# THINK LIKE ELON MUSK

# Think Like Elon Musk: Part 1.

**(Version 1.08 Beta)**

*Content*



## *0000 Introduction*

This book is not about how to become a billionaire; although, it will also provide some insights into that. It's about how to make your dreams come true. Whether you want to take a trip around the world, become an outstanding scientist, or be the first person ever to step on Mars, it's your thinking that will determine how far you go. If we take into account the way our mind operates, we can learn to think more effectively. In the end, our thinking determines how effective we are in making the most out of a situation. It's our thinking that determines if we manage to achieve our goal at all.

Whether our task is designing a most accurate 3-D scanner, flying to Mars, or dealing with a common life difficulty, it is possible to resolve it in the most productive way. Effective problem solving is enjoyable and feels like play, while ineffective problem solving resembles endless suffering or going round in circles, and the outcome is uncertain.

This book is dedicated to outstanding scientists and inventors, brilliant engineers and developers, and all those people who make a change and give a sense of hope to humanity. We will try to find out what their way of thinking is and what makes them so efficient in problem-solving. Our contemporary Elon Musk is an example of such a sharp person. His actions are the best illustrations of the ideas in this book. Unlike us, he has managed to figure it out on a subconscious level, how it works, how to become superefficient. This book will tell you how to touch upon this wonder and start doing the same.

Now, try to solve this problem from a Math Olympiad contest: There are twelve coins, and one of them is counterfeit. Your task is to isolate the false coin by using a balance scale only three times. And here is the tricky part: you don't know if the counterfeit coin is lighter or heavier than the genuine ones. For most people, this specification makes the puzzle too complicated. But you will be able to solve it, as well as lots of other problems that require exceptional thinking and skills, if you use the information given in this book. Because you're going to learn some tricks.

Obviously, I cannot guarantee that after you read this book you will immediately start thinking like Elon Musk — actually, we still don't know if he is even human :) You're going to use your common sense and sense of humor, so get ready, they will come in handy anyway. I want to share with you ideas, rather than specific data. This book is more an entertainment than an attempt to educate. Authors usually make

references to boring scientific texts just to support their point, but my task is to provide you with information that will add to the material of the book. So, you will find here links to Wikipedia, YouTube videos, and other sources that are easy to find and don't require going through the jungles of dusty pages of highbrow books. Each hyperlink also has a QR code so that you can open it on your smartphone without having to type in the website.

This book also aims to resolve a more complicated task: When Elon Musk launched his Roadster into space,[1] some people asked me why would he do that. I have an answer to that, but it's quite hard to explain. Was it a smart marketing move? Was it dumping a body dressed as a dummy astronaut? We will try to unravel this puzzle too.

The book consists of several parts, each taking you deeper into the questions related to the way our mind operates — from how to plan your thinking process to how often you should air your room. To show how much you can gain in efficiency if you follow this advice, I provide an example from the life of Elon Musk for each bit of information. Many people use these methods, but what Elon is doing is important for all of us. I want to support him, and my way of doing it is to demonstrate how hard it is to be Elon Musk. To understand him better, we need to start thinking like he does.

## *0001. Limitations of Mind*

Imagine you are in charge of a company; you have one hundred recruits. Your task is to distribute the responsibilities among them. This distribution will affect the outcome of the war and whether your people will survive it. During World War I, the U.S. army used so-called IQ tests to solve this task effectively. The army adopted IQ tests from schools, where simple questions were used to determine if a child had reached sufficient development stage to go to school.

By now, IQ tests have changed significantly. They have been the subject of much research, and today we can say that IQ, an intelligence quotient, represents just a part of our abilities. Our social skills, like being able to understand other people and their perspectives, are equally important. Thus, a high IQ is not a sure sign of success, and a low one does not necessarily imply being a loser.

One thing that the IQ test tells us for sure is how quick we are at resolving tasks of various levels of difficulty. Of course, the task is not about ordering a hamburger—even professors would find themselves lost trying to choose from the offerings of a cluttered fast-food menu.

One person can resolve a problem in a few seconds. Another one will do it in a few minutes. If the difference in time is clear, how do you define the difficulty of a problem? How do you measure it? Difficulty level is related to the number of elements one has to keep in mind, as well as the concepts that need to be applied to those elements.

Remember the counterfeit coin problem from the introduction to this book? It is very hard to resolve. There're twelve coins in the problem specification, but for now let's assume there are just three of them. One coin is counterfeit, and we don't know if it's lighter or heavier than the others. How many weighings are required to separate a fake coin? You see now how much easier a task becomes when you reduce the number of elements you're working with.

Short-term memory can accurately reproduce between four and seven units of information in the first twenty seconds. That's why you won't remember a credit card number if you glance at it quickly. Besides short-term memory, which is there just to keep bits of information in mind, we also have working memory to make operations with those bits.

Working memory is more reliable than IQ in terms of predicting one's success in studying. But the scientists are not certain as to how it works. Its capacity is hard to measure, as it's connected to short-term memory. Graeme Halford suggested we measure connections between the items instead of the number of items held in memory. Together with his colleagues, Halford asked people to read a sentence describing relations between objects and then to pick up a drawing that best illustrates the sentence. For instance, "If the cake is from France, then it has more sugar if it was made with chocolate than if it was made with cream, but if the cake is from Italy, then it has more sugar if it was made with cream than if it was made with chocolate."[2] This sentence only contains three variables: country, ingredient, and the amount of sugar. Still, for most people that's the most they are able to comprehend.

To test your working memory capacity, imagine there's a person looking at you. Then there's another person looking at the person who is looking at you. Next to them, there is another person who is looking at the person who is looking at the person looking at you. And so on, and so forth. Imagine them all simultaneously, and not one after the other. How many people can you imagine? Hard, eh?

We know that working memory span is determined genetically. As of today, the scientists know no way that would drastically increase it. As Garry Kasparov,[3] an illustrious chess player, recalls in his book, in complicated situations he would calculate all possible moves as far as eight to ten plies[4] in advance. Such depth of calculations in chess is far beyond what an average person can do. We can only process a limited number of items at a time. That's why most people cannot resolve the coin weighing problem in their mind.

What is interesting is that a genius and an average person have almost the same working memory capacity, with just a minor difference. In fact, humans are very close to monkeys, whose working memory is slightly less than the human one.[5] Compared to an alien with the working memory capacity of ten items, we all would seem equally disabled. Therefore, it's important to learn to use your mind in the way that works the best, even if you are the smartest person on the planet, as there are tasks that are beyond your limits too.

Another factor that contributes to a task's difficulty is the **concepts** that need to be applied to solve it. For instance, the concept of adding is fairly simple, we use it every day. But if you were to solve a logarithmic equation, it's at times more difficult. In fact, there're thousands of concepts around us, and we learn to apply them throughout our life. Some of them are complex, others are very simple. Remember how your parents taught you to read a clock. There was a time when we, each of us, had no clue time could actually be measured! And now, can you imagine your life without any clocks? Where did the idea of the clock come from, then? If you put a stick into the ground, you will see the stick's shadow moving around it clockwise, unless your spaceship is caught in a Klein bottle or you're walking upside down like Australians. So, basically, the person who designed the clock simply reproduced the movement of the shadow.

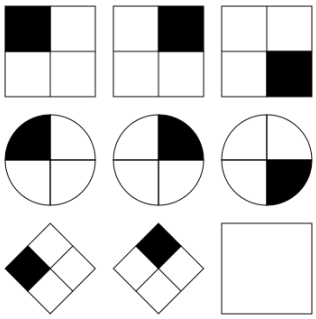
The famous Einstein's formula ($E=mc^2$) does not include a lot of elements. But its symbols stand for super-complex concepts. Even given a detailed explanation, these concepts are hard to picture, much less discover. We can see light but we don't see that it has speed. We can sense gravity but we don't see that it can affect light. The values in these calculations are either very large or extremely small. They are outside our everyday worldview. Basically, Einstein came up with the concepts that were not there before. And since we cannot perceive those concepts with our senses or discover the theory of relativity experientially, Einstein's discovery is truly ingenious. First, he developed a theory, and only later, his theory was proven empirically.

Einstein's theory is as difficult to understand as DNA replication mechanism. But if we spend a few years studying these concepts, our mind will get used to operating them. Then we will be resolving complex tasks as easily as we are adding numbers in our head. Even an average person can grasp complex ideas if they invest time and effort in them. Besides, each of us tends to comprehend certain concepts better than others. That's why human activities are so varied.

| |
|---|
| Advice: If you fail to grasp a certain concept, just spend more time studying it. |

Have a look at the image below. It's a simple task from Raven's Matrices IQ test that is used to measure general nonverbal intelligence. You're to identify the missing object in the lower right corner, which currently contains an empty square.

To solve the task, our mind looks for "patterns"—similarities and differences between the figures. First, we identify the **form of the figure**. That's quite easy. It stays the same in the first two rows. Therefore, the unknown figure will have the same form as the other two figures in the third row. Then, we need to find out **what all the figures have in common**, and that is two lines with a colored sector. The third thing we need to know is **the concept of clockwise movement**. We use visualization and get the result. So, this task includes several simple tasks and one concept.



Similarly, a more complex problem will also comprise a set of easier ones. It's just the number of actions and concepts involved that will be different. So, even an extremely complicated test consists of simple actions. To resolve a complex task, you should break it down to a few easier ones.

> Advice: If the problem is complicated, find a way to divide it into a few simpler ones that your mind can comprehend.

That's how engineers and scientists work. Even the smartest engineer's mind has its limitations—it cannot keep all the details of a machine in memory. That's why engineers divide complex objects into units, decide how those units will interact, and then design each unit separately. When software developers create separate libraries and apply object-oriented programming, they do the same. Science, too, consists of simpler components. First, people learned to count and write basic formulas, and later, when they made progress in mathematics and physics, they managed to calculate the velocity of light. Similar to that, all future human discoveries will also be based on those more basic elements that we already know.

The idea of breaking down a complex problem into simpler elements seems obvious. But that's just on the surface. We tend to overestimate our capabilities and strive to deal with the problem right away, without dividing it into components. People who solve complex tasks professionally have abandoned this harmful habit. You, too, should apply this rule, be persistent, and act without unnecessary hurry. Our mind has many limitations, and it's better to accept it. I hope this principle will help you solve the twelve-coin problem. And if you don't get to solve it, never mind, I'll give you another hint in the third chapter.

