BRIDGEWATER COLLEGE

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

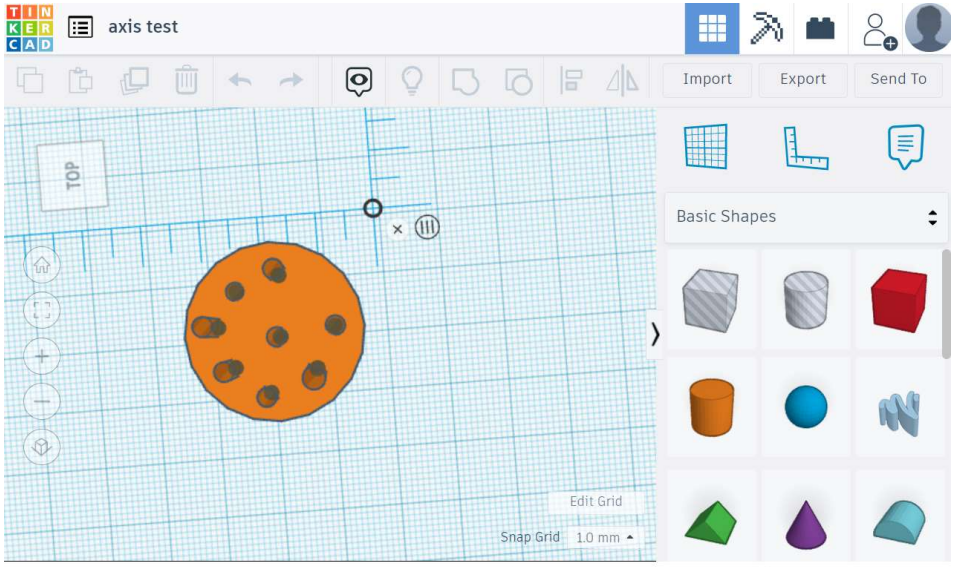
Opportunities

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.

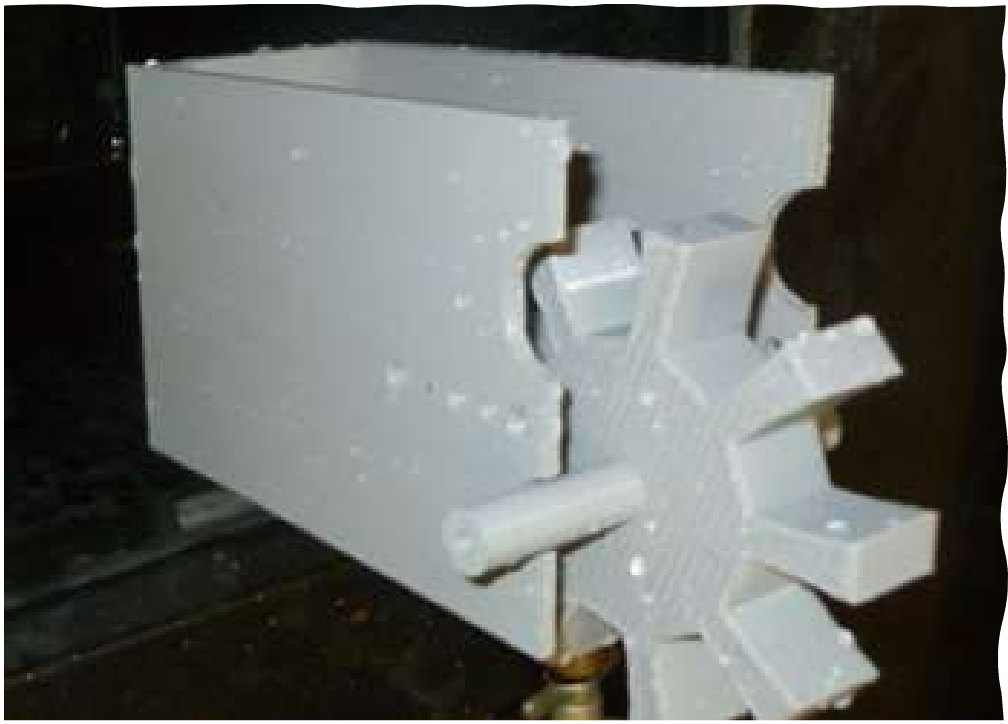
Examples of 3D printing projects

waterwheel
fan cart
gear box
mechanical arm

Water Turbine

Goal:

