



Doing 3D Printing with Students in Physics Labs

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Outline

Opportunities for 3D printing in Physics

Examples of 3D printing projects

Sharing & Obtaining Resources: PICUP



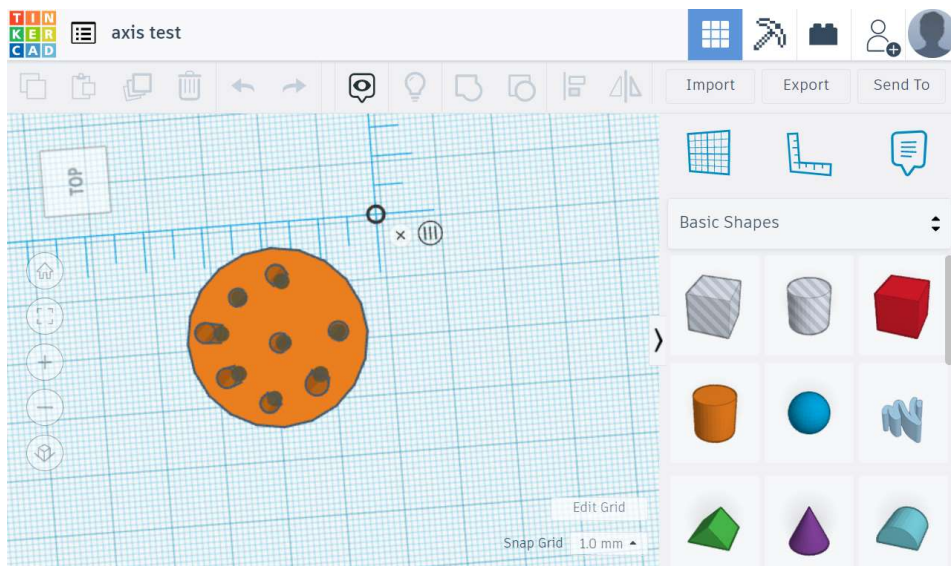
Opportunities

General Physics Labs

Independent Studies in
AutoCAD

Senior Capstone/Design
Projects

Physics Department
Internships



TinkerCAD

Introducing Physics and
Chemistry majors to
computer-aided design

General Physics I

- 2 projects over the course of the semester
(4 lab sessions)
- Choice of 3DP or doing a traditional lab.

Session 1: Design (using TinkerCAD -> students who chose the traditional option did an alternative activity.

...Printing...

Sessions 2: Use the printed object to do experiment; all students did the same activity, sharing the printed equipment.

Examples of 3D printing projects

waterwheel
fan cart
gear box
mechanical arm

Water Turbine

Goal:

Measure the work done by a turbine in lifting a load using water power.





PICUP

Partnership for Integration of Computation into Undergraduate Physics

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[Exercise Sets](#) » [Efficiency of a Water Turbine \(3D Printing Lab\)](#)

Efficiency of a Water Turbine (3D Printing Lab)

Developed by [Deva O'Neil](#), [Benjamin Hancock](#), and [Benjamin Hanks](#) - Published May 23, 2020



This Exercise Set describes one way to incorporate 3D printing into lab sessions in Physics I: Students design and print a water-wheel, and measure its efficiency in lifting a load. An optional exercise at the end uses video analysis to verify that the system is approximately in equilibrium for almost all of the lift process. Concepts applied include power, energy, and efficiency.



Subject Area Mechanics

Level First Year

Learning Objectives

- Learning Objectives
- Students who complete this set of exercises will be able to:
- Apply the concept of density to calculate the potential energy of a water reservoir (**Exercise 1**)
 - Calculate work done in lifting a load vertically and relate it to power (**Exercise 2**)
 - Calculate efficiency and identify sources of energy loss (**Exercise 3**)
 - Practice design thinking and develop CAD skills in designing and printing a water turbine (**Exercise 4**)
 - Use video analysis to verify that the system is in equilibrium (**Exercise 5**)