## *0002. A Difficult Journey*

Would you like to become a billionaire, an owner of cutting-edge companies that create great things and change the world? What do you think it would take? The first thing that comes to any mind is to design a unique product then build your company around it. Come up with something everyone will need, something that will be even more innovative than Apple and Google! Let's see how Elon Musk has managed to achieve his success.

At the time of this book's publication, Elon Musk has founded, cofounded, or acquired shares in The Boring Company, Neuralink, Tesla, and SpaceX, and created the concept of Hyperloop. Each company develops leading-edge technologies that are literally changing the world. For example, The Boring Company can potentially put an end to traffic jams, while Hyperloop and SpaceX might be able to take you anywhere on Earth in less than an hour. And don't forget the projects that SpaceX is working on: transportation to Mars and satellite constellations around Earth. Investors are queueing up to put money into Elon's new projects.

By 2016, when The Boring Company was founded, Elon Musk had already become famous as a determined entrepreneur. That's why many people supported him when he brought up the idea of underground car tunnels. Elon started to sell branded baseball caps to get funding, and they sold out in just a few days! Those sales brought in Elon's his first million dollars for The Boring Company. His next step was selling flamethrowers for $500 each, which brought in $10 million. That money enabled Elon to start digging tunnels and to modify the tunnel technology that had been the same for many years. Improving tunnel technology will reduce the construction costs and resolve traffic jam issues.

In 2006, Elon Musk helped his cousins Lyndon and Peter Rive start SolarCity, a solar panel installer. Ten years later, the company merged with Tesla. Tesla had not been able to cover the solar panel division for quite a while, but Elon foresaw that it would be more cost-efficient for people using electric cars to generate electricity in their own house without having to rely on electricity providers. That's especially relevant for sunny California, where solar rooftop panels produce a major part of electricity for household use. When Tesla got on its feet, Elon acquired SolarCity, merging two companies to combat global warming.

Contrary to popular belief, Elon wasn't the original founder of Tesla. He invested in the company then joined the board in 2004, following his childhood dream of designing electric cars. It was Elon's talent and money that saved Tesla in the crisis of 2008. Back in 2004, there was no trend for electric cars, none of them had been successful on the market.[6] The idea to invest in technology no one had ever used before looked insane the automotive industry, which operates on just 10 percent profit margin. But it made perfect sense to Elon Musk. He saw potential in the idea, and his courageous actions set the trend for electric cars, thus transforming the entire auto industry. Fourteen years later, the companies that would not even consider it before were now competing with each other to produce more and more electric vehicles.

In 2002, Elon Musk started SpaceX,[7] which in itself is worth a separate book. Besides designing the first[8] truly reusable space rocket, the company has disrupted the space launch services market, making journeys to space way cheaper. Musk has proved that small private companies can be profitable, and thus, has opened the door to space startup investments.

To fund Tesla and SpaceX, Elon relied on the money he got from selling PayPal. Established in 1999, PayPal was originally called X.com. Musk was one of the founders; he invested $10 million in the company. X.com's goal was to transform the banking industry and to introduce modern internet technologies to the conservative banking sector. Later on, X.com merged with Confinity, the company that owned the PayPal trademark. And it is this service that was finally acquired by eBay for $1.5 billion with Elon getting the largest share, $165 million.

The $10 million that Elon invested in X.com came from selling his first company, Zip2. Elon and his brother Kimbal Musk started Zip2 in 1995. All they had was one computer that was their web server during the day, and at night they used it to code. When Elon founded Zip2, he had $110,000 in student debt. The brothers did not have enough money to rent an apartment, so they lived and worked in the office and showered at the YMCA. As Kimbal Musk recalls, “The only thing we could afford was fucking fast food. Yuck. Even now, twenty-three years later, I can still recite the Jack in the Box menu.” In 1999, Compaq bought Zip2 for $307 million in cash and $34 million in stock options. Elon’s take was $22 million, as his share in Zip2 was just 7 percent.

Elon came to the U.S. from Canada, and he moved to Canada from South Africa when he was seventeen years old. He was granted Canadian citizenship through his mother, Maye Musk, who was a Canadian. Maye moved to Africa with her parents, passionate adventure-seekers who traveled around the world on a small propeller plane. Elon was a very gifted kid. He taught himself to code, and when he was twelve, he made a computer game and sold it to a journal for $500. Elon read a lot and displayed his encyclopedic memory to everyone.

If you look at the journey from the teenage Elon Musk to the most influential tech leader billionaire Elon Musk, you’ll see many years of hard work and perseverance. In movies and books, time flies, so you don’t feel those years of expectations and hope that precede the success. The main character is a twelve-year-old wonder child in the opening scene, and a few seconds later he’s an adult who has built a rocket that’s now returning to Earth. A leap like that happens in fairy tales, but not in real life. If you want to achieve the results that are compatible with Elon’s, you should learn to think dozens of years ahead and get ready for constant struggle. You should learn to divide a complex task into simpler parts. It’s very hard to build a multibillion-dollar enterprise from scratch with no money or experience. An easier way is to first create a small company and learn the basics of doing business then grow.

Understand that Elon finding himself in a specific time and place was not mere luck. In fact, he took a lot of effort to get there. First he came to a country where you can actually become a billionaire without killing other people. Then he made several thousand dollars to fund his first company and gain his first $22 million. Then he invested that money to make $165 million. And the investments he made afterward are what turned him into a billionaire.

Of course, money is not the main goal for Elon Musk. He wants to create outstanding things, and his fortune increases are proportional to the value of the products he makes. In his case, money is just a corollary.

Breaking a task into smaller parts is present in every project implemented by this genius. For instance, the first SpaceX rocket had just one Merlin engine. Later, they constructed the Falcon 9, which had nine engines. SpaceX made several modifications before the rocket was capable of returning to Earth. They made amends with each launch, gradually reaching their goal, with no ambition of making it immediately.

Even the journey of a thousand miles begins with one step. (Lao Tzu)

### *0003. Turing Machine*

It's hard to imagine it today, but there was a time when computers did not exist. To create them, scientists needed to rely on mathematical concepts. Alan Turing was a prominent scholar and the founder of contemporary computer science. He contributed a lot to creating what we now call computers. For instance, in World War II, he helped British government decode super-complex Nazi ciphers.[9] In 1936, he described a mathematical model that enabled people to formalize what they intuitively experienced as an algorithm. An algorithm is a well-defined sequence of steps to solve a given problem. If you write an algorithm on a computer, it becomes a program.

Alan Turing designed an abstract automatic device that was later called the Turing machine. This imaginary machine is loaded with a tape that contains symbols, one symbol per cell. The machine can "read" the symbols, write them on the tape, and move the tape to the left or to the right, according to the instructions. The machine also has its "state," which determines the way it reacts to the instructions.[10] This state can be modified by the instructions on the tape. The state of the machine and the instructions on the tape determine the next action of the machine.[11]

This mathematical model enabled Turing to formulate a hypothesis:

*Any algorithm can be realized by a Turing machine.*

For us it means the following: any difficult operation can be performed with a set of simple, well-defined operations. If we assume that for every problem there's an algorithm to solve it, we reach a conclusion that **we can solve any problem, no matter how difficult**, if we rely on simpler actions. All we have to do is figure out how to "make an algorithm of resolution" out of these simpler actions.

I dare say if humanity does create an artificial intelligence one day, each component of this intelligence could be simplified to the Turing machine.

When developers write an algorithm to solve a problem, they should choose a way to solve it, since there're several ways the problem can be solved.[12] For example, three algorithms can be used to sort names alphabetically. Each of them will perform the task, but the amount of time they take will be different. That's why software developers do not simply solve problems, they search for the most efficient way to do it.

Olympiads in informatics often include problems that can be resolved in two ways. The first way is to do a brute-force search, which will take a great deal of machining time. The second one is to simplify the problem and to reduce it to a simple mathematic formula that does not require advanced knowledge of computer science. Therefore,

> before you start solving the problem, look for the best way to think about how to work on the solution.

The shoemaker first makes a shoe tree, and then the shoe itself. Before shipbuilders construct a ship, they construct a slipway. Same with problems: before we start solving a complex problem, we should use our mind to simplify it.

Remember there are limits to the number of objects and connections our mind can store at a time. If the problem is within that range, we can solve it with no stress at all just by looking at it. If it's more complex, we should use tools that help simplify it until it becomes easier. Trying to solve a complex problem in one go is like trying to open a can with bare hands. If, on the contrary, you start playing with the problem, searching for helpful tools, the task will become an inspiring adventure. Your success will be more dependent on persistence and your knowledge of methodology than your intelligence. Yes, an ingenious person will solve the problem sooner, but the persistent one might end up having more patience.

Humanity has already invented lots of problem-solving methods.[13] Breaking the problem down to its simpler components, which was mentioned earlier, is one of them. You can also reduce difficulty by simplifying the problem. For example, if you have a three-dimensional object, you can first project it in two-dimensional space and try to solve the problem for only two dimensions, then when you get the solution, apply it to three dimensions. Sometimes several people get together and start brainstorming – gathering possible solutions and then choosing the best one. Some methods of problem-solving take quite a while to study before you can apply them – like Ford's eight disciplines problem-solving, the OODA loop, TRIZ, and others.

Often the solution to the problem lies in a totally different field. That's why you'll save yourself a great deal of time if you give at least some effort to searching for another perspective. Usually we are so focused on getting the result that we skip looking for strategies and jump to problem-solving right away. And in the end, it takes us way more time than those who thought it through before taking action.

The science knows many cases when discoveries happened by accident. Take infrared radiation discovered by William Herschel, for instance. Yet, in other cases discoveries came from meticulous work – like the discovery of Neptune. So you can choose your way of solving problems – relying on planning or luck.

Our twelve-coin problem can also be solved if instead of sifting through all the possibilities you try first to answer these questions:

- What's the thinking behind my approach to dividing coins into groups?
- Why do I make these particular groups?
- What is the information that I don't take into account / that I lose?

This hint should be enough for you to solve the fake coin problem and go for a new and more difficult one. It's the so-called Einstein's puzzle, and it is believed that just 2 percent of the population can solve it. Both problems might turn out to be difficult, so you can return to them later after you've read the entire book. It might be easier for you to solve them then.

