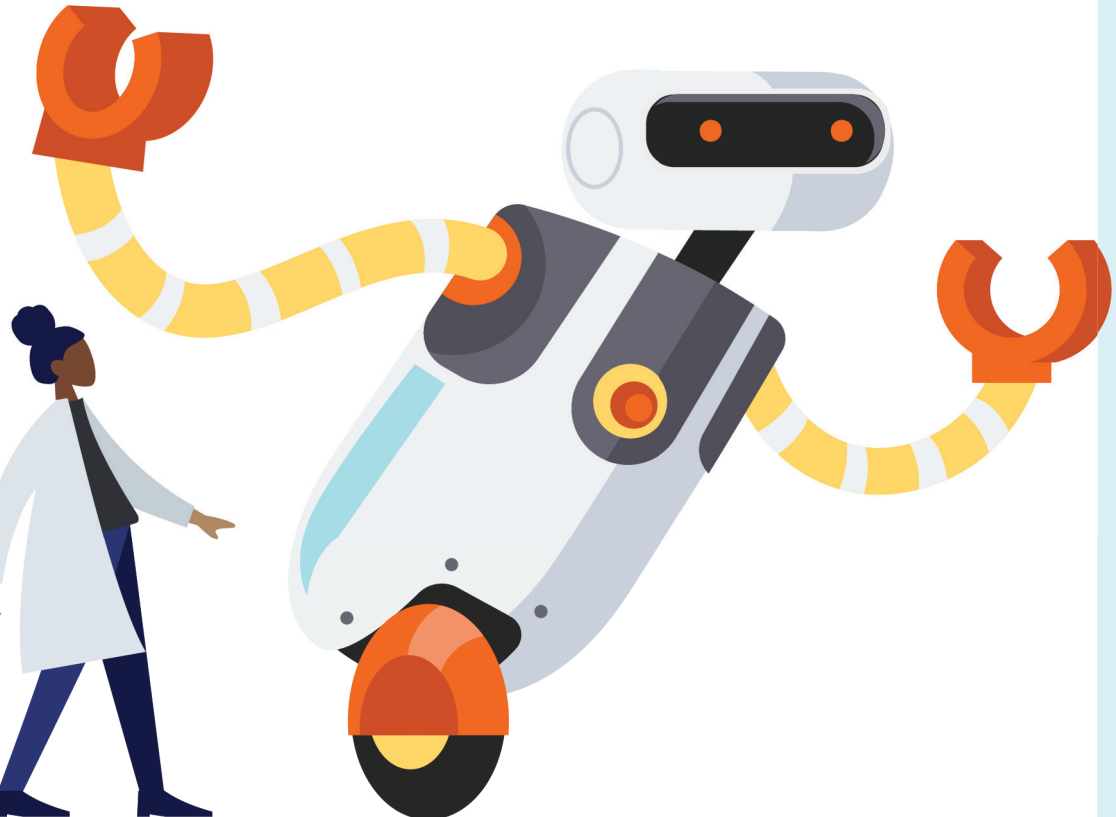
PRIMARY + STEM

Teaching Resource



ACTIVITY: Machines

ACTIVITY OVERVIEW

In this highly engaging hands-on activity, students design and make machines that do not do any meaningful work, do not make their lives any easier, nor mitigate effects of climate change. What their machines CAN do is wrestle opponents out of the ring, create art pieces, and jiggle and dance their way into their hearts! Watch the class turn into a sumo wrestling ring, a disco floor and a Jackson Pollock-esque art studio.

And, in the process, students cycle quickly and repeatedly through the 'Generate', 'Produce', 'Evaluate' components of the design process as they make their machines do different activities.

SYNOPSIS

From the stone age, when the hand axe - the oldest of the simplest machines - was invented to make work easier, to the many inventions that helped humans progress settlements into civilisations, to our reliance on machines now - it is fair to say that machines are an inseparable part of the human experience.