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



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

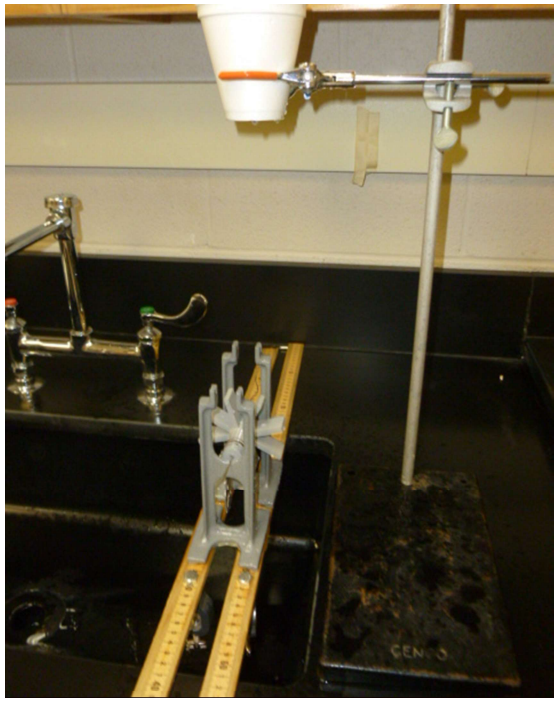
Learning Objectives

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)**

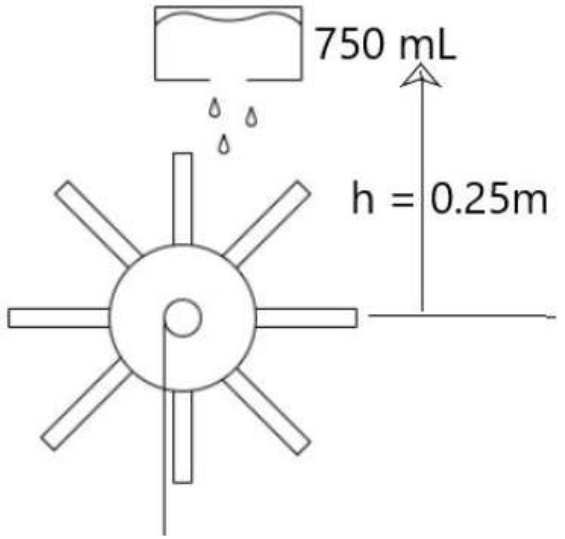
Theory | Experiment | Exercises | Solutions | Sample designs



Instructor's Guide | Theory | Experiment | **Exercises** | Code | Solutions | References

These exercises are not tied to a specific programming language. Example implementat
the Code tab, but the Exercises can be implemented in whatever platform you wish to us
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.