Personally, it took me over a year to find an answer to Einstein's puzzle. I don't belong to those rare people who can keep up to twenty-five items in their mind at a time. But I believe the hints provided will enable you to deal with the puzzle in a couple of hours and to test out the knowledge you received. Enjoy!

**Einstein's Puzzle**:

1. There are five houses.
2. The Englishman lives in the red house.
3. The Spaniard owns the dog.
4. Coffee is drunk in the green house.
5. The Ukrainian drinks tea.
6. The green house is immediately to the right of the ivory house.
7. The Old Gold smoker owns snails.
8. Kools are smoked in the yellow house.
9. Milk is drunk in the middle house.
10. The Norwegian lives in the first house.
11. The man who smokes Chesterfields lives in the house next to the man with the fox.
12. Kools are smoked in the house next to the house where the horse is kept.
13. The Lucky Strike smoker drinks orange juice.
14. The Japanese smokes Parliaments.
15. The Norwegian lives next to the blue house.

Now, who drinks water? Who owns the zebra?

In the interest of clarity, it must be added that each of the five houses is painted a different color, and their inhabitants are of different national extractions, own different pets, drink different beverages, and smoke different brands of American cigarettes. One other thing: in statement six, *right* means *your* right.

— *Life International, December 17, 1962*

### *0004. A Hellish Task*

Traffic jams are one of the issues humanity faces today. It is especially acute in the U.S., where everyone tries to live the American dream, which includes buying your own house. While skyscraper office buildings are situated downtown, people with a dream usually live far from the center and spend several hours driving to work. Normally, a residential area in the U.S. is a vast land covered with one-story buildings, and the nearest supermarket is 3–6 miles away. You literally *need* a car to get anywhere outside your house. That's why, for U.S. teenagers, passing their driving test is so important – it means they no longer depend on their parents. In Europe, settlements are more condensed, but there, too, congestion has become an issue.

Unless we apply the rule from the previous chapter, we will be trying to solve transportation problems in two ways: by widening roads or by reducing traffic intensity, that is, encouraging a shift from private vehicles to public transportation. Unfortunately, experience has shown that widening roads does not help alleviate traffic. Public transportation might be somewhat helpful for European cities due to their higher residential density, but is not effective at all in the U.S.

Before attempting to solve this puzzle, Elon looks for the best way to contemplate it. He notices that skyscraper office buildings are 3D structures with people situated on many stories. Yet when the working day is over, those people move from one place to another on a 2D plane. Obviously, when you look at it from this angle, the problem becomes a question of converting 3D constellations of people into 2D, and vice versa.

That means the congestion issue can be resolved by making office premises one story, or, on the contrary, by making roads multilevel. Since skyscrapers have already been built, we can only change the roads. So, the next question is how to start moving in 3D space.

Let's think what will be the best approach to this problem. One way would be to simplify the model, so that it's easier for our brain to comprehend it. Let's remove one dimension and look at the city and its roads from the side. Then roads become lines, and buildings become squares. And we realize that constructing new roads is not convenient at all, as the space is already occupied with buildings. But there's plenty of space underground. We've simplified the problem, and it gave us several possible solutions. We can construct roads aboveground, dig tunnels underground, or design flying cars. The next step is analyzing efficiency and convenience of all those technologies.

Flying vehicles already exist. Those are helicopters, very noisy and demanding machines when it comes to maintenance. Their massive use will cause overwhelming din in the city, as well as clouds of garbage and dust stirred up in the air. Let alone safety – life will become an endless French Revolution with thousands of guillotines flying above. Better to postpone the idea until humanity finds a better way of air transportation.

To choose between tunnels and multilevel roads, we should consider the cost-effectiveness of both. It is cheaper to construct one level of road than one level of tunnel. However, with tunnels you can add as many levels as you like and construction costs stay the same. Meanwhile, with every road level you add construction costs go up. And that's the next problem that Elon is trying to solve.

Musk started The Boring Company[14] to lower tunneling costs. For Elon, it was a hobby that took about 2–3 percent of his time. Neither Elon nor his friends had ever bored before, so, to get started, they dug a large pit at SpaceX parking lot and began testing existing tunneling technologies. They ordered their first tunnel-boring machine (TBM), which they called Godot. Waiting for it to be delivered took a long while, so they named it after Samuel Beckett's play. In the play, two characters, Vladimir and Estragon, wait for the arrival of someone named Godot who never arrives.

While experimenting, Musk discovered that the tunneling technology had become out of date. For example, the truck that's taking soil out of the tunnel operates on diesel fuel. Air is crucially important for

tunnels, and diesel fuel means you have to ventilate the exhaust gas emitted by the truck. Also the TBM was electricity-operated, so to run it one had to lay a heavy high-voltage cable several miles into the tunnel. The cable obstructed the machine, so it was very difficult for it to advance in the tunnel. Taking the earth out of the tunnel and disposing of it turned out to be expensive as well, as excavated material was shipped miles away from the construction site. On top of that, the TBM itself was low-efficient. All in all, the existing boring technology allowed you to build tunnels fifteen times slower than the snail moves.

Elon Musk set a task for his company – to construct a TBM that will move faster than the snail. Today, electric trucks replaced diesel ones, and high pressure is used to recycle excavated earth into bricks. NGOs can get those bricks free of charge; others can purchase them at ten cents per piece.

Elon Musk believes this tunneling technology is valuable for the Mars mission too. Because of significant solar radiation, the scientists considered the option of placing a Mars habitat underground. If we proceed with Musk's tunneling idea, city roads could be replaced with park zones. And there would be zero traffic-related deaths.

When you read this history, everything looks logical, as though it could not have been otherwise. But for some reason The Boring Company was the first one to do it, no one had done it before.

Why?

## *0005. Chinese Room*

Alan Turing's genius also touched on what we now call artificial intelligence. After World War II, the transistor was invented, and the first computers started to appear. Excited about the news, fantasy writers felt that the creation of artificial intelligence was just around the corner. Yet, designing artificial intelligence opened many questions for the scientists. To begin with, it was not clear how to define intelligence.

Alan came up with the Turing test, which offered a solution to that puzzle. The test suggested that instead of trying to find a definition for intelligence we ask the question "Are machines capable of behaving like humans?"

Here's what the test looks like. The interrogators are invited to communicate with a computer and a human, both situated in separate rooms. The communication only takes place in written form, so that there's no secondary information that could help distinguish between a computer and a human being. When the test is over, the interrogators are to identify the real person and the machine. The artificial intelligence imitates human behavior to confuse the judges. If the machine succeeds in persuading the interrogators it is human, then it has passed the Turing test.

Religious people who shared René Descartes's vision of mind-body dualism were challenged by the Turing test. Descartes stated there were two worlds: the physical world (brain) and the mental world (mind, consciousness). If one can make a machine that has no soul but acts like a human, then the human has no soul either. That's why Turing's theory was criticized by a number of scientists. They argued the test was incomplete and failed to define true intelligence, which they believed was a combination of mental and physical. The most famous argument was the thought experiment described by John Searle in 1980.

The experiment is that a person sitting in a closed room receives a set of Chinese characters as input. The person does not understand Chinese, but they follow the same algorithm as an AI. So, the person looks up the characters, finds the response, and gives out the "answer" characters. Thus, the person appears to understand Chinese, although they do not.

Searle suggested his thought experiment as a critique of the Turing test. It demonstrates that the machine can behave automatically, without awareness or intelligence, which human beings possess. The machine just receives the characters and produces the output, unaware of its actions. What makes this experiment interesting to us is that it clearly demonstrates the way our mind normally functions. John Searle wanted to prove the machine could not have intelligence. In this chapter, we will look at this model through the lens of the question "Do humans have intelligence?"

Why do you believe you have intelligence and not just a preprogrammed set of reactions your parents and teachers taught you? I'm talking here about ready-made answers. We're so willing to go for the solutions that are already there, and we spend so little time thinking! We have this tendency because of many factors – from the way our brain is built to the evolution of social relationships.

Normally, this quick and convenient mechanism is very helpful. Just imagine that each time your dog is jumping up to lick your face, you are figuring out what that animal is and whether you should run away. From the evolutionary perspective, our "Chinese room" is a great invention. Our brain stores plenty of ready-made solutions and, thus, enables us to act much more quickly. We're so used to these solutions we don't even question them. For instance, the belief that you shouldn't open your umbrella indoors or bad luck will "rain" on you is passed on from one generation to another. Superstitions like that are an example of how often we accept the answers made by someone else without giving them a critical thought.

By the way, authoritarian governments can play on this weakness of ours and use TV shows to "fill in" the spectators' "Chinese rooms." These TV shows typically feature an audience member asking awkward questions that always get answered the "right way." Thus, people watching the show start to believe they

know the “truth” – as they can support their opinion with what they heard on TV. The same goes for the internet – a whole class of people claim they are right simply because they don’t watch TV.

Ready-made answers help us orient in everyday life, but they get in the way when it comes to solving engineering, physics, or even social problems. Our patterns prevent us from moving forward. Besides, people that surround us have their own “Chinese room,” which is similar to ours. They, too, keep us from changing behaviors. That’s why the ability to “hack” one’s Chinese room is a sign of a gifted person, capable of thinking outside the box.

History knows many cases when inventors had to confront public opinion. But the most shameful one, to my mind, is the story of Ignaz Semmelweis. In 1847, while working in a Vienna obstetrical clinic, Ignaz discovered the reason why 15 percent of the clinic’s patients were dying.

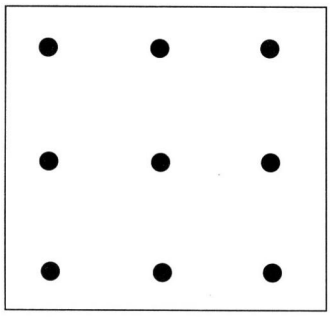
Physicians at the time did a lot of autopsies. Often the only hygienic procedure before going in for delivery was wiping their hands with a cloth. Thus, doctors infected their patients. Professor Semmelweis obliged the clinic staff to wash their hands in chlorine solution before examining the patients. And the mortality rate dropped to 2.5 percent, that is, seven times less.

