Math Skills Required in Case Interviews

Overview

This lesson provides an overview of the specific math and quantitative skills typically required in Case Interviews. Much of the material in this lesson is covered in articles linked to from the FastMath Ace the Case Course Page. I'm including the content here in case you didn't read it previously and because this information is very relevant to preparing for Case Interviews and so I want this information to be part of the course materials as well.

We will first review some examples of the types of quantitative problems most frequently given in case interviews and the sort of analysis you are expected to do. We will then discuss the specific quantitative skills needed to solve these problems. You should try to solve all these problems under interview conditions without using a calculator or spreadsheet (pen and paper is permitted).

Example Quantitative Case Interview Problems

Question Type 1: Break-even Analysis

A very common type of quantitative Case Interview problem is a **Break-even Analysis,** where you are given some financial information on a proposed project and asked to calculate how many units must be sold in order to "Break Even," or recoup the initial investment. Below is a sample **Break-even Analysis** problem:

Question
Your client is evaluating whether to open a number of MRI scanning clinics. Each proposed MRI clinic would have two MRI machines, two Technicians and two Radiologists. The table below shows the annual cost for a **single** unit of each line item required to operate a clinic. Each MRI scan would generate $420 in revenue and will have $70 of costs for consumables, which are items that are consumed in the scanning process.

How many MRI scans would a clinic need to perform annually in order to **Break Even** on the costs of operating a clinic? Try to solve this without a calculator or spreadsheet.

Facilities (rent, utilities, etc.)	$100 K
MRI Machine leasing cost (per machine)	$300 K
Technician (per technician)	$25 K
Radiologist (per radiologist)	$150 K

If you are having trouble with this calculation, read below for a **Hint.**

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Hint

Keep in mind that there are **two** MRI Machines, **two** Technicians and **two** Radiologists per center, in addition to the cost of running the Facility itself. Using these values will make the math work out easier.

End of **Hint**

Read below for the **Answer**

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Answer

Each MRI clinic would need to perform **3,000 scans** annually to **Break Even.** Watch the lesson titled **Break-even Analysis** for a video explanation of efficient methods to calculate this answer.

Quantitative Conclusions and Recommendations
After finishing any quantitative analysis or calculation in a Case Interview, you should ask yourself what **Conclusions** you can draw and/or what **Recommendations** you should make based on the quantitative result you calculated. In short, you should be asking yourself, "**So What?**" That is: "What specific **action(s)** should the client take based on this result?"

As an example, let's say you have calculated the net profits generated for each product in a group of products a client sells. Based on these calculations, you might recommend the company invest further in the products that generate the most profits and/or eliminate products that contribute the least profit. If you calculated annual growth rates for different product lines, you might recommend that the client invest in the products with the highest growth rates or highest future net profit. Your **Recommendations** should be based on the specific context of the Case **and** your analytical results.

Returning to the MRI Clinic example, the purpose of a **Break-even** analysis is to quickly estimate whether the Break-even Quantity is realistically achievable. An outstanding interview candidate would proactively identify the additional information you would need in order to determine whether the Break-even Quantity is achievable and then ask the interviewer for this information. If you don't proactively do this, the Interviewer may ask you whether you think the Break-even Quantity is achievable. Proactively doing this type of analysis shows you can anticipate questions and interpret results, and is usually viewed favorably.

Information Required
To determine whether the Break-even Quantity is achievable, you would need to know the average duration of an MRI scan and the number of hours an MRI clinic is open per week.

Supplemental Information
The interviewer states that an MRI scan takes 30 minutes. Based on this information, do you think the **Break-even** Quantity is achievable?

To answer this, we'll use a value of 50 weeks per year (rounding from 52).

$$\frac{3,000}{50} = 60$$

So we will need to perform 60 scans per week. Remember there are **two** MRI machines per clinic, so we would need to perform 30 scans per machine per week. Since it is reasonable to assume that an MRI clinic would be open at least 40 hours per week, and each MRI scan takes a half hour, the Break-even Quantity is logistically achievable as long as sufficient customers can be attracted.