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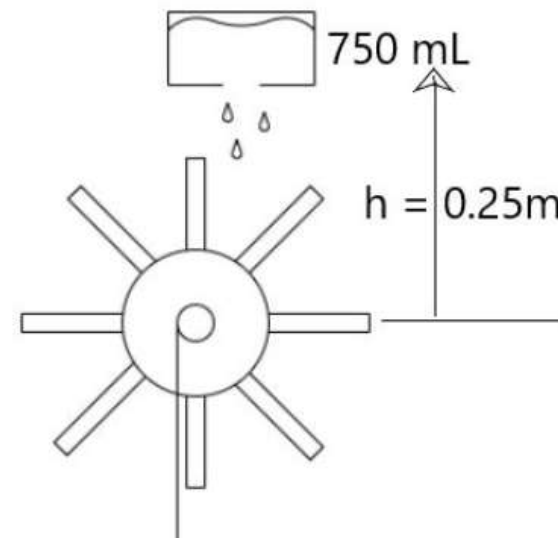
Theory | Experiment | Exercises | Solutions | Sample designs

Instructor's Guide Theory Experiment Exercises Code Solutions References



These exercises are not tied to a specific programming language. Example implementations are provided in the [Code](#) tab, but the Exercises can be implemented in whatever platform you wish to use (e.g., MATLAB, etc.).

Exercise 1: Finding Potential Energy of Water Flowing Through a Turbine



- Not shown to scale

Exercise 1: Finding Potential Energy of Water Flowing Through a Turbine

$$U = mgy$$

$$m = V\rho$$

$$U = V\rho gy$$

$$U = 0.75L * (.998kg/L) * (9.81m/s^2) * 0.25m$$

$$U = 1.84J$$

Exercise 2: Finding the Power Exhibited by a Water Turbine

Let us call the distance the block is lifted d . With no acceleration, the tension in the string will provide a force of mg , where m is the mass of the block.