Instead of getting recognition and reward, as you might think, Semmelweis was dismissed from the hospital and harassed by the medical community. He tried to organize conferences and wrote letters to prominent physicians, but all his efforts were in vain. In 1865, he was treacherously committed to a psychiatric asylum, where he was prescribed laxatives and doused with cold water and severely beaten by the staff. By a twist of fate, Semmelweis died of septicemia – blood poisoning, the disease that he had saved his patients from.

It took a long time for the scientific community to learn to accept new ideas. You can learn more on the topic in *The Structure of Scientific Revolutions*, a wonderful book by Thomas Kuhn.

So, to solve the task, sometimes you have to go beyond what’s known, to hack or get rid of your “Chinese room.” It takes practice to do that, so don’t be surprised at the conflicts between geniuses and the public. Geniuses have to bring society out of balance to shake the existing beliefs even a little bit.

**Exercise 1**
Now I invite you to solve a famous problem that is the best fit for this chapter. Connect all the dots on the picture with four straight lines without lifting your hand off the paper.



**Exercise 2**

Observe yourself as you go through the day.

Notice when you do the same thing every day. For example, maybe you always brush your teeth with your right hand or always take the same way to work.

Also notice when you do something differently or not the way you did it before. How do you make choices?

This exercise will help you become more familiar with your Chinese room.

### *0006. Being Like Everybody Else Doesn’t Hurt*

For Silicon Valley, nerds coming up with weird ideas is no surprise. Sometimes those ideas start multimillion-dollar companies. However, when Elon Musk left IT to try to make a change in the real world, to go beyond the expectations, he could not possibly imagine what was coming for him.

When Elon announced he was going to build rockets, almost everyone turned against him. The space launch market was a monopoly controlled by the companies established a long time ago, sharing multimillion-dollar NASA state funding. But even that wasn't the core issue. The society was not ready for someone to dare build a rocket all by themselves and manage to avoid bankruptcy. Everyone pressured him to abandon the idea. A friend of Elon made a selection of launch explosion videos to persuade Elon to give it up. A group of opinion leaders – scientists, astronauts, people Elon had looked up to as a child – were publicly criticizing and picking on him. Imagine your hero calling you a loser, and all you can do in response is keep trying to make your dream come true – in vain. Among those who turned their back on Elon were even some of the associates he planned to cooperate with on “Mars Oasis.”

For some time, all SpaceX ventures were ending in failure. They didn’t have a suitable engine for the rocket for a long while. Tests ended in explosions. The company was facing accidents, explosions at testings, and rockets crashing on the ground. One step forward and two steps back. Of course, it was hard to find investors.

Entering the real world was grueling for Elon. The difference between IT companies that produce code and companies making physical products is huge. To get a sense of the difference, compare how the end products are made.

> A programming company focused exclusively on the internet market can quickly correct mistakes. Some bugs can stay unnoticed for years simply because people don't use all the program’s functions. Often developers don't even try to correct all the mistakes – they're fine if most customers are satisfied with the program. Those who are not happy are either given a troubleshooting manual or ignored.
>
> In the virtual world you can track the code changes. If something stops working, you can easily go back to the old version.
>
> Software developers normally test the program lots of times. Even if you add a single line of code you can check how it affects the result.
>
> Once you have written a program, you can copy it as many times as you like, it won't cost you a penny. Thus people can get bumper profits, having once invested their time into a program.
>
> You can take a program that's barely functioning, show it to a bunch of people, and use their feedback to figure out where to take the idea.
>
> On top of that, IT technologies gain in quality and performance every day.
>
> Staff is easy to find. A huge demand creates a rich learning database and makes talents from other fields switch to IT. That’s a reason why a professional CNC lathe operator is harder to acquire today than a qualified software developer.

Real life doesn’t have these benefits.

> To find at least some specialists, Elon opened the office in El Segundo, CA. It’s a suburb of Los Angeles inhabited by 17,000 people, most of them employed in the aerospace industry. That was a strategic decision. Had SpaceX been headquartered elsewhere, it would have been way more difficult to find the professionals needed.
>
> But it’s not enough to have qualified engineers. If you create a physical object, you need units produced by other companies. The thing is, once you have chosen a supplier and made technical

drawings, it's hard to change that if anything goes wrong. The units might turn out to be bad quality; your supplier might fail to adhere to the drawings or delay the delivery.

By the way, that's a reason why SpaceX tries to manufacture units in house. Having everything under one roof ensures the details are better quality and keeps costs down and perfectly predictable.

Even when all the units are ready, you cannot test your rocket. You can only partially test some units. If just a segment of the rocket is functioning, there's no flight to show to the investors. You have to wait until the rocket is fully assembled.

If there's been a mistake, you cannot just replace the part. The rocket has already performed a rapid automatic disassembly, and you have to start from scratch. And, to make it even tougher, the launch site is hundreds of miles away from manufacturing locations.

Program code is "fixed": when you copy it, it stays the same, whereas the accuracy of rocket assembly is fully subject to the person performing it. This means that each rocket you make could be assembled differently. Mistakes made due to human factor are hard to track. With thousands of details in place, there's always a risk of it being misassembled.[15] Therefore, it's not enough to manufacture one rocket. You need to set up the whole process.

These two examples are merely an attempt to describe the essential difference between an IT company and an enterprise functioning in the real world. And this difference is most visible in the inner experience of the person running the project. In the IT sphere, a mistake is added to the bugs list and assigned a priority. Every developer knows it's not an issue and any bugs can be fixed.

The experience is totally different when you witness the explosion of the rocket you devoted a couple of years to. It blows up and leaves you wondering: why it happened and what needs to change. SpaceX engineers worked for six years and experienced three failures before they made their first successful launch. In fact, that fourth attempt could have easily put an end to the company – according to the initial budget, they could afford three launches only.

High risk of failure leads to increased bureaucracy and inspections – no one wants to be held accountable for the fiasco. Engineers rely on tons of documents to protect themselves. As a result, costs go up and the design process slows down. Unlike large state-funded companies, SpaceX could not afford high production costs. So imagine how much courage it must have taken Musk to leave the comfort of the IT world and enter the rocket manufacturing one! All the field gave to him were stones and competition with large monsters that clung to the state funding like limpets.

After the profitable sale of PayPal, Elon could have created a successful IT project, designed a virtual reality, or developed a popular computer game. A venture like that would definitely have been a success.

But Elon did not stop at the crazy rocket project. He invested in Tesla and, thus, raised the insanity of the situation to the tenth power.

He now had two non-IT companies to take care of, each operating in a rough market. Throughout the one hundred–plus years the U.S. automotive industry has been operating, 1671 companies have gone bankrupt.[16] The competition has become so fierce over time that the industry has only a 10 percent profit margin. Besides, each vehicle is made out of ten thousand parts! With rockets, it makes sense to have all the production under one roof, but with cars it's not profitable at all. So, you have to deal with hundreds of suppliers. If just one of them delays a delivery, you won't be able to assemble the car. It could be just one screw left before the car is assembled – and this screw is not there because the ship carrying it from China was caught in a storm. This missing screw can potentially cause losses hundred times higher than the cost of the screw itself. To avoid delivery delays, you need a warehouse to stock parts. Therefore, you have to invest half a year before you will be able to sell your product. Car production is a constant headache and a huge money struggle.

Some people criticize Musk and claim that flying to Mars is just a pretext for him, and his real goal is to make lots of money. Those people are hardly aware of the circumstances involved. But the difference is easy to feel if you leave your comfortable office and try creating something in the real world yourself.

When the crisis of 2008 hit the economy, Elon had two companies rapidly eating up his money yielding no profit at all. The global financial crisis made it hard to find new investors. The media kept picking at Musk, dragging his companies through the mud and looking forward to his bankruptcy.

To understand Elon, recall a scene from *Terminator 2*. Sarah Connor dreams that she is at a playground where kids are playing. She screams warnings, but nobody pays attention to her. The children keep playing, until a nuclear strike kills everyone.

Similar to Sarah, in those times of crisis, Elon felt very clearly he was on the right track. He was aware of what could happen if he gave up. He knew he was doing the right thing; he saw how valuable both companies were for the world. Unfortunately, most people didn't see it that way and weren't eager to help. During the crisis, everyone was focused on making sure their money was safe, and very few were thinking of the future of humanity. Certain about the value of his ventures and the road he had chosen, Musk contributed all he had to fulfill the task. Still, he was running out of money. He scraped together all the funds, but it was still not enough. "I could either pick SpaceX or Tesla, or split the money I had left between them," Elon recalls. "That was a tough decision. If I split the money, maybe both of them would die. If I gave the money to just one company, the probability of it surviving was greater, but then it would mean certain death for the other company. I debated that over and over."

Imagine that pregnant pause: he wouldn't have been abandoning just the company and the people who committed themselves to it for years, he would have been giving up on a whole branch of human development. If electric vehicles had failed, all automobile manufacturers would have reached the same conclusion: this is not worth the effort; fuel engines are beyond competition; battery technologies are not ready yet – we might try again in twenty years.

If the first rocket project had failed, humans might have abandoned space exploration altogether! In 2011, the U.S. had already spent way too much on the space shuttle program, and in the end, decided to shut it down. In fact, since 2011, American astronauts have been ferried by Russians on a rocket built after the Soviet model, similar to the 1967 spaceship. And due to corruption and the current state of Russian society, there is not much left for Russian launch platforms. You can see now how much space exploration has been dragging behind.[17]

All civilized humanity is looking forward to Boeing and SpaceX flying astronauts to the International Space Station (ISS) in 2019. But the crucial choice was made back in 2008.

That's an enormous responsibility, right?

Elon chose the riskiest option – he invested in both companies. Musk counted on a bunch of people who supported him and realized he was acting wisely. If you read Ashlee Vance's book *Elon Musk: Tesla, SpaceX, and the Quest for a Fantastic Future*, you'll get a deeper insight into the situation and find even more respect for Elon Musk.

Unlike Ignaz Semmelweis's case, American society turned out to be quite educated and supported Elon. SpaceX and Tesla engineers worked overtime to bring the launch date closer. Californians preordered electric cars and patiently waited for their vehicles. Investors, close friends, and even relatives helped scrape together enough money. NASA contracted SpaceX to deliver cargo to the ISS.