End **Answer**

Follow-up Questions
a) In order to have profits of $1.4 Million per year, how many scans per year would an MRI clinic need to perform annually? Is this Quantity achievable?

b) How much profit would an MRI clinic generate annually if it were open from 8:00 AM – 10:00 PM, seven days per week, and operated at full utilization (i.e. **all** time slots are used to perform MRIs on customers)? How much profit would it generate if it operated at 80% utilization or 50% utilization (i.e. only 80% or 50% of available time slots are used to perform MRIs)?

c) How many MRI clinics would the company need to operate at 50% utilization to generate total annual profits of $100 Million from the MRI clinics?

Read below for **Answers**

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Answers
a) You would need to perform 7,000 scans per clinic per year. There is sufficient capacity to perform this many scans, as long as the MRI clinic is open at least 40 hours per week.

b) Each MRI clinic is open for 14 hours per day, which is ($14 \times 7 = 98 \approx 100$) hours per week. Rounding the number of weeks in a year to 50 (from 52), and the annual costs of operating a facility to ~$1 Million, gives an annual profitability of $6 Million at 100% utilization.
    80% $\Rightarrow$ $4.6 Million annual profit.
    50% $\Rightarrow$ $2.5 Million annual profit.

c) To generate $100 Million in total annual profits from MRI clinics, the company would need to operate 40 clinics at 50% utilization. The **Conclusion** is that this quantitative result tells the client how many clinics they need to open to achieve their target overall profits of $100 Million. This analysis also provides information on required levels of utilization to achieve target profitability.

These answers intentionally have limited details on the solution methods and how the calculations were performed — the rest of the *FastMath* **Ace the Case** Online Course explains how to solve these problems without a calculator.

End of **Answers**

Question Type 2: Revenue and Profit Calculations

It is a very common Case Interview scenario for the candidate to be given information on Price, Quantity and Profit Margin for a Product, or a group of Products, and then be asked to calculate specific metrics regarding Revenue and/or Profitability.

Example Question
A firm sells three Products, with financial data for each Product given in the table below.
a) What percentage of the firm's overall **Revenue** does each Product contribute?
b) What percentage of the firm's overall **Profit** does each Product contribute?

Product	Price	Quantity (Millions)	Profit Margin
A	$5	5.0	16%
B	$5	10.0	12%
C	$10	12.5	8%

Read below for the **Answers**

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Answers
The answers are given in the table below:

Product	Price	Quantity	Profit Margin	Rev (%)	Profit (%)
A	$5	5.0	16%	12.5%	20%
B	$5	10.0	12%	25.0%	30%
C	$10	12.5	8%	62.5%	50%

End of **Answers**

Question Type 3: Percentage Growth Calculations

A common Case Interview problem is to be given annual Revenue for a company (or a Product Line) and an annual percentage growth rate, and then be asked to estimate Revenue at some point in the future.

Example

A company had annual Revenue of $400 Million in its latest calendar year, and their Revenue is projected to grow at 4% per year. Approximately, what will the company's Revenue be six years in the future?

Read below for the **Answer**

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Answer

In Case Interviews, it is appropriate to say the company's Revenue will be approximately $500 Million. Using a calculator, you can determine that the precise value is $506.12 Million.

When given this problem, many people will try to accurately compound the annual growth, but this is very difficult to do without a calculator. In a Case Interview, you would want to calculate an approximate answer with much less effort than doing a detailed compound growth calculation.

End of Answer

Question Type 4: Market Sizing & Estimation Questions

Another common Case Interview question is to estimate the Market Size (i.e. annual sales) for a given Product Category in a country or region, or to estimate another figure related to a Market Size. The following are example Market Sizing & Estimation questions candidates were asked in real Case Interviews:

Examples
1) What are the total annual sales for McDonald's restaurants in the United States?
2) Approximately how many school buses are there in operation in the United States?
3) How many weddings occur each year in the United States?
4) How many gas stations are in the United States?
5) How many **passenger** automobiles are sold annually in Germany?