$$P_{out} = W_{block}/t$$

$$P = \vec{F} \cdot \Delta\vec{r}/t$$

$$P_{out} = mgd/t$$

$$P_{out} = (0.01kg * 9.81m/s^2 * 0.7m)/120s$$

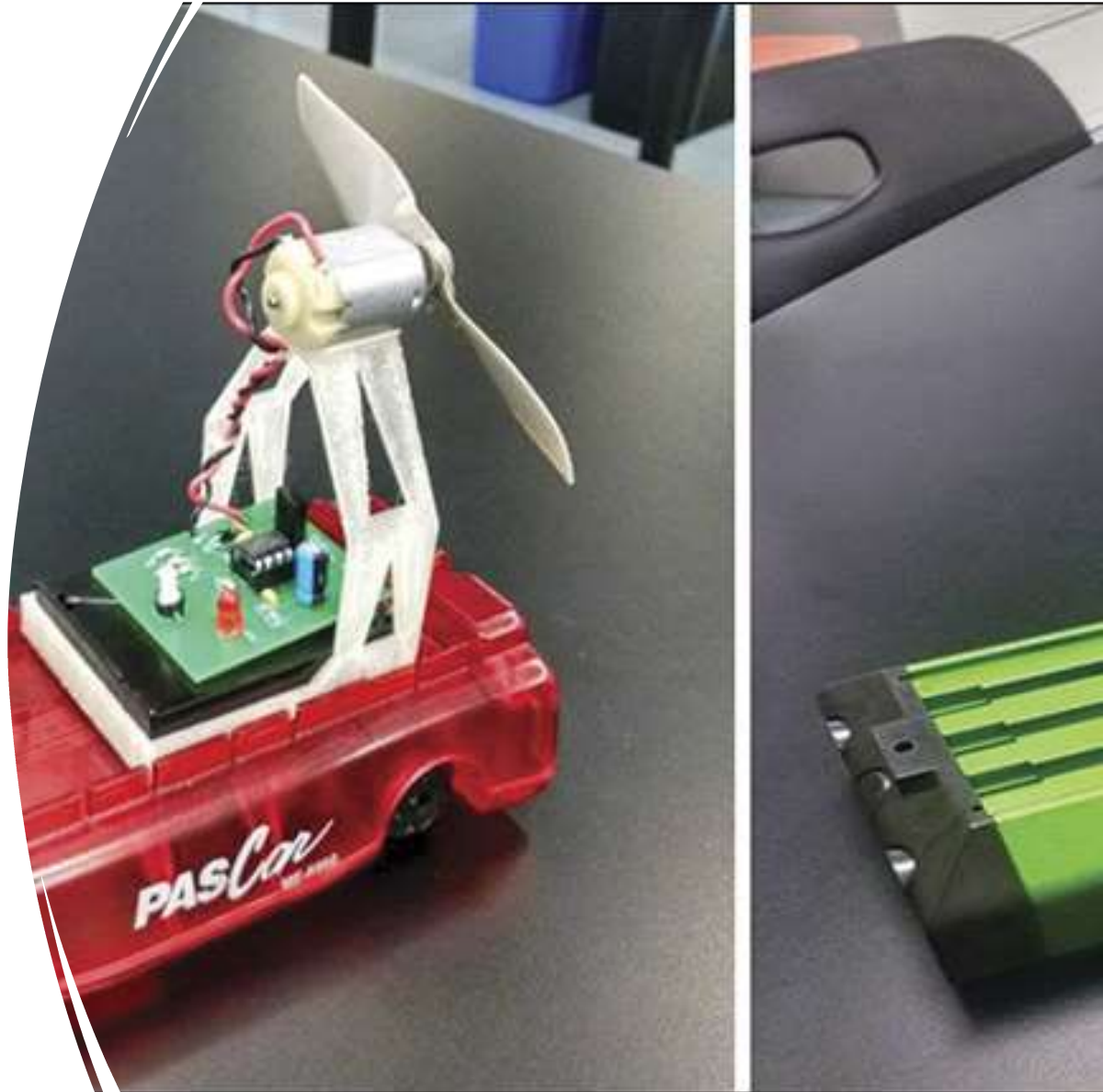
$$P_{out} = 5.7 * 10^{-4}Watts$$

Fan Cart

- Design fan blades for a fan cart with the goal of optimizing thrust.
- Brian Lamore provides instructions and equipment needed for 3D printed fan carts

