There are a total of 80 marbles. The ratio of green marbles to black marbles is 7:3. How many green marbles are there?

So here, Y:Z will become 7:3 in our formula…

$$\text{Number of Y} = \frac{7}{(7+3)} \text{ x } 80 \quad = \quad \mathbf{56}$$

Rearrange the formula according to what values are available to you.

If your ratio is a 3-part (or more) ratio, then simply add those extra values into the denominator and the total number of values like below:

Q: There are a total of 70 viewers from three different devices. For every 5 phone viewers there are 10 tablet viewers. For each 10 tablet viewers there are 20 TV viewers. Out of the 70, how many viewers are watching via their phone?

As this is a 3-part ratio, we need to create a ratio that looks like A:B:C

This question luckily allows us to just input the values because they are already in proportion to one another. So, the ratio becomes 5:10:20

$$\text{Number of A} = \frac{5}{(5+10+20)} \text{ x } 70 \quad = \quad \mathbf{10}$$

The answer is therefore 10 viewers.

You may be confused as to why in the formula it changed from number of Y in the first question to the number of A in the second question. The 'Y' and 'A' are simply there to signify the green marbles and the phone viewers; it is representative of the value of the numerator in our formula.

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