

# ChatGPT for Theoretical Physics

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# Summary

- What is ChatGPT?
- What is Theoretical Physics?
- Example 1: Texting
- Example 2: Analytical calculations
- Conclusions

# What is ChatGPT?

In 2015 it was founded **OpenAI**, an American private non-profit company dedicated to the development of **Artificial Intelligence (AI)**. In 2019 **OpenAI** opened a for-profit subsidiary.

In 2022 **OpenAI** launched **ChatGPT** (Chat Generative Pre-trained Transformer)<sup>1</sup>, a **chatbot** based on generative AI.

```
Welcome to
EEEEEE LL IIII ZZZZZZ AAAAA
EE LL II ZZ AA AA
EEEE LL II ZZZ AAAAAA
EE LL LL II ZZ AA AA
EEEEEE LLLLLL IIII ZZZZZZ AA AA

Eliza is a sock Rogerian psychotherapist.
The original program was described by Joseph Weizenbaum in 1966.
This implementation by Norbert Landsteiner 2005.

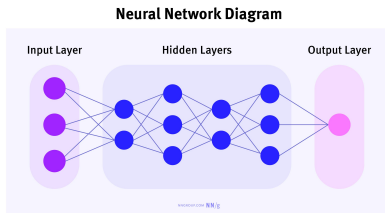
ELIZA: Is something troubling you ?
YOU: Men are all alike.
ELIZA: What is the connection, do you suppose ?
YOU: They're always bugging us about something or other.
ELIZA: Can you think of a specific example ?
YOU: Well, my boyfriend made me come here.
ELIZA: Is it important to you that your boyfriend made you come here ?
YOU: He says I'm depressed much of the time.
ELIZA: I'm sorry to hear that you are depressed.
YOU: It's true, I am unhappy.
ELIZA: Can you explain what made you unhappy ?
YOU:
```

A **chatbot** is a software application designed to have textual or spoken conversations, in our case with a computer program. In the figure the 1966 ELIZA chatbot, an early natural language processing computer program developed at Massachusetts Institute of Technology (MIT).

<sup>1</sup>A Generative Pre-trained Transformer (GPT) is a Large Language Model (LLM), designed for natural language processing by using machine learning

# What is ChatGPT?

Generative AI is a set of computer programs (generative models) which learn the underlying patterns and structures of their training data (text, images, videos, etcetera). Generative AI produces new data, based on the input, which often comes in the form of natural language prompts.

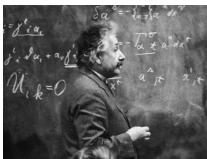


The learning is obtained by using machine learning, i.e. statistical algorithms which run on a computer, usually based on artificial neural networks (John Hopfield and Geoffrey Hinton, Nobel Prize in Physics 2024).<sup>2</sup>

<sup>2</sup>The input is converted into a set of numbers, the output is a set of numbers which is then reconverted, and the links (weights) of the neural network are determined with a training to get the best weight configuration.

# What is Theoretical Physics?

**Theoretical Physics** is a scientific discipline with the aim of understanding the laws of Nature through mathematics and logic.



**Theoretical Physics** works in symbiosis with **Experimental Physics**, which uses experimental tools to probe the natural phenomena.

## Major areas:

- 1 Classical Physics (Mechanics, Electrodynamics, Thermodynamics)
- 2 Quantum Physics (Quantum Mechanics, Field Theory, Information)
- 3 Relativity and Gravitation (Special and General Relativity, Cosmology)
- 4 Statistical and Mathematical Physics (Complex Systems, Chaos, Foundations)

# What is Theoretical Physics?

## Interdisciplinary role in recent years:


- 1 Biophysics and Neuroscience (Statistical models of life, Brain networks)
- 2 Materials Science and Nanotechnology (Condensed matter, Quantum materials)
- 3 Finance and Complex Systems (Econophysics, Risk modeling)
- 4 Artificial Intelligence and Machine Learning (Quantum computing, Data-driven physics)




# Example 1: Texting


My experience is that **ChatGPT-4o** (free version) is excellent in texting, also in the context of **Theoretical Physics**. Here a simple example.

## ChatGPT in Action: A Simple Example

 **User:** *What happens if I fall into a black hole?*


 **ChatGPT:** *If you fall into a black hole, you will experience extreme gravitational effects. Far from the black hole, an outside observer would see you slowing down and fading away due to gravitational redshift. However, from your perspective, you would cross the event horizon without noticing anything special—until tidal forces become overwhelming near the singularity.*


 **User:** *Can you explain it in a single equation?*

 **ChatGPT:** *A key equation describing black holes is the Schwarzschild radius:*


$$r_s = \frac{2GM}{c^2}$$


*This is the critical radius where the escape velocity equals the speed of light, defining the event horizon.*

 **User:** *And in simple words?*


 **ChatGPT:** *It's the point of no return. Anything crossing this boundary, including light, can never escape.*

# Example 1: Texting

 **User:** *What are  $c$ ,  $G$ , and  $M$  in your formula?*

 **ChatGPT:** *Great question! These are fundamental physical constants:*

- **$c$  (Speed of Light):**
  - $c \approx 3.00 \times 10^8$  m/s
  - The maximum speed at which information and matter can travel.
- **$G$  (Gravitational Constant):**
  - $G \approx 6.674 \times 10^{-11}$  m<sup>3</sup>kg<sup>-1</sup>s<sup>-2</sup>
  - Governs the strength of gravitational attraction.
- **$M$  (Mass of the Black Hole):**
  - The total mass of the black hole, determining its gravitational pull.