In this highly engaging hands-on activity, students design and make machines that do not do any meaningful work, do not make their lives any easier, nor mitigate effects of climate change. What their machines CAN do is wrestle opponents out of the ring, create art pieces, and jiggle and dance their way into their hearts! Watch the class turn into a sumo wrestling ring, a disco floor and a Jackson Pollock-esque art studio. And, in the process, students cycle quickly and repeatedly through the 'Generate', 'Produce', 'Evaluate' components of the design process as they make their machines do different activities.

Foundation – Year 2

- Explore the characteristics and properties of materials and components that are used to create designed solutions. (VCDSTC017)
- Use materials, components, tools, equipment and techniques to produce designed solutions safely (VCDSCD020)
- The way objects move depends on a variety of factors including their size and shape: a push or a pull affects how an object moves or changes shape (VCSSU048)

Year 3 – 4

- Explore the characteristics and properties of materials and components that are used to create designed solutions (VCDSTC017)
- Investigate the suitability of materials, systems, components, tools and equipment for a range of purposes (VCDSTC027)
- Select and use materials, components, tools and equipment using safe work practices to produce designed solutions (VCDSCD030)
- Evaluate design ideas, processes and solutions based on criteria for success developed with guidance and including care for the environment and communities (VCDSCD031)
- Forces can be exerted by one object on another through direct contact or from a distance (VCSSU064)

Year 5 - 6

- Critique needs or opportunities for designing, and investigate materials, components, tools, equipment and processes to achieve intended designed solutions (VCDSCD038)
- Apply safe procedures when using a variety of materials, components, tools, equipment and techniques to produce designed solutions (VCDSCD040)
- Energy from a variety of sources can be used to generate electricity; electric circuits enable this energy to be transferred to another place and then to be transformed into another form of energy (VCSSU081)

ACTIVITY, MATERIALS AND INSTRUCTIONS

Activity

Critique needs or opportunities for designing, and investigate materials, components, tools, equipment and processes to achieve intended designed solutions (VCDSCD038)
Apply safe procedures when using a variety of materials, components, tools, equipment and techniques to produce designed solutions (VCDSCD040)

Energy from a variety of sources can be used to generate electricity; electric circuits enable this energy to be transferred to another place and then to be transformed into another form of energy (VCSSU081)

Materials - The estimated quantities are designed for children working in pairs (for a class of 30)

- 15 pre-assembled circuits (see 'Preparation beforehand')
- Something to unbalance the motor (e.g. hot glue gun sticks, Blu-Tack, ice-cream sticks, etc.).
- Adhesives (e.g. masking tape, rubber bands, PVA glue, etc.).
- A variety of low-weight plastic and paper containers in different sizes and shapes to act as machine body (e.g. 500ml large plastic/ paper cups, empty milk bottles, 1kg yoghurt containers)
- Decorations (e.g. googly eyes, feathers, ribbons)
- A source of music
- A large piece of paper
- Markers

Preparation beforehand

- 30 small ferrules White Ferrule Crimp Terminals
- Needle-nose pliers
- 15 cable ties (200mm)
- 15 3V-motors Motors
- 15 AA or AAA battery holders with a switch Battery Holder - 2xAAA
- 30 rechargeable AA or AAA batteries
- 30 alligator clips with wires Alligator Test Leads

1. The motors should be prepped to prevent the wires from twisting off.

a. Attach a small crimp ferrule on the free ends of the wires with needle-nose pliers.

b. Secure the wires onto the body of the motor with a cable tie.

2. Pre-assemble the circuits

a. Using alligator clips with wires, connect the battery casings to the motors.

Troubleshooting Tips

If the motor doesn't work, check:

a. the switch on the battery pack is turned on

b. all the parts are connected. They may disconnect while the machine is moving.

c. the wires are connected in the correct way (i.e. black-black; red-red)

Watch out!

If there are signs of smoke from the circuit, check that there isn't a wire directly connecting the two terminals, bypassing the motor. This sets up a short circuit and can cause overheating. By taking this 'shorter circuit', the electrical energy is not dissipated, and the excess energy is converted directly to heat. Turn off the switch and leave it to cool before using it again.

