NASA STEAM:
Simple Machines Shoe Box Rover

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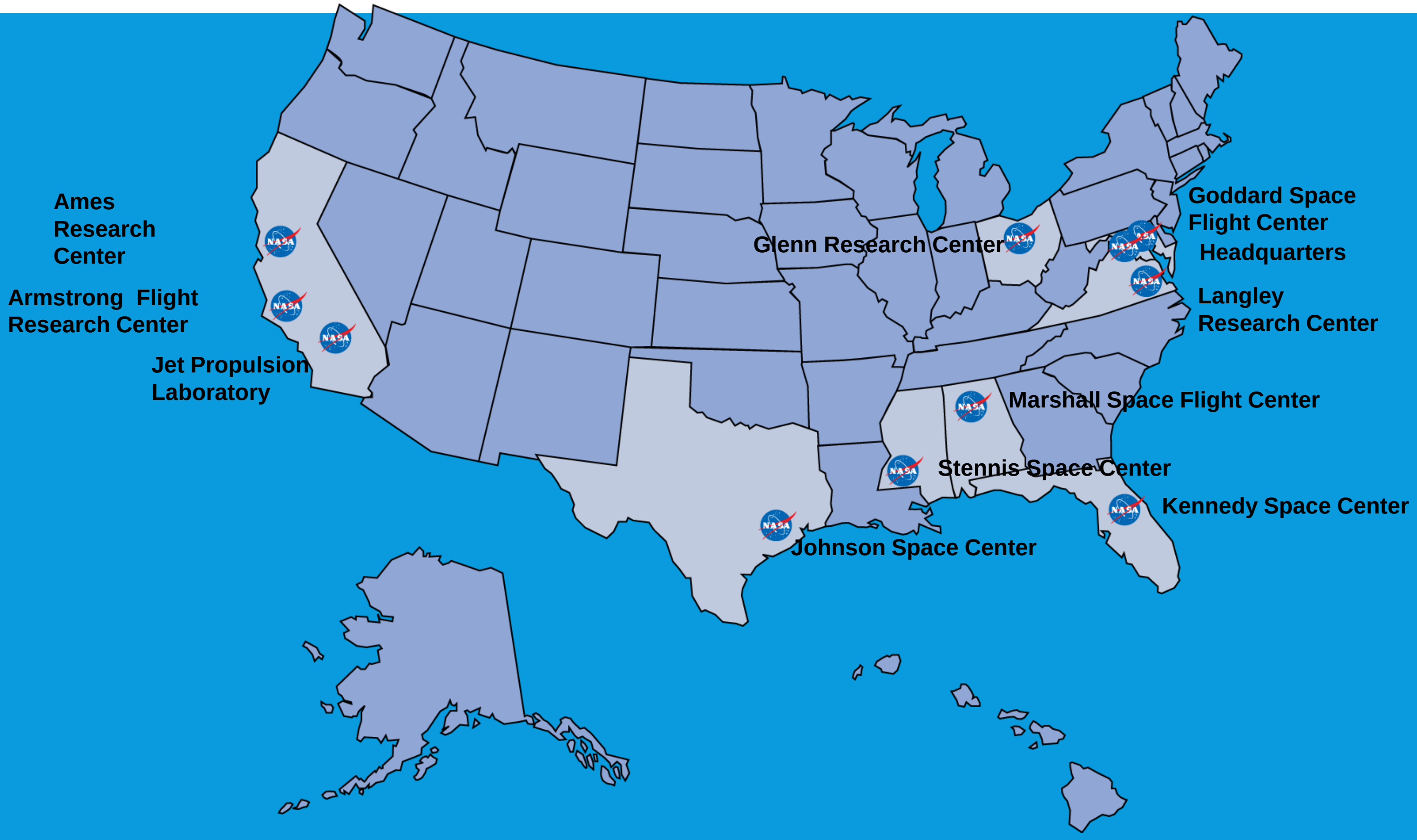
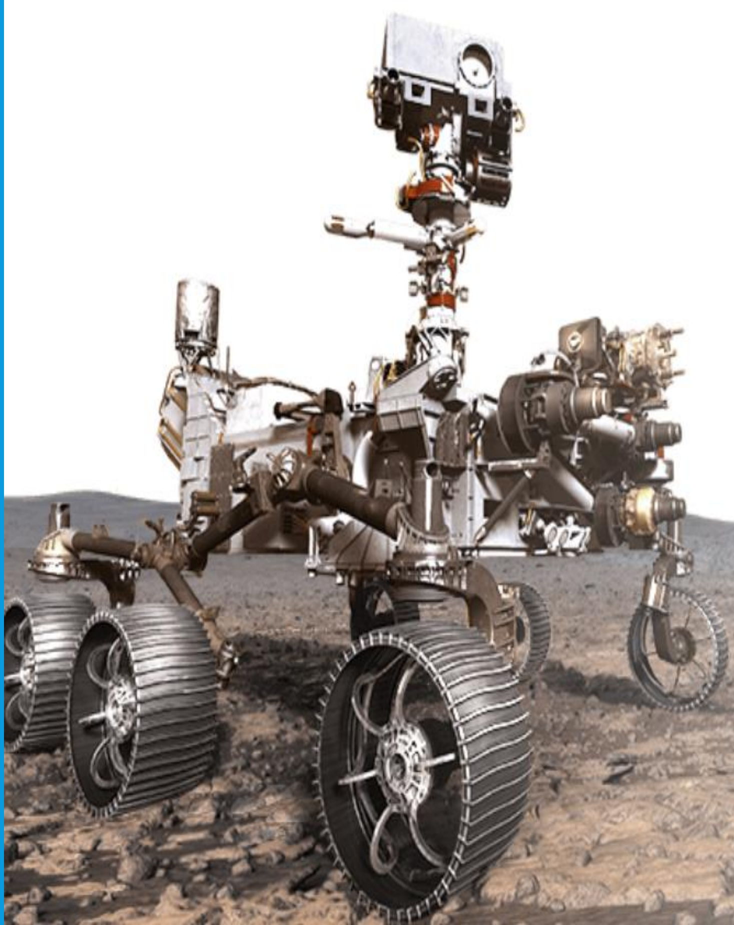
NASA CENTERS