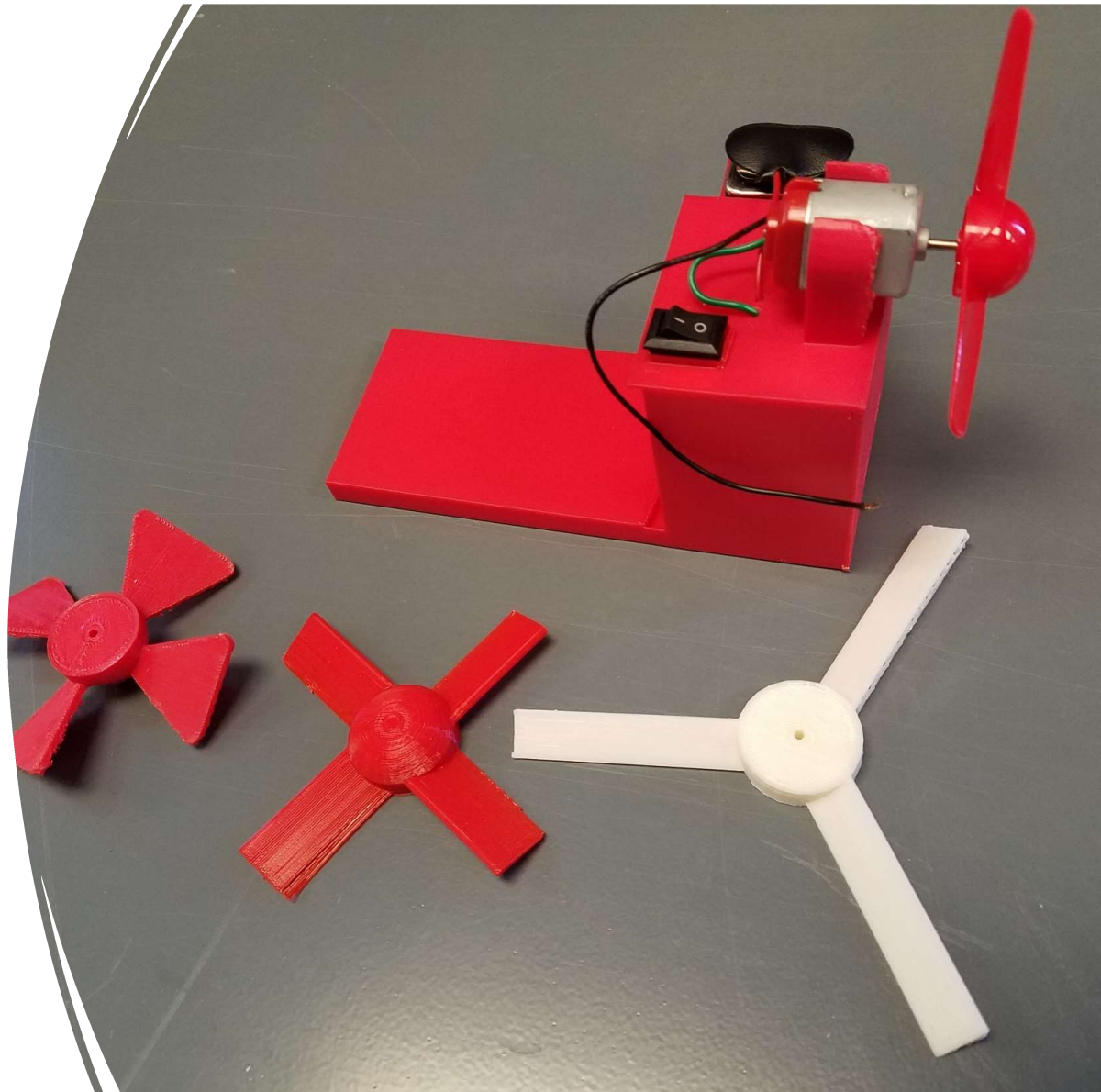
Fan Cart: The Next Generation

The Physics Teacher **54**, 408
(2016); <https://doi.org/10.1119/1.4962775>



Fan Cart

- **Introductory physics students designed the fan blades**
- **Chassis and circuitry were designed by students doing an independent study in AutoCAD**
- **Most fan carts were able to generate enough thrust to overcome friction on a low-friction track**
- **Most did not have enough thrust to tow a load.**



Gear Box

- The goal of the project was to achieve a 2:1 gear ratio
- Lift a load attached to one gear by cranking the other gear.
- Students designed the gears successfully
- Difficulty: designing a holder to mount the gears so that they would couple without jamming





Mechanical Arm

Used for torque balance

Share your activities at gopicup.org

The screenshot shows the homepage of the PICUP website. At the top, there is a navigation bar with the PICUP logo and the text "Partnership for Integration of Computation into Undergraduate Physics". To the right of the logo, there are links for "My Account | Logout", "My Reviews | My Bookmarks", "Authoring Dashboard", and a "Feedback" button. Below the navigation bar is a horizontal menu with tabs for "Home", "Exercise Sets", "Faculty Commons", "Resources", "Community", "Events", and "About PICUP".

The main content area is divided into several sections:

- Welcome to PICUP!**: A green banner with a "Sign up to receive PICUP Announcements" button.
- View the PICUP Collections - materials and support for integrating computation:**: A section with two columns: "Exercise Sets" (with "Browse" and "Author" buttons) and "Faculty Commons" (with "Explore" and "Contribute" buttons).
- All Mechanics Exercise Sets**: A section with four images representing different mechanics topics: a 3D plot, a rocket launch, a diagram of Earth with a vector, and a diagram of a person on a curved path.
- Join the PICUP Community on Slack for in-depth discussions on computation in physics courses**: A section with the PICUP logo and a Slack icon.
- Get Started!**: A section with two main items:
 - PICUP Virtual Conference**: A section with a description: "This conference will feature 18 presentations and 5 panel discussions to provide you with tips, tricks, and best practices to help you teach physics online!" and details: "Dates: Friday, June 26 and Wednesday, July 1, 2020" and "Location: On your computer!".
 - PICUP Capstone Conference 2020**: A section with a description: "The PICUP Capstone Conference has been POSTPONED UNTIL 2021 due to the ongoing crisis." and details: "Dates: July 15-18, 2020" and "Location: POSTPONED".

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