 **User:** *So, the Schwarzschild radius grows if the black hole is more massive?*

 **ChatGPT:** *Exactly! A more massive black hole has a larger event horizon.*



# Example 1: Texting


My experience is that **ChatGPT** can help a lot in writing **scientific documents** and, maybe, also **scientific papers**. For instance:

- 1 I can upload the **draft** of a scientific project asking to **ChatGPT** to complete the project. **ChatGPT** performs this task obtaining a quite good final result.
- 2 I can ask to **ChatGPT** to write the **reference letter** for a student simply giving to **ChatGPT** some hints of the qualities of the student. The resulting letter is very good.
- 3 I can ask to **ChatGPT** to write the **syllabus of a course** of Modern Physics for bachelor students in Philosophy. **ChatGPT** does it immediately. Then I can suggest to **ChatGPT** some changes, based on some specific ideas I have, and **ChatGPT** produces a wonderful syllabus.

# Example 2: Analytical Calculations

**ChatGPT** is very strong in helping users for software coding and numerical calculations. However, **ChatGPT** is useful also for analytical calculations. Here a simple example.

## ChatGPT in Action: Solving an Integral

 **User:** Compute the integral of the square of  $\sin(x)$  with respect to the variable  $x$ , in the interval from 0 to Greek pi.


 **ChatGPT:** Sure! The integral to evaluate is:


$$I = \int_0^{\pi} \sin^2(x) dx$$

Using  $\sin^2(x) = \frac{1 - \cos(2x)}{2}$ , we get:

$$I = \frac{1}{2} \int_0^{\pi} 1 dx - \frac{1}{2} \int_0^{\pi} \cos(2x) dx$$

$$I = \frac{1}{2}(\pi - 0) - \frac{1}{2} \times 0 = \frac{\pi}{2}$$

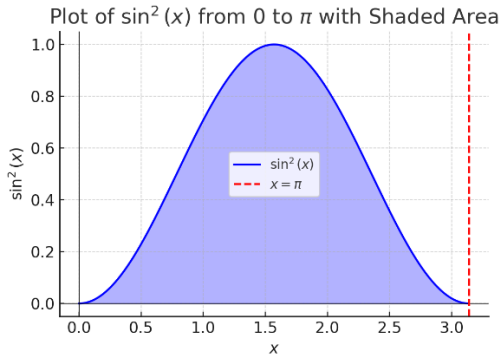
 **User:** So the answer is  $\frac{\pi}{2}$ ?

 **ChatGPT:** Yes! The integral evaluates to:

$$\int_0^{\pi} \sin^2(x) dx = \frac{\pi}{2}$$

# Example 2: Analytical Calculations

Good. By the way, can you to a plot of  $\sin(x)^2$  from 0 to  $\pi$  with the shaded area under the curve?



Here's the plot of  $\sin^2(x)$  from 0 to  $\pi$ , with the shaded area representing the integral. Let me know if you need any modifications! 😊 [:-]

🔊 🖨️ 📌 🔄 🔄



You've hit the Free plan limit for GPT-4o.

You need GPT-4o to continue this chat because it has images. Your limit resets after 2:35 PM.

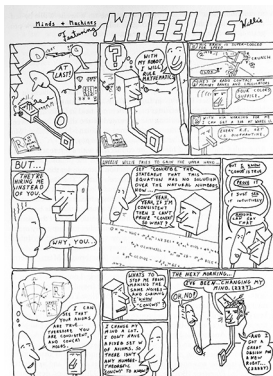
New chat

Get Plus

# Conclusions

- I have discussed some skills of **ChatGPT**, which could help when the user is doing **Theoretical Physics**.
- Sometimes **ChatGPT** makes errors, but fixes itself if the errors are highlighted.
- **ChatGPT** knows a wide range of scientific literature across many fields because of its training and internet connection.
- **ChatGPT** (**Scholar AI**) helps a lot to find new solutions, new applications, and meaningful generalizations of known scientific problems.
- Is **ChatGPT** somehow **intelligent**?
- Does **ChatGPT** have some kind of **consciousness**?

# Acknowledgements: Thank you for your attention!



Rudy Rucker, *Infinity and the Mind. The Science and Philosophy of the Infinite* (Birkhäuser, 1982; Princeton Univ. Press, 2019).