Store batteries according to manufacturer's directions to reduce fire risk.

How to Store Batteries: 8 Steps (with Pictures) - wikiHow

Demonstration

The teacher assembles one machine.

1. Show students a pre-assembled circuit.
   A simple circuit, joining batteries to a 3V motor, is required for this activity. For an electric current to flow, the wires and components must be connected in a certain way.

   Wires of the components (i.e. battery packs and motors), are colour-coded to help us do it correctly – black wires connect to black wires, and red to red. Alligator clips come in various colours, and it doesn't matter what colour is used - as long as the colours of the components are aligned.

2. Secure a weight onto the tip of the motor.
   Newton's first law of motion describes how a machine with its motor perfectly centered on the machine body, without anything attached, will remain stationary.

   By adding a weight in an off-centre fashion, an overall unbalanced force is created, which makes the motor change its state of motion. By keeping the forces unbalanced, the machine will jiggle. To create interesting ways for the machine to move, change the centre of gravity by moving the motor and decorative items to different places of the machine body.

3. Secure the circuit onto the machine body with a generous amount of masking tape.

4. Fit-out the machine with the necessary parts for dancing, sumo wrestling, and markers for making scribbles.

Activity

Students start with jiggling machines that dance, then progress to sumo wrestling machines that push opponents out of a marked-out area, and end with scribble machines that produce abstract art.

Investigate

In groups of two or three, students explore and test a range of casings and weights that would be appropriate for their machine. Which casing is light enough for the motor to support? Which decorations will move in an interesting way? They also explore ways to attach these components securely (e.g. using rubber bands or glue).

Generate

Students design machines in this order: 1) disco dancer 2) sumo wrestler 3) artful scribbler. They build the first machine to dance, exploring ways to make it move in interesting ways. They then move onto designing their sumo wrestling machine, that could have extended parts that can push opponents of out the marked space. Finally, they attach markers onto the machines that will scribble onto a piece of paper.

Produce

In their groups, students gather materials and to make their machine for each of the tasks.

Evaluate

Students bring their machines to the dance floor, wrestling arena, and art gallery for a party! How did their machines do? Did their machines do what they were designed for? How did their machines differ from other machines? Did students work well as a team, taking turns to do the tasks? Are there ways they can make improvements for the subsequent stage?

HOW TO USE THIS ACTIVITY WITH YOUR STUDENTS

Foundation - Year 2

In science, students learn that the way an object moves depends on how it is pulled and pushed. Emphasise how students can bring changes to the movement of their machines, by altering the forces acting on it. They can alter the forces acting on their machines by attaching their motors to different places on the machine casing, by adding decorations to either increase or reduce friction, or manipulating the weight on the motor tip by making it more unbalanced or less unbalanced.

Years 3/4

Common forces that students learn in the Science curriculum include direct forces, such as friction, and indirect ones, such as gravity. Can students use their machines to compare how they perform on smooth surfaces (e.g. hard floor vs rough surfaces/carpets)? Is there a marked difference, given that the machines don't really roll or slide? Students could also compare the stability of the machines by varying the centre of gravity on a tall container (i.e. attaching the motor closer to the top of the container or closer to the bottom). In which instance is the container more likely to topple over under the influence of gravity?

Years 5/6

This activity is ideal for students when they are learning about electric circuits and energy transformation in science. Students can assemble their own simple circuit, in this instance, and identify the energy transformation from the battery to the machine (i.e. chemical energy in the battery to electrical energy in the wires and to the motor, then finally to kinetic energy and sound energy as the motor runs). Can students design another use for this circuit? Perhaps something useful that can be done with a motor (e.g. making a spinning fly-swatter or fan)? What else can students add to the circuit (e.g. LEDs)? How about replacing the battery with a mini solar panel for students who are keen?