This is only a small sample of potential Marketing Sizing questions. The interviewer could ask you to estimate the market size for any product category in any country or geographic region. Interviewers are most likely to ask candidates to estimate the Market Size of products in the country in which the candidate is interviewing or in other local countries with large economies,

in industrial countries (e.g. U.S., U.K., Germany, France), or in the largest developing economies in the world (e.g. China and India).

Read below for the **Answers**

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Marketing Sizing Answers

1) **What are the annual sales for McDonald's restaurants in the United States?**

    In 2016, McDonald's restaurants in the United States had total sales of $36.3 Billion. This includes sales at both franchise restaurants (which are owned by third parties) and sales at restaurants owned by McDonald's Corporation ("Company owned").

2) **Approximately how many school buses are there in operation in the United States?**

    There are approximately 500,000 school buses in operation in the United States.

3) **How many weddings occur each year in the United States?**

    Approximately 2.4 Million weddings occur annually in the United States.

4) **How many gas stations are in the United States?**

    There aren't exact figures on the number of gas stations, and it depends on how a Gas station is defined. Most official figures state there are between 100,000 and 200,000 gas stations in the United States.

5) **How many passenger automobiles are sold annually in Germany?**

    From 2004 - 2015, between 2.9 Million and 3.8 Million cars were sold annually in Germany. In 2015, 3.2 Million passenger vehicles were sold in Germany.
    Source: https://www.statista.com/statistics/416827/passenger-car-sales-in-germany/

Accuracy
Note that, for Market Sizing and Estimation problems, getting an answer within 2x or 3x of the actual number is usually considered a "good" estimate. In some cases, within an "Order of Magnitude (i.e. within 10x) is acceptable. You do not need to be within 10% or 20% of the actual answer to be considered successful in answering the Marketing Sizing or Estimation question. Of course, the closer you are, the better. Answers within 25% or 50% are probably considered accurate enough that closer estimates aren't needed.

End of **Market Sizing Answers**

Math Skills Required in Case Interviews

Overview

Nearly all the math required in Case Interviews is arithmetic: addition, subtraction, multiplication and division. You will likely need to perform these calculations with percentages, decimals or fractions, and calculate a percentage value (which requires division). Most candidates understand these math concepts; the challenge for many people is performing multiple calculations with large numbers quickly and without calculators or spreadsheets, in a high-pressure environment with a six-figure salary and your future career on the line.

Case Numbers are "Round" with Few Significant Digits

The good news is that most of the numbers you encounter in Case Interviews (what I will call "**Case Numbers**") are "Round" numbers and have only a few **significant digits** (i.e. only a few digits are non-zero), but may be in the Millions or Billions. For example, the number 200 Thousand, which is 200,000 in long form, has a single digit that is not zero ("2"), and so has one **significant digit.** The number 2.5 Million, which is 2,500,000 in long form, has two non-zero digits ("2" and "5"), and therefore has two **significant digits.** Case Numbers frequently have only one or two significant digits, less frequently three significant digits, and in rare cases four or more significant digits. The term **Case Calculation** refers to a calculation required in a Case Interview, and may provide specific Case Numbers or refer to a general calculation without specifying the numbers involved, such as calculating Revenue, given Price and Quantity.

Addition and Subtraction

Most of the Case Numbers you need to add and subtract will have only a few significant digits. If they have more than one significant digit, the last or "trailing" significant digits will often be "5" or "25," which makes them easier to add/subtract.

Example 1: Add 250 Million, 300 Million, and 150 Million.

Read below for the **Answers**

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Answer

700 Million

End of **Answers**

In this addition example, the leading digits (prior to the Million) are: 250, 300 and 150. These numbers are either one significant digit (300) or two significant digits, where the last significant digit was a "5," which makes addition easier.

When you need to add Case Numbers with three significant digits, the last two significant digits are often "25" or "75," which are also easy to calculate with.

Example 2: Add 225 Million, 375 Million and 200 Million.

Read below for the **Answer**

•   •   •   •

Answer

800 Million

End of **Answer**

You may need to add some Case Numbers with three significant digits that don't end in "25" or "75," but they most likely end in "5." For example, you might need to add numbers like 115 and 165. Since these numbers both end in "5," they are relatively easy to add without a calculator, and the answer is 280.

