Interview Questions: SOLUTION

By Thomas Gordon and Zach Barnett

This “interview” is composed of nine real-world questions. Unfortunately, the questions seem nigh-impossible to answer! There’s no real way, for instance, to determine how many potato chips have been consumed on MIT’s campus since its inception in 1861.

What do we do? At the conclusion of the interview, it is suggested that we take the floor of the logarithm of our answers (base 10). This is a fancy way of saying that, ultimately, we’re counting the number of digits in our answers (minus one). So we don’t actually need to pin down any answer exactly. All we need is to determine the approximate size of our answers, and the result will be the same.

(These kinds of questions are known as *Fermi problems*, *order-of-magnitude problems*, or *estimation problems*. Looking up any of these terms can provide guidance to the uninitiated, though this is not necessary.)

Below are the estimates we obtained, the floor of the logarithm of these estimates, and the associated letters extracted alphanumerically.

Q	Estimated Value	$\lfloor \log 10(x) \rfloor$	Letter
1	$2.63*10^{8}$	8	H
2	$6*10^{25}$	25	Y
3	21,800	4	D
4	$3*10^{18}$	18	R
5	56	1	A
6	$4*10^{21}$ (or $1*10^{21}$)	21	U
7	$5.43*10^{12}$	12	L
8	$3.6*10^{9}$	9	I
9	10^{3}	3	C

The answer to the puzzle is **HYDRAULIC**.

Discussion

While we believe that each question on the exam can be answered precisely enough to determine the to-be-extracted letter, it’s worth stressing just how cautious it is possible to be, while still determining the answer uniquely.

For illustration, take the first question.

At the low end, **assume that the entire MIT campus has eaten one bag of chips per week, for the last twenty years, and zero before that**. This is obviously a drastic underestimate, and gives a lower bound of 24 chips/bag × 1 bag/week × 52 weeks/year × 20 years = 24960 chips.

At the high end, assume that **every student at MIT has eaten a hundred bags a day, since MIT was founded in 1861**. MIT used to be much smaller than it is now, and potato chips weren't even invented until 1920, but let's ignore all that. This is a ridiculous overestimate, and gives an upper bound of 24 chips/bag × 36,500 bags/year/student × 12,000 students × 163 years = 171,345,600,000 chips.

Given how the extraction works, the lower bound gives a D, and the upper bound gives a L. So, being *preposterously cautious*, we can infer that the true first letter of the answer must lie somewhere from D to L in the alphabet.

Using this method, you can generate wide letter ranges for each position, producing something like the following query:

[defghijkl][uvwxyz][abcdefgh][nopqrstuv][abcde][qrstuvwxy][hijklmnop][efghijklm][abcdefg]

And this query returns… one result.

Justifying our Estimates
As was demonstrated above, determining these values to a high degree of precision was not necessary to solve the puzzle. But we did our best to ensure that the true answers to these questions do produce the desired letters. Below, we'll justify the estimates that we made for each of the questions on this interview.

1. **How many potato chips have been consumed on the campus of MIT since its inception in 1861?**

MIT's student population is about 12,000 people, including graduate students. Let's say that the average MIT student eats one bag of potato chips each fortnight. There are 24 potato chips in the average chip packet. So, accounting for the fact that students only spend about 70% of the year on campus, the average MIT student eats 438 potato chips on-campus each year, for $5.26*10^6$ chips eaten each year in total.

Potato chips only became really popular in about the 1920s, about a hundred years ago. If we say that MIT students only kept up this level of consumption for the last 50 years (which would account for the growing student body and the fairly recent popularization of junk food), then that would mean there were about $2.63*10^8$ potato chips eaten on-campus.

2. **How many drops of water are there in all of Europa's oceans?**

An easy question. Estimates of the volume of water in Europa's oceans are readily available online: it's about twice or three times as much as Earth's oceans, or roughly $3*10^{18}$ m^3 of water.

A drop of water is about 0.05mL. That makes $2*10^7$ drops per cubic meter of water.

So, in all of Europa's oceans, there are $3*10^{18}$ * $2*10^7$, or <u>$6*10^{25}$ drops of water</u>.

3. **If, once the coin for the 2025 MIT Mystery Hunt was found, you hired someone to read out the words in the Oxford English Dictionary (not including the definitions) as a full-time job, how many minutes from starting their job would it take them to read the answer to this puzzle? (Include time off.)**

The Oxford English Dictionary has about 600,000 words in it. The answer to this puzzle happens to be about halfway through, or approximately 300,000 words in. (You could guess this, or you could work out roughly what letter the first question extracts to, in order to estimate this more accurately.)

Let's say you could read approximately one word every second, or 60 words per minute. (The average person could read slightly quicker, but they would also have to take breaks, so this seems like a good estimate.) Therefore, it takes about 5000 minutes of active reading time to reach the answer.

There are 480 minutes in a working day. This means that you would read the answer to this puzzle on your 11th day of working. If you started at 9am on Tuesday, January 21st, 2025 (note that January 20th is a federal holiday), you would read the answer at some point in the afternoon on Tuesday, February 4th (or within a few working days on other side.)