Geniuses desperately depend on society for support! And the support benefits both parties. Thanks to SpaceX, the U.S. has regained its leading role in space exploration. Tesla has created thousands of jobs and is an example to other companies.

Musk is constantly drawing public attention by consistently pushing boundaries. “To build a rocket is one thing,” space experts used to say. “But to make it return and land on those small legs – that’s bullshit.”

As if to mock them, Musk went even further: he launched his own electric car toward Mars. Not only did he design an electric vehicle, but also supplied it with an autopilot to get ahead of the largest players on the market. Obviously, Elon is not going to stop. Looks like he has no patterns, except thinking outside the box.

But what is it, specifically, that enables you to come out of the box? When does one start seeing the world from a different perspective?

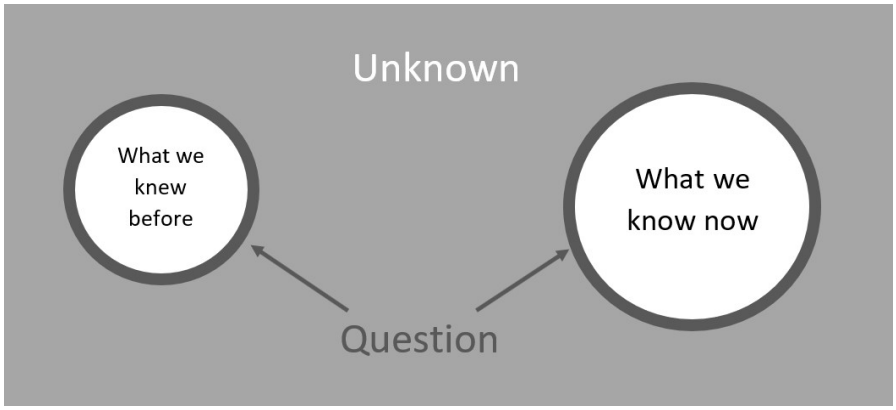
### *0007. Information Is Boundless*

It doesn't matter how smart we are if we don't know how to search for information. Our mind won't help us if the information we find turns out to be inaccurate – wrong information will lead to wrong conclusions. Being able to find information, process it, and draw conclusions is a valuable skill that is worth developing. A way to search for information is to ask questions.

What is interesting about questions is that we ask them to expand our knowledge about the things we already have some information about. For instance, to ask what the speed of light is you need to know that light exists. And only when you know the answer to the previous question, will you start wondering why the speed of light is always the same.

For a long time, people had been dying for unknown reasons, but physicians discovered the cause and gave it a name: cancer. Now we can ask the next question: How do we cure this condition? By the way, Ukrainian scholar Ol'ha Brovarets discovered a scientific explanation of the causes of cancer. So, conquering this deadly disease is a matter of time.[18]

Questions are always about the things we are familiar with but don't fully understand yet. Let's represent the process of learning in a diagram, one of those that Neil deGrasse Tyson,[19] American science communicator, is fond of. Neil describes knowledge as a circle: its inside is what we already know, and what we don't know yet is on the outside. The more we learn about the world, the more questions we have. Our prehistoric ancestors had a very small circle of knowledge. Of course, they knew it was a bad idea to eat yellow snow, but their overall knowledge was less than 1 percent of what schoolchildren know today.




If we stop finding answers to questions, human progress will stop. Yet, there's nothing to fear – we keep making new discoveries and having new questions.

Today, no questions have been proven to be unanswerable. Therefore, we can assume that

any question can be answered except those that are useless to reflect on.[20]

Even if we assume some questions are unanswerable indeed, it will be better for us to think otherwise. To accept there's no answer is to refuse an exciting journey that might bring you the answer and a lot of learning. So, to search for an answer is already a significant accomplishment. Even a small step in the quest is much more than nothing. So, let's believe we can find all the answers!

Before we take action, we must ask the question: How do we do it? We already know we can answer any question; therefore, we are able to do anything. If we can do anything, then our abilities are unlimited.

### Consequence 1: Your abilities are unlimited.

Obviously, we are, to some extent, limited in time and resources. But look at the human advancements – they don't have these limitations. Mankind has done the impossible! It has learned to fly to space, communicate over large distances, and even send their machines to other planets. That's miraculous!

You should base your strategy in life on this principle. If you believe there are no limits to what you can do, you will achieve much more!

Perhaps you'll have to wait for forty-eight years – that's how long Peter Higgs had to wait for a confirmation of his theory, when the Large Hadron Collider was built. Limitations in resources will force you to take more effort and accumulate those resources first. Yes, achieving your goal requires careful resource management. But you can learn this too!

Things we consider impossible today might become our everyday life in a couple of years. The question is, will you be among those who change the world and believe there're no limits to what they can do – or have you already limited yourself, ready to give up at the first sign of challenge?

### Consequence 2: The answers to most of your questions have already been found.

Some questions are complex scientific matters; others are common everyday problems. Some answers you can easily find on the web, while comprehending others will require extra effort or study.

The second consequence is important. It accelerates development and enables us to apply the knowledge we've already acquired. All we have to do is to learn to use it in the right way. Even if you're trying to make a truly unique and unparalleled thing, a part of your work or the tools that you're going to use are already known.

If it's a common life issue like repairing your Portal Gun or cooking a traditional Ukrainian borshch, the answer is already there – you just need to look for information.

Thus, those who apply both consequences together will be more successful. First, keep in mind: if you have a goal, you can achieve it. Second, the better you are at combining and applying the knowledge that's already there, the less time your journey to the goal will take. A person who doesn't learn from other people should get ready for failure.

Check yourself: Do you know how to search for information? Are you ready to learn from the experiences of others? What kind of knowledge do you need to solve your current problems? Has anyone dealt with similar problems yet? Who can help you find the information you need?

### *0008. The Right Question*

It wasn't Elon Musk's love of space exploration that started SpaceX. It was the one right question he asked.

Of course, space travel has been Elon's dream since his childhood. As a kid, Musk read comic books, and the first movie he saw in the movie theater was S*tars Wars IV*.[21] The first game[22] he developed for the magazine *PC and Office Technology* was set in space. But it's one thing to dream of flying to remote planets, it's a whole other thing to make dreams come true by building rockets.

When you sell your company for $165 million, you face a serious problem: What are you going to do now? You have enough money to pay for any folly for the rest of your life. You literally have money to burn.

This is the moment any mentally sound person stops focusing on increasing their fortune and starts considering another question: What can I do in my life that will be interesting and valuable, that will give me a reason to wake up in the morning?

That's exactly what Musk did. He recalled his childhood dreams and decided to play a bit: to revive the human dream of interplanetary travel. First he researched the existing projects. He contacted the Mars Society and even joined its board of directors. But the Mars Society lacked ambitious plans. As he wanted to expand the number of people taking part in discussions, so Musk created his own organization, the Life to Mars Foundation. He started organizing conferences, bringing together the most talented engineers and space scientists to discuss ideas. The group participants shared Elon's dream, but didn't have money for it. That's why a millionaire willing to fund daydreams appeared right on time.

One of the ideas discussed, in the form of a project called "Mars Oasis," was sending plants to Mars. When the plant machine landed, its dome would open, and the world would see a picture of green plants on Mars. The dreamers hoped it would draw the world's attention to space exploration and stimulate investors to fund space projects. Initially, Elon planned to spend between $20 and $30 million on the idea. That should have been enough to build a capsule and buy a rocket to deliver it to Mars.

At the time, Russia was a leader in the rocket launch industry and possessed the technologies Musk's team needed. Even a simple ballistic missile would be enough for the task. So, a team of associates set off to Moscow to buy a rocket.

Humanity was very fortunate that Elon wasn't the guy to give bribes. The Russians turned out to be arrogant fools, so the story continued as we know it now. The Russians asked for an insanely high price for their old written-off cans.  And then the events happened that brought about all further changes in the space industry: Russia lost its position as a space superpower, while the U.S. regained it (with the creation of Falcon 9 reusable rockets).

Elon asked a question: Why are rocket launches so expensive?

This small question is like a gap. There's a huge difference between the person who knows the right question and the one who doesn't. No wonder the movie *Hitchhiker's Guide to the Galaxy* is about searching for the question when the answer is already known. So, as soon as Elon asked the right question, everything fell into place. It became evident that the only reason people stopped flying to space, despite interest and willingness to do so, was the high cost. Even superpowers don't fly people to Mars because they cannot afford it with current technologies and prices. Thus, in a split second, Musk the daydreamer, his head in the clouds, became a person with a clear action plan, the one who knew where to look for the answer.

Elon was still on his plane back from Russia when he showed calculations to his friends and reached the conclusion he had enough money to build the rocket himself. The plan changed completely. Instead of ferrying plants to Mars, they would use the money to design the rocket. Naturally, some of Elon's associates didn't like that. Not everyone could see that gap between dreams and reality.

SpaceX spent the following years working to lower the costs of space travel. Each engineer was searching for ways to make the mechanism reliable and reusable, but also cheap. And SpaceX succeeded. In the sixteen years the company has existed, it has achieved a 63 percent share of commercial launch market, and this percentage keeps growing. Meanwhile, Russia has disappeared from the commercial flights market, even though back in 2010 it used to perform over 55 percent of the launches.

But what about flying to Mars? At the time I'm writing this book, it hasn't happened yet.

The thing is, Musk can now send a bunch of Mars Oases. But he set for himself a more ambitious task – to ferry humans to Mars. This problem is too complex. It's not just flying people there; it's also bringing them back alive. Complex tasks are hard to solve because they resemble multivariable equations. What kind of fuel do you use and how do we transport it to Mars? Or should you make it on Mars? Change the fuel and you need a different kind of engine. The new engines affect the mass of the rocket, and the altered mass implies a change in the amount of fuel required... This equation includes hundreds of variables that affect one another; a small circle of SpaceX engineers know them very well.

That's why, just like before, it was the right question that was missing. SpaceX engineers were modeling possibilities, but the solution kept slipping away. That's the reason we saw numerous modifications of BFR.[23] Finally, at the presentation of #dearMoon,[24] a lunar art mission, Elon Musk announced they had found the crucial question that had made everything fall in place again.