PERSEVERANCE

HTTPS://MARS.NASA.GOV/MARS2020/



Quick Facts

Mission Name: Mars 2020

Rover Name: Perseverance

Main Job: The Perseverance rover will seek signs of ancient life and collect rock and soil samples for possible return to Earth.

Launch Window: July 22 - Aug. 11, 2020

Launch Location: Cape Canaveral Air Force Station, Florida

Landing: Feb. 18, 2021

Landing Site: Jezero Crater, Mars

Mission Duration: At least one Mars year (about 687 Earth days)

Tech Demo: The Mars Helicopter is a technology demonstration, hitching a ride on the Perseverance rover.

Fact Sheet

Launch Press Kit

https://www.nasa.gov/perseverance

THE IMPACT OF DISCOVERY

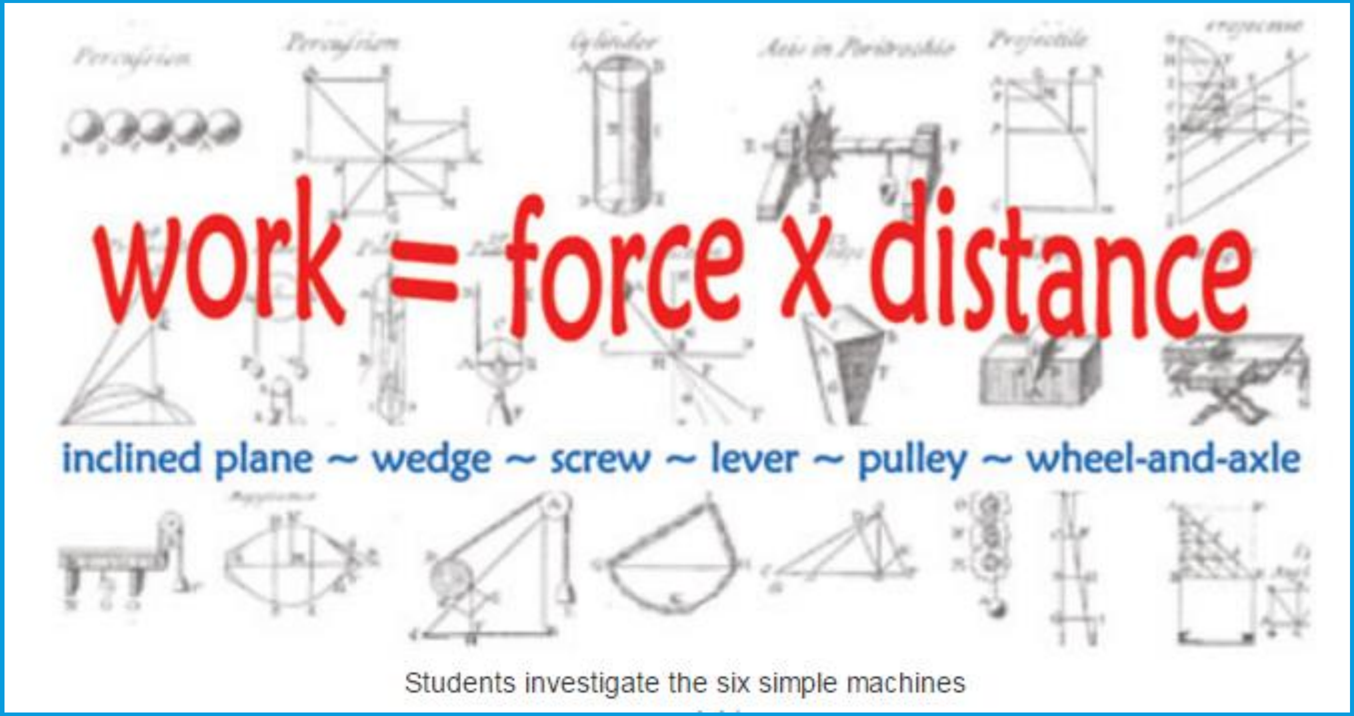
https://www.youtube.com/watch?v=zZEp_3f6K4k&list=PLmdoikyGMi-ZeVTSfWwUedIWjYehgAPRt&index=2&t=0s

WHAT IS THE BIG IDEA?

- Simple Machines Trade force for distance.
- There are six simple machines.
  - **Levers**
  - **Wedge**
  - **Screw**
  - **Pulley**
  - **Wheels & Axle**
  - **Inclined Plane**

Combine these simple **machines** and do more complex jobs!

USING SIMPLE MACHINES



SIMPLE MACHINES SHOE BOX ROVER

Explore mission design and engineering through kinetic Making!

Note: The links on the NASA site are not working, so we've housed everything on Google Drive. Please send us an email if you have trouble accessing.

- **Introductory Videos**
  - Student Video
  - PD Video
- **Intro PD Materials**
  - NASA Discovery PD Video
  - Table Top Instructions *(Print and cut in half)*
  - Automata Step-by-Step Slides
  - Simple Machines Glossary
  - Shoebox Rover Materials List
  - Materials Ordering List
- **Box Marking Templates**
  - Box Side Marking Template
  - Box Top Marking Template
- **Shape Templates**
  - Combined Shapes *(print 1/maker if you want to limit materials or budgets)*
  - Lever Practice Templates
  - Antenna
  - Large Rectangular Prisms
  - Small Rectangular Prisms
  - Cube & Trapezoidal Prisms
  - 5 mm Grid
- **Inspiration Decks** *(Print sets and cut in half for learner use)*
  - NASA Spacecraft
  - NASA Instruments
  - Shoebox Rover Models
  - Everyday Simple Machines
- **Maker Videos on YouTube**
  Instructable Videos to Guide Making & Provide Inspiration
  - Getting Started: Mark Your Shoebox
  - Wheels & Axles: Locomotion
  - Making Automata: Drive Motion
  - Make a Simple Lever Arm
  - Make a Scissor Lever
  - Make a Complex Lever
  - 2D to 3D Shapes: Make Instruments
  - Rover Cameras
  - Make a Wedge Shovel Arm
  - Make a Swivel Mount
  - Make a Simple Pulley
  - Make a Complex Pulley