DISCUSSION SECTION AND KEY THEMES

KEY THEMES

Machines

A common definition of a machine is a moving mechanical device that makes work easier for humans. A machine could be as simple as a screw, or as complex as a car. It can be as small as a mechanical watch, or as large an aircraft carrier. It could even be as sophisticated as a robot that is fully automated – with the ability to make decisions and execute actions using their sensors and actuators.

What a machine isn't, by this definition, is a device used for transmitting information (e.g. mobile phones, radios, and computers).

Energy Transformation

Machines require energy input to make them operate as designed. This is normally in the form of chemical energy (e.g. fuel or electrical energy). While the machine is working, these energies are often transformed into other forms. Take, for example, a petrol-run car – when the fuel is burnt in the cylinders, the chemical energy is released as heat energy, which, in turn, gets converted to mechanical energy as the pistons set off a series of movements to make the car move. Electric cars, on the other hand, have a completely different set of energy transformation (i.e. electrical energy is used to create mechanical energy by creating a magnetic field).

Electricity

Electricity is a form of energy where a stream of charges (e.g. electrons), called a current, flows around circuit, and, in the process, releases the electrical energy through the different devices in the circuits. The electrical

energy is then transformed into different forms (e.g. light bulbs convert electrical energy to light energy, speakers convert it to sound energy, and motors convert it to mechanical energy).

Circuits

Current electricity will be produced if:

1. Electrical current can travel in a loop. We call this path a circuit. A good analogy is the Formula One races. Cars can only race around the circuit if there is a continuous pathway.

2. There is a pump to push the electrical current (i.e. battery). The battery has two terminals – a positive and a negative. There must be wires to join the negative to the positive end of the battery in a circuit.

3. Conductive material – not all materials allow current electricity to move through them. Wires and other components used to make circuits are made of metal, because metals are a rich source of moving electrons.

4. Load – Any device which allows the electrical energy to be converted into other forms of energy (e.g. sound, light, heat).

Forces at work

Newton's first law of motion explains how a machine - with its motor perfectly centered on the casing and without anything attached to its tip - will remain stationary. It is because the forces acting on it are balanced. It is when the forces acting on the machine are unbalanced that the machine is forced to change its state of motion.

By keeping the forces unbalanced, the machine continually jiggles.

QUESTIONS AND ANSWERS

Is my machine a robot?

No. Generally, robots are machines but not all machines are robots. A robot is more than a machine because robots can: make decisions on their own by sensing the environment using their sensors; do complex computations with their central processing unit (CPU); and perform all sorts of actions in response.

When robots have mechanical parts that can move to make work easier for humans (e.g. an automatic door, an automatic vacuum cleaner, etc.) they are considered to be machines. But software applications that mimic human activity on the Internet, called web robot or bots, are not machines.

What is a Rube Goldberg machine?

A Rube Goldberg machine is a chain reaction-type of machine or contraption that has been designed to accomplish a very simple task in a very convoluted fashion. These types of machines are named after the American cartoonist Rube Goldberg.

Honda Commercial: https://youtu.be/YWk9N92-wvg

Music video: https://youtu.be/qybUFnY7Y8w

How can I turn my sumo wrestling machine into a robot?

Your sumo champion already has a motor and an energy source, but it is not able to make any decisions for itself. To be a robot, it will also require sensors (e.g. pressure sensors, light sensors, etc.) and computer, which is programmed to make decisions, depending on what information it gets from the sensors. Once the computations have been made, the output devices carry out the necessary actions. Transforming the sumo wrestler from machine to robot can be done with controller boards that integrate all three components – the sensors, CPU, and output devices. Favourite controller boards include the Arduino Uno and Raspberry Pi.

Why does my dancing machine topple over easily?

It has to do with gravity, the force that pulls objects towards the centre of Earth. Gravity acts on an object at their centre of gravity – this is a theoretical point where the body's total weight is thought to be concentrated.

In a regularly shaped object, such as a round ball, the centre of gravity is in the middle of a ball. However, when objects are irregularly shaped, such as the machine made in class, gravity acts on it in more complex ways. The centre of gravity is not in the centre of the object, but a distance away from it.