Later on at the Starship presentation at Boca Chica,[25] Musk revealed his secrets and pointed out the key changes that would enable another powerful breakthrough in the rocket industry. First of all, the Starship uses methane for rocket fuel and adopts a new closed-cycle type of engine.[26] That resolves several issues in one go such as **where to get fuel on Mars** and how to raise **engine efficiency**. You can get methane and oxygen from Mars's ice and atmosphere, which means a substantial amount of savings on resources required for the return journey, and since you need two times less fuel, the fuel tanks also decrease in size. Besides, the theoretical maximum combustion efficiency in a methane engine is 99 percent (two heated gasses have fairly simple $CH_4$ and $O_2$ molecules that enable them to start a reaction sooner). Meanwhile, rocket-grade kerosene has longer carbohydrate molecules that need to recombine before the reaction; therefore, the theoretical combustion efficiency barely reaches 95 percent.

The next important issues to consider are **cost and ease of spacecraft production**, as well as the Starship's **resilience** when exposed to different temperature ranges in space. The thing is, Elon's new rocket is much larger in size, which means that with slow construction technology building the rocket can take decades, and even the fact that it will be reusable won't save the situation. That's why spacecraft construction should be fast. As Elon pointed out, a crucial step toward resolving those issues is using 301 stainless steel. As the spectators said jokingly during this presentation, if the vehicle breaks down on a planet, you would be able to make something useful out of it from the new material.

Yes, it's almost like iron that you could work on with a hammer and a standard welding machine. That's what makes the vehicle easy to repair, both on Mars and in space. Contrary to other materials, steel does not require a particular room or equipment to work on. Furthermore, Starship's 301 steel alloy becomes two times stronger under cryogenic temperatures, and the strength-to-weight ratio becomes equal to or above that of carbon fiber and aluminum-lithium alloy. Besides, steel has a high melting point of 1399°C, which is a huge advantage for the spacecraft entering the Earth's atmosphere like a meteor. Because the heat resistance of the metal is higher than that of aluminum or carbon, you can decrease the weight of the ceramic tiles that protect the spacecraft from the heat. As a result, the vehicle is lighter than it is when constructed from other materials. After all, steel costs $2,500 per ton, while carbon fiber, which was planned to be used initially, is $130,000 per ton.

Refueling in space is the next step in making long-distance heavy cargo transportation possible; it's also important for creating a Mars base. SpaceX is already working on this technology while docking with the ISS.

Maybe few people realize how important these technologies are. But these innovations are drastically changing the way things are done. It's not just something different; it's something that determines if the whole project succeeds or fails.

Note that the right question appeared as a result of Elon's interaction with many people. First, he accumulated information, then transformed the information into actions, which, in turn, helped acquire new information. The cycle repeated itself until the right question was identified.

It was Musk's energy and perseverance that kept it all running.

### *0009. Awareness of the Problem*

If we have so many limitless opportunities as outlined in chapter seven, why do some people achieve incredible success while others cannot escape the enchanted circle of small problems?

Because you can only act in the right direction once you realize the problem itself. Each of us is able to find the answer to any question, each has endless possibilities. But not everyone can see the problem and ask the right question. We look like magicians who have a crystal ball, but only use it to look at pictures of cats.

At the end of the nineteenth century, there was a struggle among engineers for who would make the first aircraft. Advances in mechanical engineering encouraged investors to fund airplanes, and the spirit of flight had already flown in the air. Talented engineers dreamed of making their name known in history and died many times in the flight trials, but all in vain. Those days, engineers thought of an airplane as a train or a car: it would fly provided it was equipped with a powerful engine that would lift the weight of the airplane. It was believed that the pilot would direct the plane by shifting their body weight, and turn the aircraft to the left or to the right, just like in a car.

But the brothers Wilber and Orville Wright[27] noticed the problem of the aircraft instability. Before adding the engine, they created a glider that could be operated. The brothers invented a three-dimensional aircraft control system that is still being used. Adding an engine has become a technicality.[28]

When Steve Jobs created the iPhone, there was already a number of phone companies that employed lots of talented engineers. The capital was enough to do anything. For instance, Microsoft believed it was more convenient to poke the smartphone with a stylus and the programs should look as they do on a large PC. In December 2006, the most common smartphones were the once from Microsoft. The company had 34 percent of the smartphone market.[29] No one saw the problem except Steve Jobs. The phone revolution is not the first revolution in Jobs's life. However, it is that revolution that has affected the modern world the most.

These two events are one hundred years away from each other, but the essence is the same – when you understand the problem, you can make a tremendous change to the situation.

We may think that the solution to these problems was obvious, and therefore, simple. It seems that if we were the Wright brothers, we would do the same. But this is a deceptive feeling. We are still surrounded by many unsolved problems, and we do not even think about if we can improve anything. We are used to things being as they are today and do not notice the problems that are there. Our "Chinese room" is full-on happy to serve us!

The figure below schematically represents solving the problem. Green indicates what everyone can do, what everyone is taught to do, and blue indicates what we still need to learn.


The current educational system spends a lot of time teaching people to solve problems. Yet we learn to see problems all by ourselves, by trial and error.

Typically, studying looks like this: you're given a formula, you memorize it, and you figure out how to apply it. Then you are given a problem solely for this formula; you just have to insert the corresponding numbers. Even in laboratory experiments at a university, the main task is simply to replicate the experience of another person and to record previously known results. In the end, after many years of

basic study, you as a postgraduate student may encounter a problem that your teacher will propose. And you will write your dissertation on this topic.

That is, for the most part, the learning process reduced to reproducing information. However, the information itself is secondary to the concept it is related to. For example, when a person is told that the Earth is spherical, it is a piece of information. If our brain is able to grasp this information and turn it into a concept, it can play with it like a toy. If the Earth is a sphere, then when I go east, I will arrive at the same spot I am now from the other side – that's an assumption that can be made by the person who understands this concept.[30] If the concept is not clear, it remains just a piece of information. Today you have the information that the Earth is spherical. Tomorrow someone says it is flat. Well, let it be flat. It's just information! Therefore, when a person only has information, they are not able to operate it. They cannot combine it with other concepts, draw conclusions, or create new concepts. Those who have not grasped the concept can only blindly repeat the information – that's the most they can do.

As our studying is based on passing on the data, grasping the data is considered to be the result of the educational process. The successful student is not the one who understands the subject, but the one who has a good memory and has learned to repeat the information. It works, to some extent, but complex concepts are based on understanding simpler ones. If the indigenes witness the rocket launch, they will perceive it as a manifestation of the deity they believe in. They don't have the knowledge of many concepts that would otherwise explain this phenomenon. Conversely, if you see a person in the air, you will be more prone to look for a device that enables them to fly.

Of course, studying at school is not in vain. Based on the information received, our brain builds its internal concepts in an effort to comprehend the information. If a person has successfully mastered the concepts, they begin to manipulate them to find their vocation. As no one checks the mastery of the concepts, schooling resembles a huge filter for percolating children. Initially, students are provided with some simple information that anyone can transform into concepts on their own. As they learn, the concepts become more sophisticated. If you have missed a few classes and haven't learned the previous concepts, it gets increasingly more difficult to learn the new ones. So, by the time of graduation, only a few people understand what they are studying and why it is needed. The information remains the information and is doomed to be forgotten.

Each of us has our own penchant. While some concepts are particularly easy to grasp for one person, another person might be struggling with them, yet be fluent in other ones. But it does not mean that a mathematician cannot be taught music. It's just that you need to apply a different set of basic concepts. The teacher's task is to identify which concepts are missing for the student to understand the subject. Perhaps the student should go back and learn simpler concepts. Perhaps it is necessary to rely on the concepts that are clear to this particular student to illustrate the new ones. This is exactly what talented teachers do. A gifted teacher will find a way to explain a sophisticated topic in simple words.[31] A mediocre teacher will give a lot of information, but fail to explain it. Probably, they don't really understand the concepts themselves, and simply reproduce the information. Information is like a photograph. You can only see one side of the problem. A concept, meanwhile, is a 3D image. You can rotate it, look at it, and describe it from different perspectives.

Of course, education is important to us. It sets us apart from the animals. But why do kids really go to school? What if schools exist just to take time off? One hundred years ago, children could easily be sent to work at the factory – the law of the time allowed for that. The current laws prohibit child labor.

Unless you give children something to do, they can harm themselves. So the child should be charged with something. Something that will be useful. What exactly will be useful is unknown to anyone; therefore, children are taught all sorts of things. And since our goal is to occupy children's free time, it doesn't really matter who the teachers are or how many students are in the classroom. That is why you can pay a small salary to a teacher to keep an eye on thirty students. Under such conditions, none of the students will

receive enough help in mastering concepts and understanding problems. Instead, rigorous disciplinary methods will be applied to rid students of individuality. Under such conditions, this is the only way to control a bunch of children.

If the society does not value teachers' work, pays them a meager salary, and does not ask too much of them, the question arises: Why would anyone become a teacher at all? Some people just love talking to children; they enjoy teaching. There are also those who choose the profession because they failed at pursuing other careers. In other words, it is possible for a teacher to be a person who has not yet found themselves or their vocation. Such a person cannot teach to notice the problems because they don't see their own ones.

I'm lucky – in my life, I've met some teachers who love their job.[32] However, more often, I see teachers who cannot teach.

I have a lot of appreciation for teachers' work. I believe they should be respected and receive a decent salary. In turn, this should raise the selection criteria for this honorary position.

An interesting example would be a learning system where the teacher can attend to each student and be personally responsible for their continued success. Such a system is used in the martial arts – probably because students have always represented the mastery of their teacher. Asia has a long tradition of competition between schools. When one school loses to another, the students go to the winner's school, and the inept teacher loses all the money and has to start over. It was the same in religious schools of ancient India. That practice fostered competition and teachers' responsibility, and developed the philosophical thought:

> When choosing a teacher, check on the older students, they reflect the teacher's capabilities.

Today we can see the modern world trying to restore those traditions. An example could be the mentorship institute, where a successful person helps several others to start their own business.

In fact, everyone needs a mentor, and here's why: In our life, we make decisions based on the thought patterns we have discussed before. Sometimes these patterns lead us into a jam. The same program that brought us there will prevent us from getting out.

With a broken navigator, it's easy to get lost, but hard to find a way out. So our thinking patterns don't help find the right direction since they always lead to the same mess.