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

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

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

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

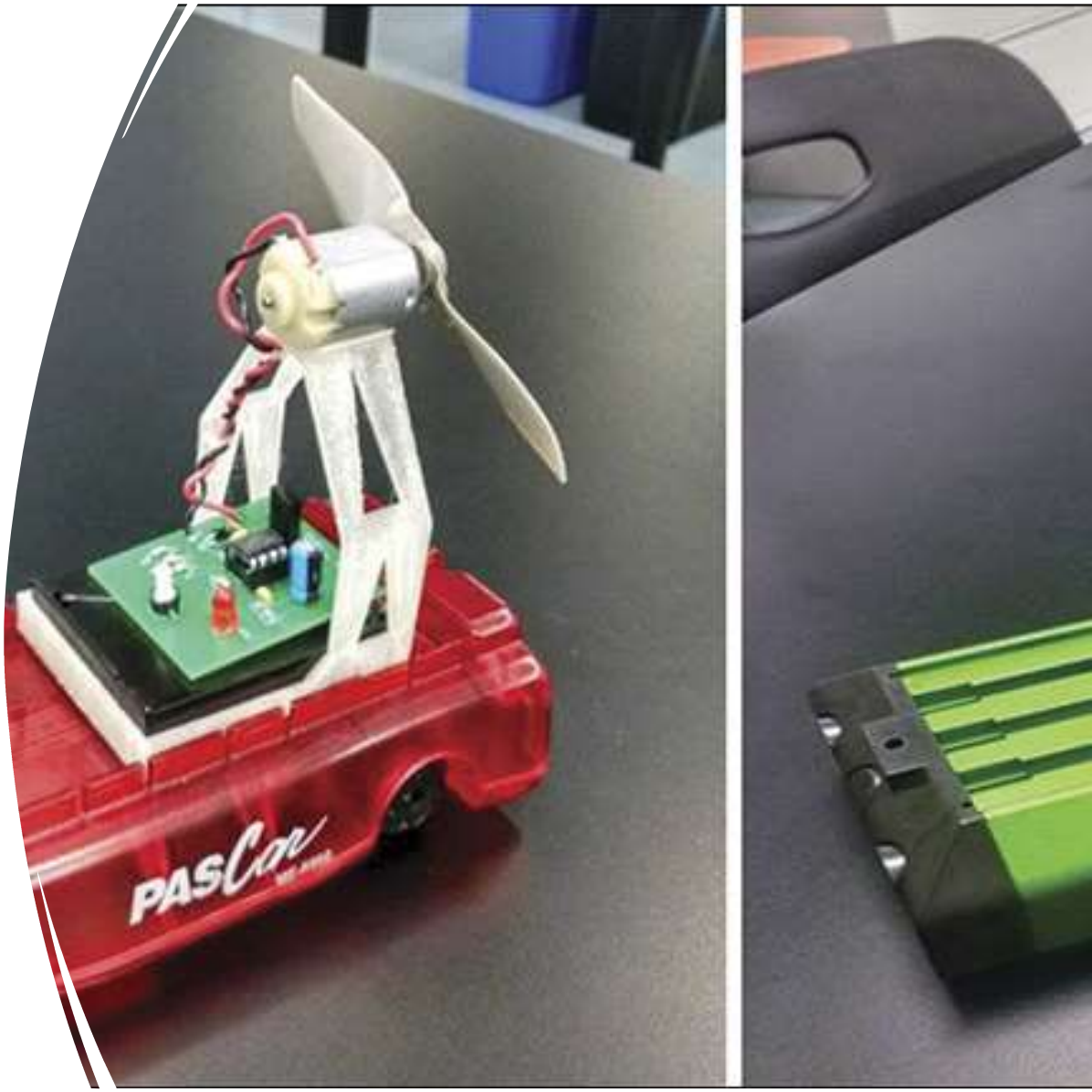
$$P_{out} = 5.7 * 10^{-4}Watts$$

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**