It is highly **unlikely** you will need to add or subtract a series of numbers with three or more significant digits, where all the digits are effectively random, such as: 147,368 and 434 (where the last significant digits are **not** "25" or "75").

Multiplication and Division

As you can see from the prior examples, candidates need to perform multiplication and division calculations using numbers in the thousands, millions or even billions (but with a limited number of significant digits). In Case Interviews, candidates often need to perform multiplication and/or division with percentages, decimals and fractions. For example, you might need to multiply a number by a percentage (e.g. calculate 25% of $500 Million), or divide two numbers and express the result as a percentage (e.g. what percentage of $80 Million does $16 Million represent?). Similar operations using fractions instead of percentages are also frequently required.

Most of the Case Numbers you need to multiply or divide will be Round numbers with only a few significant digits. In Example 2 with the table of Price, Quantity and Profit Margin, the number of units sold for each Product is 5 Million, 10 Million, and 12.5 Million. In a Case Interview, you are unlikely to receive a similar problem where the number of Units sold is something like 9,618,493, which has many significant digits that appear random. The percentage values you need to multiply/divide within Case Interviews will also usually have only a few significant digits. A typical Case Calculation would be calculating 20% or 25% of another number. It is **unlikely** you would need to calculate 23.7% of a value in a Case Calculation.

Example 3: Calculate $120 Million times 250.

Read below for the **Answer**

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Answer

$30 Billion

In the next article we'll discuss methods to efficiently multiply and divide these types of Case Numbers.

End of **Answer**

Compound Growth

Candidates also need to understand compound percentage growth and how to make approximations with compound growth. It is a very common Case Calculation to be given a firm's Revenue (or another metric), and the associated Compound Annual Growth Rate (CAGR), and be asked to estimate that value at some point in the future.

In an earlier example you were told that a firm had Revenue of $400 Million in the past year, with Revenue growth of 4% per year, and you were asked to calculate their Revenue six years in the future. The next article discusses methods for performing Case Calculations that involve Compound Growth without calculators or spreadsheets.

Net Present Value (NPV)

Another common Case Calculation involves assigning a financial value to monetary payments that will occur in the future. Management Consultants usually determine the current value of future payments using a financial method called **Net Present Value** or **NPV.** Hence, candidates need to be able to calculate the NPV under a variety of scenarios.

NPV Example 1: How much would your company be willing to pay for another company that generates $20 Million in profit annually, if your firm requires an annual Return on Investment of 10%?

Read below for the **Answer**

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Answer

$200 Million

End of **Answer**

NPV Example 2: A real estate development firm is evaluating a project that involves buying a parcel of land and building condominiums on that parcel. The company forecasts they can sell the condominiums for a total of $250 Million **six years** in the future.

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What is the maximum the real estate company would be willing to spend **now** to buy the land and develop the condominiums, if all the associated costs for the project would be incurred to-day, and they require a 12% annual return on invested capital?

Read below for the **Answer**

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Answer

$125 Million

End of Answer

There is a later video lesson that covers methods for calculating **NPV** in **Case Interviews.**

Summary of Math Skills Required in Case Interviews

Here is a brief summary of the math skills required in management consulting Case Interviews. As noted, most of the numbers involved in Case Calculations will be either Round numbers or Clean numbers.

- Addition and subtraction
- Multiplication and division
- Percentages, decimals and fractions
- Compound growth and Net Present Value (NPV)

As you can see the core mathematical skills required in Case Interviews are relatively simple — there is no advanced mathematics and most elementary school students can understand the mathematics required. What is difficult is determining what specific mathematical operations you need to perform (for the more complex problems), performing these calculations without a calculator or spreadsheet (this is made easier because the Case Numbers are Round or Clean numbers), and interpreting the results within the context of the rest of the Case. The *FastMath Ace the Case* Online Course will help with each of these steps, and emphasizes teaching methods to perform the calculations required without using a calculator or spreadsheet.