If an outsider tries to help, they will probably hear, "Yes, I have a problem, but that's due to the circumstances; it's all this broken navigator. You see it, right?" Then we explain in detail how we got lost and why we can't find a way out. However, we do not listen to the advice because "They do not understand the complexity of my situation." It is for good reasons that business consultants charge insane prices for their services – this creates at least some motivation to change behaviors. Otherwise, clients would continue the way they did before. Moreover, it's not quite good manners to give advice when you weren't asked for it. So we can forever wander in broad daylight, unaware of the mistake in our thinking pattern. The way out is to find a person we trust and listen to. Of course, the requirements to the mentor are very high as well. They should be able to skillfully direct the mentee toward the goal. Professional mentors make their mentees arrive at the conclusion by themselves, by answering the mentor's questions. The highest skill is when your mentee doesn't guess they have been helped. Anyway, the main aim of the mentorship is to facilitate the development, and the main reward is the student's success being greater than the teacher's. And this is quite natural: the mentee follows the shortest way, and therefore, arrives there faster than their teacher, who had to fumble in the dark.

Until recently, to know the information was as important as to understand the concepts. People did not have the internet at their fingertips and had to rely solely on what they remembered or spend time searching for information in the library. Technology is changing the world quickly, but education does not keep up with the changes. If we shift our focus from the information to the concepts, we will see right away that teachers are wasting time repeating the same information during the lessons. It would make more sense to record an exciting video explanation once and use it in the future, then let the teachers focus on guiding practical exercises and clarifying concepts to each student personally. The students could watch videos at home, and do the exercises and communicate with the teacher in the classroom.

The future will be for those countries that are the first to change education and orient it toward understanding concepts. It is comprehending concepts that will become the basis for teaching people to grasp the roots of the problems.

### *0010. The Rebel*

In 2015, Elon's fans learned that Elon had started a riot against the system he was part of. In his interview for a Chinese TV channel, Elon described for the first time the idea of creating a new type of school for his children. "I simply never saw common schools do what I considered necessary. So, I thought, what could we do about that? Maybe, it would be better to start a school?" Elon said.

Unlike Bill Gates or Steve Jobs, who dropped out of college,[33] Elon is no stranger to scientific community and to the educational system. His story is completely different.

In 2018, Elon was invited to sign a special book. Since 1663, the Royal Society of England has been gathering signatures of renowned scientists,[34] kings, and other figures who contributed to the advancements in science. Elon's signature is right beside the ones left by Robert Hooke, Isaac Newton, John Flamsteed, John Dalton, Charles Darwin, Benjamin Franklin, Niels Bohr, Lise Meitner, Alan Turing (who was mentioned earlier in this book), and many others. In this wonderful way, the Royal Society has recognized Elon's achievements in space travel, electric transportation, and renewable energy!

Elon got his initial education in several South African schools, including the prestigious Pretoria Boys High School. When he moved to Canada in 1989, he enrolled at Queen's University in Kingston, Ontario. Because he was paying his own way through college, Musk wasn't squeamish about ways to make extra money. He was working and studying hard, and yet he managed to take the next step. In 1992, he transferred to the University of Pennsylvania on a scholarship. UPenn ranks among the top-eight oldest institutions in the U.S. and is known for its high quality of education. No wonder it's part of the top-ten best universities in the world.[35] Elon graduated from Penn with two degrees: bachelor's degrees in physics and economics from the Wharton School of Business.[36]

In his final college years, during his summer vacation, Elon did internships with two Silicon Valley companies at the same time. By day, he was helping to design ultracapacitors at Pinnacle Research Institute. And in the evenings, he worked at Rocket Science Games, writing drivers for computer games peripherals in an assembler language, a highly sophisticated programming language.

In 1995, Elon enrolled in a postgraduate program at Stanford University, California. He initially wanted to keep designing ultracapacitors for electric cars, and for that reason, he chose to pursue a doctorate in materials science. But the internet boom inspired Elon to start his own business, so he dropped out of the university after just two days of being enrolled there.

Elon was a clever young man and his personality stood out against his peers. Yet he didn't disregard his mentors' help. Musk is known to have had two mentors. He found the first one while studying at university in Canada. Back at the time, there was no internet, so to find a mentor, people would resort to unusual means. You had to find the phone number of the person you wanted to get to know and convince them to meet you.

Elon and Kimbal would not let that stop them: the brothers would cold-call renowned Canadian leaders and ask them if they were available to have lunch. The guys were very fortunate – Peter Nicholson agreed to meet them. Later, Peter became Elon's mentor and even invited him for a summer internship at the Bank of Scotia, where Peter worked as a top executive. It was Nicholson who advised Elon on setting up his first company, Zip2, and the internship at the bank came in handy when Elon was working on PayPal later on.

The next mentor the brothers found was Greg Kouri, who eventually also joined Zip2 as a cofounder. A year into the company's history, he joined the brothers in running the business and helped Elon and Kimbal, who were young and quick-tempered at the time, come to terms with the boring world of adults.

So, Elon achieved recognition in scientific community, almost got a PhD, has two degrees, and studied on two continents and in three countries. How many people do you know who achieved their success through science? How many of them are so close to it? Musk is a product of the educational system contemporary science is built on. When an unschooled person says the educational system is outdated, it might be because they simply don't want to study. But when Elon Musk says he's not happy with the schooling system and starts a school of his own for his children – that's quite a statement.

Some details about the school were released in research by Ars Technica,[37] which is partially based on the public interview given by Joshua Dann, the school's principal. Musk's school is so secretive that even the SpaceX employees know little about its curriculum and admission terms, although the school operates on the SpaceX campus. For others, the school is even more of a mystery – even though there is a huge demand for enrollment. Lots of wealthy Los Angeles families would pay any fee to enroll their children in this prestigious institution. In 2017, over four hundred families competed for a place in this new startup of Elon's. Fat chance! Elon believes the school can hardly accept more than fifty children.

In 2014, Elon Musk had a conversation with Joshua Dann, one of the teachers in his children's private school. Together, they agreed the educational system could be improved. "The traditional system is very passive. I ask parents what percentage of their time at elementary school was thoughtfully spent. We hear an average of 35 percent from most. And that's an atrocity, right? That we are wasting children's time... The day [here] is dense. There's really no down time," Dan shared in his interview. That brought him to the position of the principal of Ad Astra, a new school based on a unique project-based learning experience. "We started with eight kids in a really small conference room with transparent walls. Engineers [would] always come drop by and peek on it," recalls Dan. In the first year of the school, there were unusually few kids. When Elon took his five sons on vacation, there was just Dan and three children left in the classroom.

Now, the school has grown, there're over thirty students aged seven to fourteen. Ad Astra has got separate classrooms at the SpaceX campus, and even its own chemistry lab. Each student is provided with meals, a Mac laptop, and all the study materials needed – all paid for by Elon.[38]

The school focuses on mathematics, technical studies, and ethics. Elon believes that in the future, translation will be done by the machines; therefore, there's no point in wasting time learning foreign languages. There's no music and physical education either.

Ad Astra uses three teaching formats. There're some traditional lessons, where students learn informatics, mathematics, chemistry, physics, and creative writing.

In the unconventional lessons, the students come together in a team around the projects or problems that they are trying to solve. In addition, there's also self-study via the online courses on such popular resources as Codecademy, edX, and Khan Academy.[39]

If you look at the biographies of the founders of famous technological companies – Steve Jobs, Bill Gates, Elon Musk – you will see that at twelve or thirteen years old, they were already creating projects of their own outside the school curriculum. That way, they formed a most uncommon, ambitious, and unlimited worldview way before they graduated from high school. That's why Ad Astra schooling is unconventional. It's aimed at creating projects, as well as manifesting and strengthening the basic skills of the future top-notch entrepreneurs.

In the A-Frame module kids learn to fabricate things – whether it's balloons or battling robots. Imagine that excitement – watching the robots fight each other! The children cautiously ask their teacher if they can equip their robot with a flamethrower or an electromagnetic pulsar. Dan replies with a smile on his face, "The answer's always yes. You know, until you destroy the school."

A weekly "Folio" assignment is focused on an in-depth study of a specific topic, which might change in a wider perspective. One week it could be the cruise industry, the next one it could be gentrification.

Children choose the topics themselves, so the course curriculum is different every year. Once the students were working on the North Korea case. One of the North Korean team members led the world to a nuclear holocaust. “That’s a truly impactful moment for that kid,” Dan recalls. “The instruction points are essential to get to the heart of what is at stake here, which is making the best decision even when it’s difficult.”

The “Geneva” module gives the teams a chance to study ethical and geopolitical issues under the ever-growing role of artificial intelligence (AI). “We run simulations that include AI, which is a huge issue the kids are going to deal with in their lifetime,” Dan says. “We’ll talk about how to regulate different AI teams, nation states, and corporations. Kids are fascinated about these sorts of things.”

The students also do presentations, where they have to stand for their point of view before adults; they also have creative meetings with artists and visit other companies. Besides that, as Dan shares, there’re over twenty websites designed by the students. “One of the kids makes their own gourmet cookies [that] you can order online. Another kid creates websites for his classmates. Kids are trading Astras all the time,” Dan says about the currency used in the school. “With the skills they’re learning, we give them the ability to make money or to impress a friend.”

Obviously, this kind of intensive learning requires super-qualified teachers and some material resources in place. So the school fees are relatively high for the general public. Elon is very busy with his projects, so he's not going to expand this family startup for others. All that’s left for us is to wait for Ad Astra curriculum to be published, which would give us more details.

It’s worth saying that Elon takes care of other children as well, besides his own. We don’t know all his charitable deeds, but some of them are public, so we can mention them here. In March 2019, Musk gave laptops worth $423 000 to public schools in Flint, MI. Earlier, he had helped the city with drinkable water supply, when he donated $480,000 to install water purification systems at schools. But the $15 million Musk gave to fund the prizes for the participants of Global Learning XPRIZE[40] remains his most famous donation to date.

According to UNESCO, approximately 617 million children and teenagers in the world (that is, six out of ten) fail to get the minimal literacy skills in reading and math. Part of them go to school, but it doesn't help their learning. That means that we need around 68.8 million teachers to achieve the UNESCO goal – to provide all children in the world with quality education by 2030. The data demonstrates there’s been no progress in the field over the last couple of years either.

