How to prepare for the UPC?

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What is UPC?

The University Physics Competition

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The University Physics Competition is an international contest for undergraduate students, who work in teams of three at their home colleges and universities all over the world, and spend a weekend in November, 48 hours, analyzing a real-world scenario using the principles of physics, and writing a formal paper describing their work.

Before the contest, all teams must be officially registered on this website, state all team members, state their faculty sponsor, who will verify that they are complying with contest rules, and pay the registration fee. All registrations must be submitted at least 6 hours before the contest begins.

At the start of the contest, each team selects one of two problems which appear on this website. Problems are written to be accessible to students who have had at least one year of university physics but are designed to be conceptually rich and open-ended in nature, so that they are still challenging to senior level students. The problems may contain incomplete information, so the students have to do background research and make some reasonable assumptions in order to proceed with the analysis. This means that there may not be one unambiguously correct method, but instead there may be many useful approaches and approximations.

During the contest, teams may use books, journals, computers, the Internet, programs that they write, or any other nonliving resources, but they may not consult with any people outside of their team. Teams must perform a theoretical analysis of the scenario presented using the principles of physics, and write a formal paper, in English, detailing their work. Each paper must begin with a 300 word summary, providing key details and results of the work performed. Each paper must include a list of references used, as well as make in-text citations to these resources.

At the end of the contest, all papers must be received via e-mail at solutions@uphysicsc.com before the 48 hours have elapsed.

Key information

- A team project
- Limited time (48hrs)
- Choose one from two open questions
- May use: books, journals, computers, Internet, programming tools and any other nonliving resources!! (Chat GPT???)
- May not consult anyone!

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Must do

- A theoretical analysis of the scenario, using the principles of physics.
- Write a formal paper in English.
- Paper must begin with a 300-word summary (abstract).

Which areas in physics should we focus on?

2022	Problem A: Deflecting an Asteroid Problem B: FIFA Penalty Kicks
2021	Problem A: A Thicker Martian Atmosphere Problem B: Asteroid Ocean Impact
2020	Problem A: Ion Thrusters to Saturn Problem B: Quadcopter Stability in Wind
2019	Problem A: Protecting Travelers to Mars Problem B: Design a Roller Coaster
2018	Problem A: Sending a Light Sail Propelled Nanocraft to Alpha Centauri Problem B: Compost Pile Sizes

Most of the problems in history are Classical Mechanics problems!

$F = ma$

About the modelling

真空球形鸡

我们如果要完整地描述一个具体的系统，比如一块磁铁，这将是一个几乎不可能完成的任务。因为这个系统里面有电子、原子核，电子还有那么多不同的能级，有复杂的电子云结构，原子核里面还有质子中子等等。如果要写一个包含这所有物理的理论，会是一个极其浩繁而且无趣的工作。但是，如果我们选择研究这个系统在某个特定的温度附近的行为，那我们擅长的“球形鸡”精神则完全适用，而且极其精确。

可以说，每当物理学家发现了一个能够被球形化的鸡，都是一个巨大的进步，意味着我们抓住了一大类现象的本质。

About the modelling

真空球形鸡

Make proper Assumptions!

2.1 Basic Assumptions for Our Models

- Assume that the spacecraft is only exposed to the sun's gravity during the flight when it is free from Planet A bondage and is not captured by Planet B. Because the gravity from both Planet A and Planet B are very small contrasted to the sun's gravitational attraction during this period. And ignoring other gravities can simplify the calculation and facilitate the model establishment.
- Suppose all the planets are in the ideal position. In other words, the spacecraft happens to be captured by planet B when it is at the right velocity. It is theoretically possible to find a right launch time to achieve such an ideal result. In this paper we deal with it briefly.
- Assume the paths of all the planets orbiting the sun are circular. Since the eccentricities of the motions of the planets in solar system are very small, we can simplify the calculation by approximating them to circles.
- Suppose all objects in the system can be considered as mass points.
- Ignore the effects of planet's rotation.
- Ignore the effects of relativity.

About the modelling

Contents

About the modelling

The key is to do proper simplification!

The Navier-Stokes equation

$$\rho\left(\frac{\partial u}{\partial t}+u\frac{\partial u}{\partial x}+v\frac{\partial u}{\partial y}+w\frac{\partial u}{\partial z}\right)=-\frac{\partial p}{\partial x}+\mu\left(\frac{\partial^2 u}{\partial x^2}+\frac{\partial^2 u}{\partial y^2}+\frac{\partial^2 u}{\partial z^2}\right)+\rho g_x$$

$$\rho\left(\frac{\partial v}{\partial t}+u\frac{\partial v}{\partial x}+v\frac{\partial v}{\partial y}+w\frac{\partial v}{\partial z}\right)=-\frac{\partial p}{\partial y}+\mu\left(\frac{\partial^2 v}{\partial x^2}+\frac{\partial^2 v}{\partial y^2}+\frac{\partial^2 v}{\partial z^2}\right)+\rho g_y$$

$$\rho\left(\frac{\partial w}{\partial t}+u\frac{\partial w}{\partial x}+v\frac{\partial w}{\partial y}+w\frac{\partial w}{\partial z}\right)=-\frac{\partial p}{\partial z}+\mu\left(\frac{\partial^2 w}{\partial x^2}+\frac{\partial^2 w}{\partial y^2}+\frac{\partial^2 w}{\partial z^2}\right)+\rho g_z$$

is derived from F = ma!

Only with certain proper assumptions

About the modelling

To what extend should we simplify the problem?

To it is simple enough that you could solve it!
Meanwhile, taking as many effects in to consideration as possible.

Then, solve!!

Either numerically or analytically.

With your results

Interpret properly!

About the paper/report

Take care of the content first, then the logic, then illustration, grammar and writing is the last.

The important thing about the project is that
It is a complete, reasonable, clear story.

Let's review some gold medal UPC papers together

Good luck with you all, and keep in mind, have fun!

Thanks

Q&A