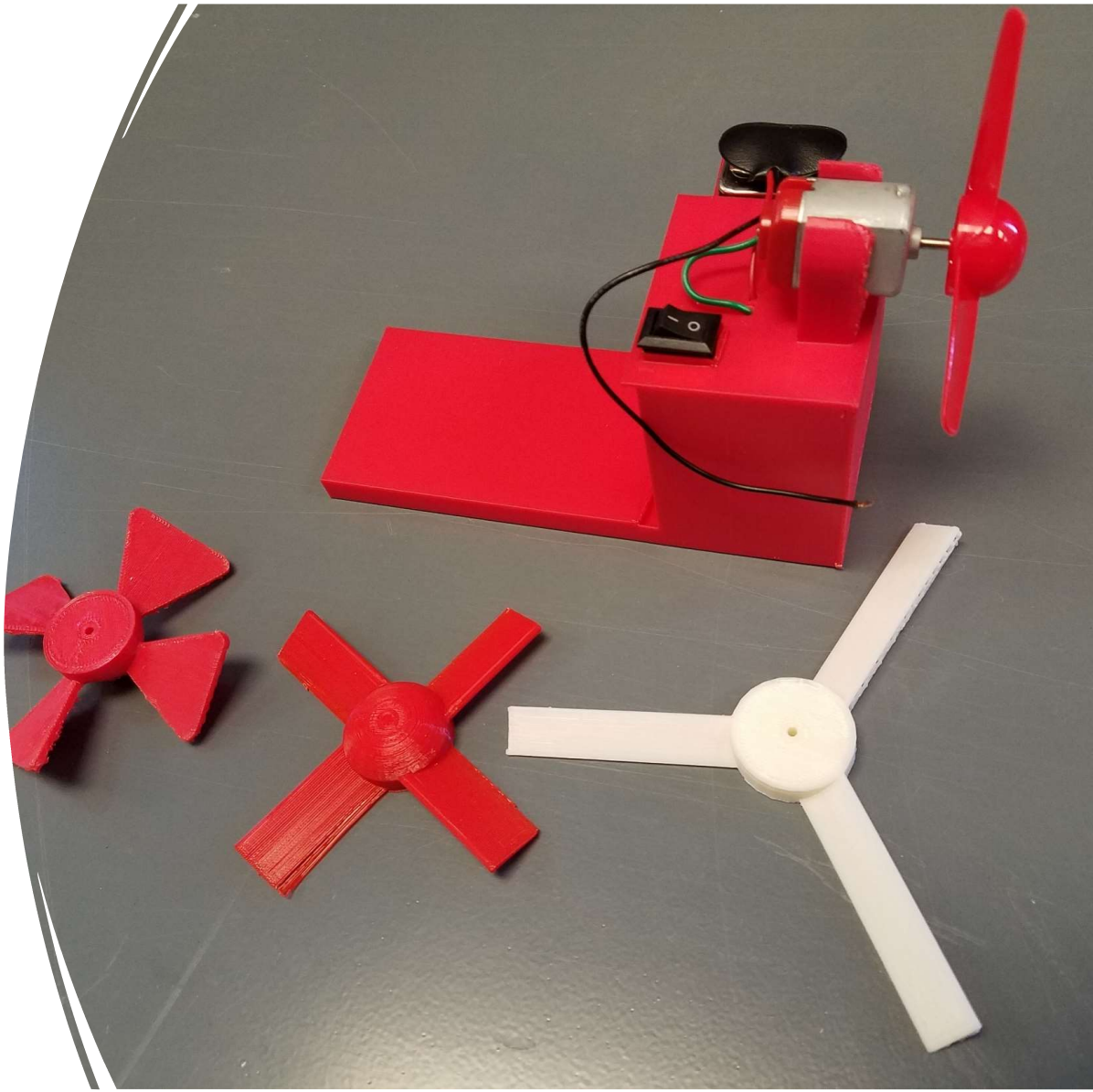
Fan Cart: The Next Generation

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



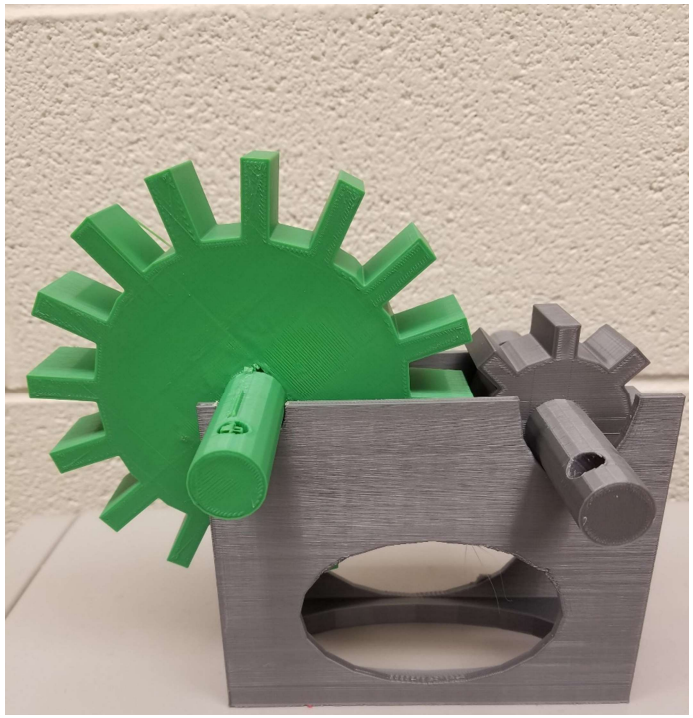
Fan Cart

- **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

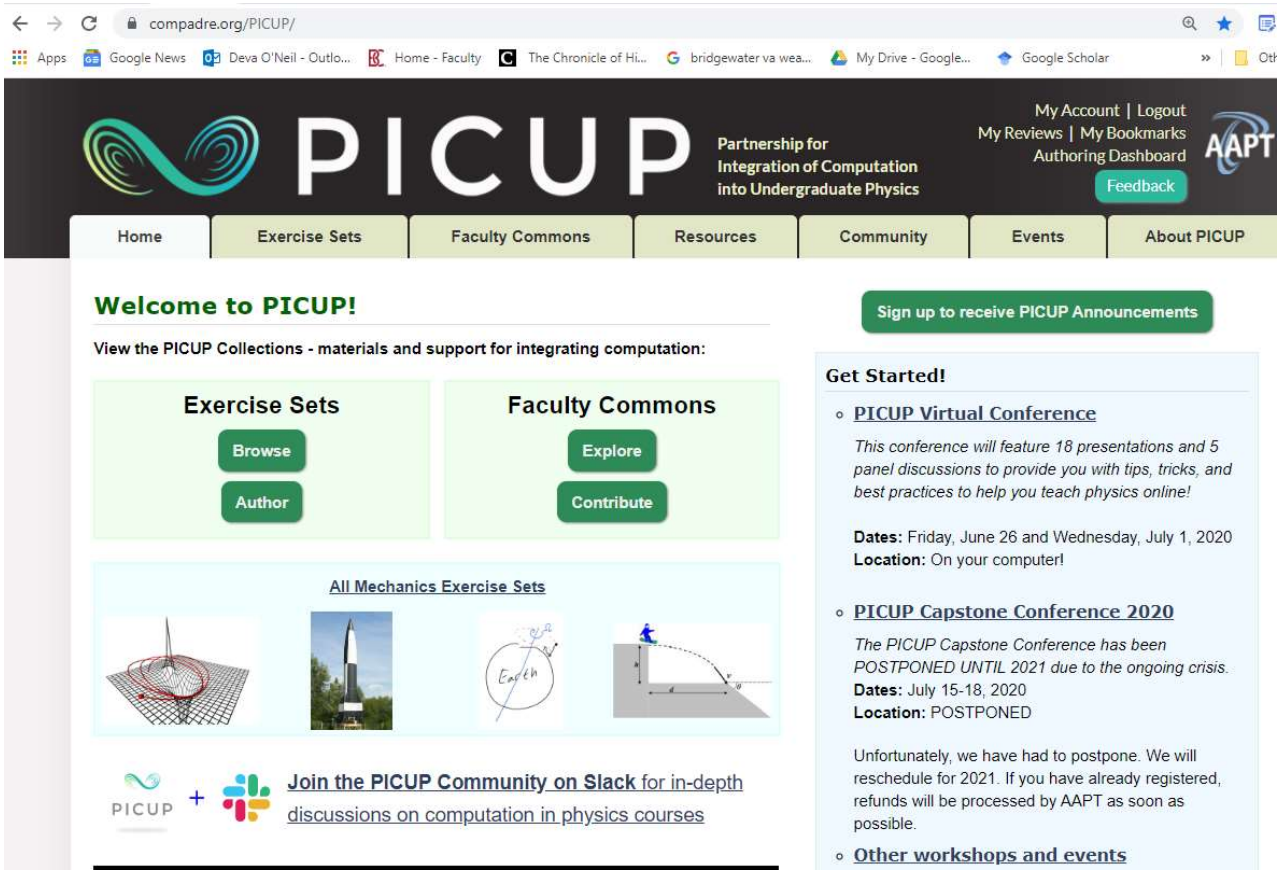
- **The goal of the project was to achieve a 2:1 gear ratio**
- **Lift a load attached to one gear by cranking the other gear.**
- **Students designed the gears successfully**
- **Difficulty: designing a holder to mount the gears so that they would couple without jamming**



Mechanical Arm

Used for torque balance

Share your activities at gopicup.org



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