That comes out to be roughly <u>21,800 minutes</u>.

4. **How many grains of rice have ever been consumed in Asia?**

The populations in China and India both consume about 120kg of rice per capita, according to [this page].

One gram of rice is about 50 grains, so 120kg of rice is about $6*10^6$ grains eaten per person per year (in just China and India).

While the population of China and India has very recently increased to over a billion people, for most of its history their combined population was around 100 million people. If 100 million people ate $6*10^6$ grains per year for about 5000 years, in total they would eat $3*10^{18}$ grains of rice.

(Notably, rice was a secondary crop to millet for most of history, and rice's current dominance as a staple food only really occurred in the twentieth century. In this estimate, we've underestimated the population of the region, and overestimated the number of grains eaten per person, but a more careful calculation should come out within the same order of magnitude.)

5. **What is the combined age, in years, of all the authors of this question?**

As of time of writing, Thomas is 20 (21 in one week!), and Zach is 36.

Our combined age is therefore 56.

6. **How many atoms were in the ink molecules used to print this page? (Include the water solvent.)**

Randall Munroe, of xkcd fame, has done some estimates for this. We'll crib his answers, because someone else's envelope is just as good as your own.

Munroe estimates that each printed character contains around 10^{16} ink molecules. Not including the art or graphic design on this printed page, there are exactly 1110 printed characters in the Expert version and 1210 in the Casual version. Let's double it to account for the title and other things. That means that Munroe would say that there are about $2*10^{19}$ ink molecules in total on this page.

Notably, Munroe excludes the water solvent from his calculations, and thus divides his number out by exactly 10. We want to include the water solvent, so for our purposes, there are about $2*10^{20}$ molecules of ink used to print this page.

Finally, we want to know how many *atoms* are in these ink molecules. The water solvent (~70%) contains three atoms; the carbon black (~5%) one atom; other compounds in the ink contain between 10 and 20 atoms on average. If estimated that the average molecule in the ink contained about 6 atoms, then the total number of ink atoms used to print the page would come out to be $1.2*10^{21}$ atoms.

(The article above did not inspire either the puzzle or this question, but once we found it we knew that we had to keep the question.)

If we wanted to run the numbers ourselves, print companies estimate the amount of ink used when printing in certain ranges. Printing a square foot of full coverage (ie printing a black square which was a foot long on every side) takes about 1mL of ink. Our page will have about 10% coverage, so we'll use about 0.1mL of ink.

We can estimate that about 15 grams of ink (or 15mL of ink) will have about 10^{23} molecules of ink (from Avogadro's constant; ink is mostly carbon and water, so this roughly holds). In the 0.1mL of ink we used, that means we'll have about $6.7*10^{20}$ ink molecules on the page. Using the same estimate of the average ink molecule having 6 atoms, that means that the total number of atoms used in the printing process is about $4*10^{21}$ atoms — the same order of magnitude.

7. **How likely is it that a monkey produces the exact answer to this puzzle using a typewriter on their first try (assuming said monkey is sure to avoid numbers and punctuation?) (Write the reciprocal of the probability.)**

The answer to this puzzle has nine letters. (You might know that by looking at the meta, or realizing that each question extracts to one letter in the answer.)

Assuming the monkey hits each key on the typewriter with equal likelihood, the probability of them typing the exact answer to this puzzle first try is $\frac{1}{26^9}$, or about $1.84*10^{-13}$.

The reciprocal of this probability is equal to 26^9, or $5.43*10^{12}$.

8. **How many microseconds would it take an able-bodied member of your team to sharpen a pack of pencils down to nubs with a manual pencil sharpener (assuming they were really trying and using their dominant hand?)**

Pencil sharpening speedruns are an actual thing. However, it's unlikely (unless your able-bodied team member has put in a lot of practice) that you'll be able to register a world-record time for sharpening pencils!

The most common pencil packs on the market usually have around 12 pencils. If we estimate that it takes about 5 minutes to sharpen a pencil down to a nub using a manual pencil sharpener, then sharpening 12 pencils down will take around an hour. (If we felt inclined, we could watch this video about someone learning to speedrun pencil sharpening, and see that our estimate is pretty correct; their first attempt at sharpening 10 pencils in a row took 49 minutes and 18 seconds, or about 5 minutes per pencil on average.)

Finally, one hour comes out to be $3.6*10^9$ microseconds.

9. **How many bank robberies will there be in the US in 2024 (including Finster's?)**

We can find a few different estimates for the number of bank robberies in the US each year: this website lists 2,431 robberies from "Bank/Savings and Loan" locations in 2022, and the FBI reported 1,263 robberies from national bank or state member banks of the Federal Reserve.

It would make sense that the number of bank robberies in 2024 would remain fairly consistent compared to previous years. Especially if we assume that the number of total robberies is higher than the number of reported robberies, the answer seems to very comfortably come out to be at least 1000, or 10^3 robberies.

Author Notes:
One author of this puzzle wanted to include the question "How many duck-sized horses would it take to defeat a horse-sized duck?", but the other author had a tragic duck-sized horse-related backstory, and vetoed the idea.