Role of AI and ChatGPT in the Education of Algebra-Based General Physics

Authors: Andrew Swift & Jorge E. Espinosa
Mentor: Vasiliy Znamenskiy
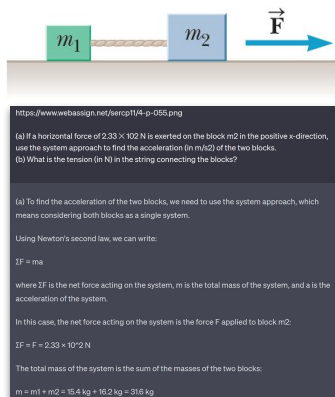Borough of Manhattan Community College

Introduction

Since the recent breakthroughs of Artificial Intelligence (AI), great interest has been taken with the accessible Language Learning Model (LLM) ChatGPT, and its ability to be utilized in various professional fields to perform complex tasks[1,2]. From this interest, a question of viability arises for its use in higher education, specifically in the field of physics, to solve problems and understand fundamental concepts, without compromising the integrity of the learning process.

Purpose

With many exams and credited assignments completed online, ChatGPT poses an easy and accessible threat for cheating, compromising the integrity of academic institutions and preparedness of the next generation workforce. The goal is to devise a mitigation strategy for cheating, but also a pathway for supplemental learning through the utilization of ChatGPT. This will be done through the determination and separation of types of problems that ChatGPT solves correctly and incorrectly, in the context of college level general physics.

Methodology

Four algebra-based physics problems comprised of text and illustrations in "Topic 4: Newton's laws of motion" from Serway and Vuille: "College Physics", 11th Edition were sent via message through ChatGPT for the purpose of finding a solution with explanation. Two of the four questions were input via text only, while the remaining two were input with only an image relating to the problem. The four results were expected to provide a clear explanation of how the correct or incorrect solution was found.

https://www.webassign.net/sercp11/4-p-055.png

(a) If a horizontal force of 2.33 × 10² N is exerted on the block m2 in the positive x-direction, use the system approach to find the acceleration (in m/s2) of the two blocks.
(b) What is the tension (in N) in the string connecting the blocks?

(a) To find the acceleration of the two blocks, we need to use the system approach, which means considering both blocks as a single system.

Using Newton's second law, we can write:

ΣF = ma

where ΣF is the net force acting on the system, m is the total mass of the system, and a is the acceleration of the system.

In this case, the net force acting on the system is the force F applied to block m2:

ΣF = F = 2.33 × 10²2 N

The total mass of the system is the sum of the masses of the two blocks:

m = m1 + m2 = 15.4 kg + 16.2 kg = 31.6 kg

Results

Problem 1 - The first problem was text-based, with three parts to the solution (a,b,c), requiring some algebraic manipulation of equations given in chapter 4. Parts a and b were solved correctly, with step by step explanations of how the solution was derived algebraically. The correct direction of the given axis was also shown. For part c, Chat GPT's answer was slightly inaccurate, differing from the textbook's correct answer by 3%.

Problem 2 - Mirroring parts a and b of problem 1, the second question was able to provide a correct step-by-step way of solving the problem and the given result being correct to the textbook's result down to three significant figures.

Problem 3 - For the first image-based question, the first part gave a credible way of obtaining the result with no miscalculations, however for the second part the formula "F - T = m2a" used by the AI was not viable, providing a wrong result. Instead, the correct formula should have been "T - F = m2a" with a result of 114 N.

Problem 4 - For the second image-based question, the explanation containing the formula was correct, but used inappropriate units, giving an incorrect solution.

Resources

1. https://arxiv.org/abs/2303.12712
2. https://arxiv.org/abs/2304.02138
3. Chat GPT-4 vs Chat GPT-3: What's new? (trustedreviews.com)
4. https://community.openai.com/t/chatgpt-simple-math-calculation-mistake/62780/5

Conclusion

ChatGPT's ability to comprehend and solve text-based physics problems proved to be successful, not taking into account some minor miscalculations. It was able to explain its correct answers with formulas and algebra that mirrored what was found in the textbook for the majority of the problems. Conversely, ChatGPT was not able to interpret information included in images, therefore unable to translate them into correct solutions. Only when supplementary information was given via text, was it able to use the image to derive the correct answers.

Later findings highlighted that the version used in this research project (3.5) could not use images alone to answer questions, but needed text as support. A newer version (ChatGPT 4) available is able to use only images to derive information.[3] An additional limitation is that the program does not perform any mathematical calculations, but only predicts what the future text will be, as stated by the developers.[4]

With these findings, it is proposed that image based problems be used for physics exams and graded assignments. This will ensure cheating using ChatGPT will not result in the correct answer. Alternatively, text based problems can be used to help explain how a problem is solved, such as the formulas and algebra used. This could be a supplemental tool to resources such as a textbook, when such resources lack clarity. Because ChatGPT is only a predicting model, it is incorrect to assume that numerical solutions to all physics problems given from other sources will be accurate.

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