The centre of gravity of the machine affects its stability. The higher the centre of gravity, the more likely it is to topple over. To make it more stable, make the centre of gravity closer to the ground (e.g. rearranging the components and decorations lower on the machine, or choosing a shorter casing for the machine).

Can batteries start fires?

Yes, if they are not stored properly, although alkaline batteries used in this activity has lower risk of flammability than other types. Batteries are best stored in the original packaging or specialised battery storage boxes to ensure that their terminals do not contact other metals and or terminals of other batteries.

Should this happen, batteries start conducting electricity and this will drain them quickly and create heat. Preventing this will reduce fire risk.

If the original packaging is not available, use a plastic container. Store new and used batteries separately in a cool place.

Can we replace the battery with a solar panel?

What a great idea! Just be sure that the solar panel can produce sufficient voltage for the motor to work. There will be a fair bit of work to make this happen, including soldering wires onto the mini-solar panel.

Examples of mini solar panels: AMX3d Micro Mini Solar Cells

Can I add more output devices onto this machine like a speaker or LEDs?

Certainly! Just be sure that the voltage of the batteries is sized correctly, or the devices will not work. The batteries must have sufficient voltage to support the combined voltages of all the devices in the circuit. The battery voltage (e.g. 1.2V, 1.5V), indicates the strength of the push it can exert onto the current flowing through the circuit. Multiple batteries are used to get enough voltage for the circuit.

There are also voltage requirements indicated on the devices (e.g. 3V) and it indicates the strength of this push that is required to make them operate.

Do animals use machines or tools?

Not machines, because these are not found in the wild. Animals have, however, been observed to use tools, including sticks, stones, and leaves, for various purposes.

Well-known examples include chimpanzees that have been observed to use sticks to forage ants, otters that use rocks to pry open oysters, and crows fashioning twigs and leaves (even their own feathers!) into tools.

In 2017, a report on raptors (birds of prey) in the Northern Territory described how the Whistling Kite, the Black Kite, and the Brown Falcon use fire as a tool! These birds have been observed carrying burning twigs in their beaks and dropping them onto dry grass - intentionally starting a fire to flush out their prey.

The native Australian bird making the bushfire crisis worse by spreading the flames | Daily Mail Online

Video by New Scientist: https://youtu.be/XJQh22sCTZI

Aren't all living things basically machines?

It's a debate that is still going on, especially when machines are becoming more human-like. In the 1600s, when many types of complex machines were being invented, a philosopher named Descartes argued that living bodies are just very complex machines. According to his definition, there would be no big difference between a real cat and a man-made one.

People who do not agree often argue that a living thing is not merely the sum of its parts. A mechanical watch, for instance, works the way it does because of how its smaller parts are designed to work. Cats, on the other hand, are more than just their organs and cells. They have personalities and are secretly plotting to take over the world.

What are simple machines?

Simple machines are mechanical devices that change the direction or magnitude of a force. In other words, simple machines allow more work to be done with less effort. The idea of simple machines started when Archimedes, known for his work on buoyancy, gave names to smaller parts of bigger machines. There are six types of simple machines that have been defined – the inclined plane, wheel and axel, pulley, lever, screw, and a wedge. Most everyday devices are actually combinations of several simple machines (e.g. can opener, a shovel, water faucets, bicycles).

OUTSIDE OR SUPPLEMENTARY READING

Articles

Other projects to create with motors

- DIY Ideas for Small Electric Motors | eHow

Simple machines

- Simple machine | Definition, Types, Examples, List, & Facts | Britannica

How to handle batteries

- How to Store Batteries: 8 Steps (with Pictures) - wikiHow
- Battery safety 101: what you should (and shouldn't) do when using batteries (panasonic-batteries.com)
- Caution advised for using rechargeable batteries, battery chargers – Canada Safety Council

TOPIC WORDS

- Alligator clips
- Forces
- Motion
- Electricity
- Energy
- Voltage
- Circuit
- Machine
- Motor
- Battery
- Terminals
- Wires
- Device

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