The Global Learning XPRIZE was created to develop a widely available software that would enable children to teach themselves to read and write in fifteen months. As a result, two teams out of 198 won the prize and proved in field that using their products led to two times illiteracy decrease. It’s quite symbolic that it was Elon who donated to the prizes.

Let’s imagine now that you have been appointed the minister of education for a small country. Your budget is fixed, you cannot increase it. The teachers that you have “inherited” have various qualifications and motivations. With the budget you have, you can only pay them a tiny salary. The classrooms in many schools are overcrowded. Education is largely regulated by the state – changes to the curriculum are not allowed. Even private schools have to stick to the curriculum – there are so few of them, though, that few people actually care about that. Let’s assume that each school has at least one highly motivated and qualified teacher.

You have one week to think it over and suggest a reform plan to the president. Time is on.

To solve this puzzle, use the skills you obtained from this book. Discuss your solution with your friends; they will be able to point out the weak spots and suggest new ideas. Go ahead and publish your explorations on our Reddit channel.[41]

## *To be continued…*

It's not the end of the book; it's just the end of the first part. There're thirty-eight other chapters waiting for you, and half of them have already been written. Soon, you will learn what your own hidden qualities are; what makes people different from one another; what one should know to build a successful company; and how to help your mind think better in the end. We will also cover topics such as philosophy, space, and artificial intelligence; we will discuss the future of humanity and how we can affect it.

You deserve a high-quality and helpful book, so that's why we worked meticulously on it. Because I am a software engineer and a bit of a businessman, writing is a hobby for me. So, shaping my thoughts so readers could comprehend them took plenty of time. For instance, I rewrote the first chapter three times until Oleksandrà, my wife, said, "Oh, I finally understand what you wanted to say." If it hadn't been for her, the book would have looked like a computer program.

It would be strange if I don't apply the advice from my own book and don't divide the task into a couple of simpler elements. You're now reading the first part. I hope it expanded your knowledge and you enjoyed reading it. If you notice any mistakes or would like to give feedback, write to me directly: mailto:ThinkLikeElonMusk@gmail.com. I will be glad to hear if the book has been useful for you!

What Elon Musk is doing is valuable for humanity, so each of us should support him. We need to spread his ideas, and sometimes, simply buy his vehicles. Since that's exactly why this book was created, feel free to share it and lend it to your friends.

Subscribe to our listserve to be informed when the new part comes out:
https://mailchi.mp/521f57f8e87f/think-like-elon-musk

…

See you in the next part.

**People who've been working on the book:**

Editors: Olexander Savytsky, Oleksandrà Suzanska

Translation from Ukrainian:  Daria Voronina

Copyeditor: Lana Barnes

Book cover design: Jonathan Sainsbury

## Нотатки

[←1]

Video of this historic event: https://www.youtube.com/watch?v=wbSwFU6tY1c

[←2]

https://en.wikipedia.org/wiki/Working_memory

[←3]

Some experts consider Garry Kasparov the best chess player ever. It was Kasparov who represented humanity in the chess match against the super-computer Deep Blue.
https://www.amazon.com/How-Life-Imitates-Chess-Boardroom/dp/1596913886

[←4]

In chess, one move consists of two plies, or turns, of each side, i.e., one move equals two plies: one ply by white and one ply by black.

[←5]

Comparative Cognition: Comparing Human and Monkey Memory
https://www.sciencedirect.com/science/article/pii/S0960982211004660

[←6]

A documentary on the ideas prevailing at the time - *Who Killed the Electric Car?*
https://en.wikipedia.org/wiki/Who_Killed_the_Electric_Car%3F

[←7]

A picture from the SpaceX opening ceremony - https://twitter.com/austenallred/status/943629490676121601

[←8]

Historic video of the Falcon 9 reusable rocket's first launch and landing - https://www.youtube.com/watch?v=O5bTbVbe4e4

Will the Falcon 9 actually be reusable or just refurbish-able like the Space Shuttle? https://www.youtube.com/watch?v=HF69nqY3TZs

[←9]

To learn more about Turing's work during World War II, watch a wonderful movie *The Imitation Game* - https://www.imdb.com/title/tt2084970/

[←10]

The car pedals operate in a different way, subject to the position of the gear lever. Similar to that, the tape instructions in the Turing machine perform differently, subject to the state of the machine.

[←11]

This paragraph is there to respect scientific traditions. We have no right to say that you going shopping with a shopping list is a Turing machine. However, it's worth saying that the only reason this description is so complicated is because Alan used the technical means available at his time. Had he had access to Walmart, he would have made his machine way simpler and easier to understand.

[←12]

The quickest way to sort books https://www.youtube.com/watch?v=WaNLJf8xzC4

[←13]

Here you can read about the problem-solving methods humanity has found -
https://en.wikipedia.org/wiki/Problem_solving

[←14]

The company’s name proves Musk has a great sense of humor.

[←15]

A video of Russian Proton M rocket explosion. The preliminary report of the investigation indicated that the angular velocity sensors were installed in an incorrect orientation. - https://www.youtube.com/watch?v=vqW0LEcTAYg

[←16]

List of defunct companies -
https://en.wikipedia.org/wiki/List_of_defunct_automobile_manufacturers_of_the_United_States

[←17]

Except for Russia, China was the only country to have launched three crewed flights in 2011–2018.
https://en.wikipedia.org/wiki/List_of_human_spaceflights#2011-present

[←18]

Article on the scientists who won the 2018 Nobel prize for significant contribution to fighting cancer - https://www.theguardian.com/science/2018/oct/01/james-p-allison-and-tasuku-honjo-win-nobel-prize-for-medicine

Ukrainian scientists in the U.S. designed a nanomedical platform for identifying malignant cells - https://ecancer.org/news/13046-fluorescent-nanomedicine-can-guide-tumour-removal--kill-remaining-cancer-cells.php

[←19]

Neil deGrasse Tyson is a renowned American astrophysicist and science communicator. He has received numerous awards for his countless achievements that are impossible to list here. *Cosmos: A Spacetime Odyssey*, a TV series hosted by Neil, is a must-see: https://www.imdb.com/title/tt2395695/

[←20]

For instance, Buddha spoke of fourteen questions that were unwise to reflect on. But we can create our own endless list of these kinds of questions. Like, what kind of shirt was Elon Musk wearing yesterday? Or, how many books did the Library of Alexandria have?

[←21]

Yes, it was *Star Wars IV*, as the series started with the fourth episode, which was released in 1977, when Elon was six years old

[←22]

You can play the game here: https://blastar-1984.appspot.com/

[←23]

The name stands for Big Falcon Rocket. Elon was joking that BFR was a kind of Rorschach test on acronyms. Musk hinted at the X-rated weapon named BFG from the *Doom* video game. Unfortunately, the initial BFR name was later changed to Starship.

[←24]

The project website - https://dearmoon.earth/

[←25]

Starship Update presentation in Boca Chica
https://www.youtube.com/watch?v=sOpMrVnjYeY

[←26]

Is SpaceX's Raptor engine the king of rocket engines?
https://www.youtube.com/watch?v=LbH1ZDImaI8

[←27]

The Wright brothers' story is impressive. Wikipedia has the full version of their biography - https://en.wikipedia.org/wiki/Wright_brothers

[←28]

Enthusiasts may also be the first to solve the problem of designing artificial intelligence. But we'll discuss artificial intelligence in another chapter.

[←29]

All trademarks are the property of their respective parties, and here is the link to statistics - https://www.slashgear.com/microsoft%E2%80%99s-window-mobile-a-downfall-1674401/

[←30]

One of the questions Elon Musk asks at a job interview is, “You’re standing on the surface of Earth. You walk one mile south, one mile west, and one mile north. You end up exactly where you started. Where are you?”

[←31]

An example of such a teacher is Carl Sagan. A descendant of Ukrainian expatriates, he explained complex theories even to children. He has made a lot of efforts to popularize space travel and science in general. You should get to know more about him - https://en.wikipedia.org/wiki/Carl_Sagan

Elon Musk about Carl Sagan
https://twitter.com/elonmusk/status/1172685676489277440

[←32]

There is a community of responsible teaching in the U.S. Maybe they could change things?
https://www.edcamp.org/

[←33]

Some people may take this fact as an example that there's no need for education. Yet it's worth mentioning that Bill Gates and Steve Jobs did a lot of self-study while still at school and accumulated enough knowledge to enroll in college.

[←34]

Video on the Royal Society Charter Book - https://www.youtube.com/watch?v=9wX-l8GFBq8

A picture of Elon's signature - https://www.reddit.com/r/elonmusk/comments/8yvexq/one_step_closer_to_become_supreme_god_emperor_the/

[←35]

Webometrics Ranking of World Universities - http://www.webometrics.info/en/world

[←36]

Wharton is one of the most prestigious and renowned business schools in the world. The school is part of the University of Pennsylvania.

[←37]

The full text of the Ars Technica research - https://arstechnica.com/science/2018/06/first-space-then-auto-now-elon-musk-quietly-tinkers-with-education/

[←38]

According to official filings, Elon gave Ad Astra $475,000 (£359,000) in both 2014 and 2015. By now, the amount must have increased as the number of students have gone up.

[←39]

Codecademy is an online resource that teaches programming. Ad Astra students learn to program in such languages as Scheme, Swift, and Scratch. Out of them, Scratch is a relatively simple way to program. If you're still unfamiliar with this programming language, you can catch up on it here: https://scratch.mit.edu.

edX (https://www.edx.org) is a collection of open university courses. In fact, if you have access to the internet, you can get a world-class education free of charge. The website courses cover subjects including architecture, physics, mathematics, electronics, and ethics. The project was started in 2012 by Harvard University and MIT (Massachusetts Institute of Technology, the best technical university in the world). Later, Berkley and another 130 global partners joined them.

Switching to online courses is a global trend. For instance, Stanford University also has free online courses (https://online.stanford.edu).

https://www.khanacademy.org/ - These courses are designed for schoolchildren and cover a wide range of topics.

[←40]

Official press release of the contest - https://www.xprize.org/articles/global-learning-xprize-two-grand-prize-winners

[←41]

Our Reddit channel – https://www.reddit.com/r/thinklikeelonmusk/