

Pump It Up

Grade level: 6-10

Summary of lesson:

Students will design and build a water pump operated by human energy. Students will learn about renewable and non-renewable sources of energy and begin to think about the potential of human energy to power a device. Students will begin to think about possible uses for a water pump powered by human energy that they will construct after calculating the force, work, and power the human body can generate. Students will work in teams to choose a use for their pump and sketch a prototype of it.

Time/Duration:

Each unit is designed to be 90 minutes. Teachers break down the lesson based on schedule minutes and available time. Example: 7th-8th grade science teaches 1 unit a week, and he meets 3 days a week, once for 55 minutes and twice for 90 minutes. It depends on deep educators who want to take it.

Topics Covered:

- Design Process
- Human Energy and Human Power
- Hydraulics
- Pumps
- Uses of Pumps

Subject areas/Standards:

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Next Generation Science Standards - Middle School

Meeting	Core Ideas	Science Standards	Cross-Cutting Concepts	Practices
Meeting 1: Invention Introduction	ETS1.A ETS1.B	MS.ETS1-1 MS.ETS1-2	- Structure & Function - Systems & Cycles - Cause & Effect	- Asking Questions & Defining Problems - Constructing Explanations & Designing Solutions - Engaging in Argument from Evidence - Obtaining, Evaluating, & Communicating Information
Meeting 2: What is Human Energy and Power?	ETS1.A ETS1.B	MS.ETS1-1 MS.ETS1-4	- Influence of Science, Engineering, and Technology on Society and the Natural World - Structure & Function - System & System Models - Patterns - Cause & Effect	- Asking questions and defining problems - Developing and Using a Model - Planning and Carrying out Investigations - Analyze and Interpret Data - Using Mathematical and Computational Thinking - Constructing Explanations and Designing Solutions
Meeting 3: Pumps and Hydraulics	ETS1.B	MS.ETS1-4	- Influence of Science, Engineering, and Technology on Society and the Natural World - Structure & Function - System & System Models - Patterns	- Developing & Using Models - Planning & Carrying Out Investigations - Constructing Explanations and Designing Solutions
Meeting 4: Pistons and Check Valves	ETS1.B	MS.ETS1-4	- Structure & Function - System & System Models	- Developing & Using Models - Constructing Explanations and Designing Solutions
Meeting 5: Building a Pump	ETS1.A ETS1.B ETS1.C	MS.ETS1-1 MS.ETS1-4	- Influence of Science, Engineering, and Technology on Society and the Natural World - Structure & Function - System & System Models	- Asking questions and defining problems - Developing and Using a Model - Planning and Carrying out Investigations - Analyze and Interpret Data - Using Mathematical and Computational Thinking - Constructing Explanations and Designing Solutions
Meeting 6: Invention Extension	ETS1.A ETS1.B	MS.ETS1-1 MS.ETS1-2	- Influence of Science, Engineering, and Technology on Society and the Natural World - Structure & Function - System & System Models	- Asking questions and defining problems - Constructing Explanations & Designing Solutions

* Loosely aligned

Standards alignment conducted by graduate students at Boston College's Lynch School of Education

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Next Generation Science Standards - High School

Meeting	Core Ideas	Science Standards	Cross-Cutting Concepts	Practices
Meeting 1: Invention Introduction	ETS1.A ETS1.B	HS.ETS1-3	- Structure & Function - Systems & Cycles - Cause & Effect	- Asking Questions & Defining Problems - Constructing Explanations & Designing Solutions - Engaging in Argument from Evidence - Obtaining, Evaluating, & Communicating Information
Meeting 2: What is Human Energy and Power?	ETS1.A ETS1.B	HS.ETS1-2 HS.ETS1-3 HS.PS2-1*	- Influence of Science, Engineering, and Technology on Society and the Natural World - Structure & Function - System & System Models - Patterns - Cause & Effect	- Asking questions and defining problems - Developing and Using a Model - Planning and Carrying out Investigations - Analyze and Interpret Data - Using Mathematical and Computational Thinking - Constructing Explanations and Designing Solutions
Meeting 3: Pumps and Hydraulics	ETS1.B		- Influence of Science, Engineering, and Technology on Society and the Natural World - Structure & Function - System & System Models - Patterns	- Developing & Using Models - Planning & Carrying Out Investigations - Constructing Explanations and Designing Solutions
Meeting 4: Pistons and Check Valves	ETS1.B	HS.ETS1-2	- Structure & Function - System & System Models	- Developing & Using Models - Constructing Explanations and Designing Solutions
Meeting 5: Building a Pump	ETS1.A ETS1.B ETS1.C	HS.ETS1-2 HS.ETS1-3	- Influence of Science, Engineering, and Technology on Society and the Natural World - Structure & Function - System & System Models	- Asking questions and defining problems - Developing and Using a Model - Planning and Carrying out Investigations - Analyze and Interpret Data - Using Mathematical and Computational Thinking - Constructing Explanations and Designing Solutions
Meeting 6: Invention Extension	ETS1.A ETS1.B	HS.ETS1-1 HS.ETS1-2	- Influence of Science, Engineering, and Technology on Society and the Natural World - Structure & Function - System & System Models	- Asking questions and defining problems - Constructing Explanations & Designing Solutions

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Breakdown of lessons:

1. Invention Introduction

Students do warm-up activities and discuss invention. Students play “Four Corners” to help the educator assign diverse teams.

2. What Is Human Energy and Power?

Students learn about the different types of energy and, specifically, how human energy can be harnessed to accomplish many different goals. They also learn the physics and mathematics

behind calculating power, work, and force. The educator introduces the main design challenge of the unit and students begin to think about possible uses for their water pumps powered by human energy.

3. Pumps and Hydraulics

Students learn about different types of pumps and their potential uses. They build and test a simple Archimedes screw pump and a prototype of a hydraulic pump. Students also continue discussing potential uses for their water pumps.

4. Pistons and Check Valves

Students take apart a bicycle pump to see firsthand how it operates, and then begin to build their own water pumps. They practice cutting PVC as they learn to build check valves.

5. Building a Pump

Students assemble their water pumps, test them, and re-sketch a design to customize their water pumps for a particular use.

6. Invention Extension

Students conceptualize a purposeful invention that uses their new minds-on and hands-on skills from the Pump It Up! unit.

Materials:

Download the list of materials and tools used in this guide.