http://www.eurekus.org/nasa-program-teaching-resources/

INTRODUCTION

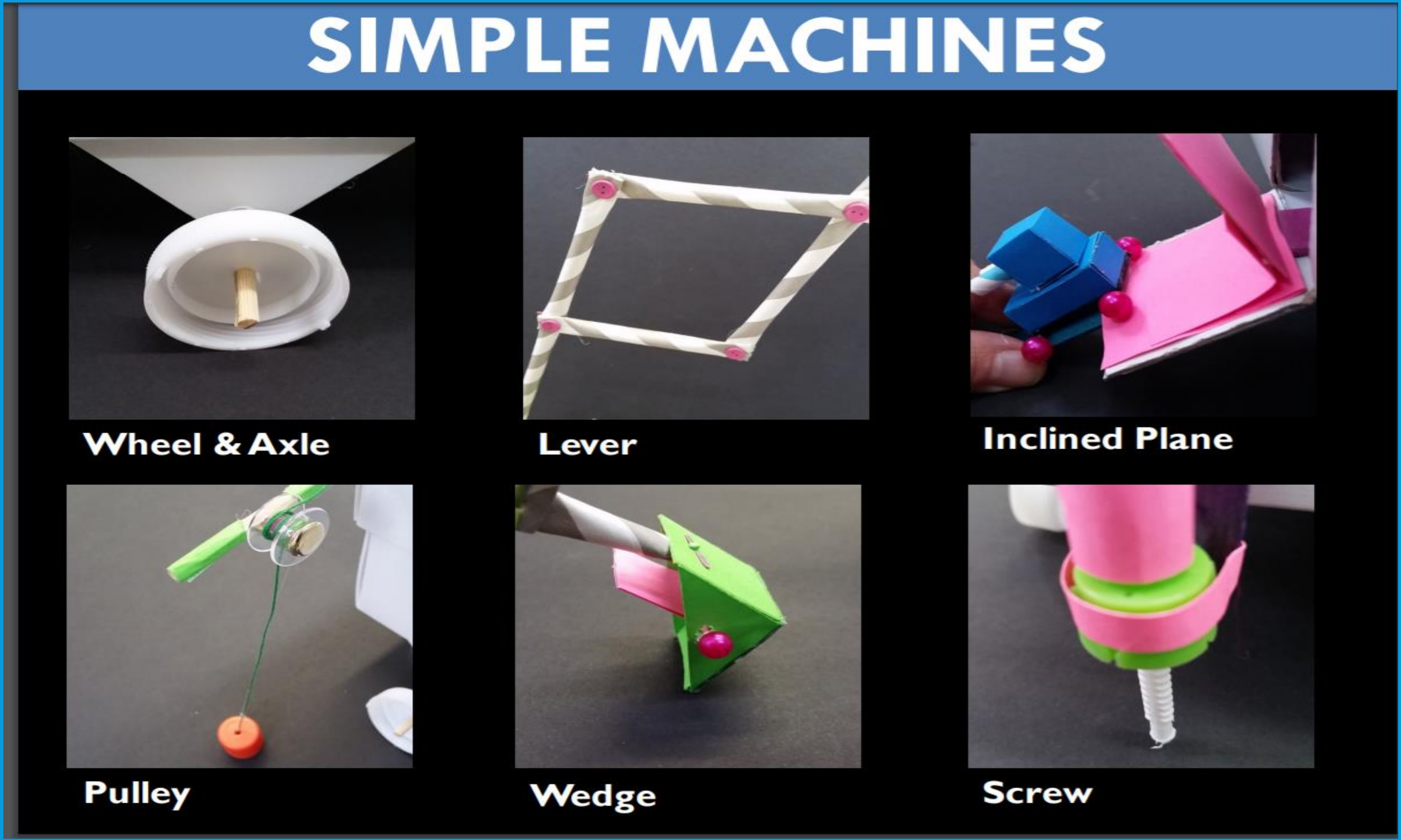
SIMPLE MACHINE SHOEBOX ROVER

HIGHLIGHTS

- NASA Mission Inspired
  - Build Engineering Literacy
  - Apply Math Skills
- Scaffolds Investigation
  - Simple to Complex Machines
  - Guided to Open Challenges
- Learner-led
  - Process Focus
  - Collaborative
- Scalable for Any Age, Any Space
  - Inexpensive &
    Up-cycled Materials

https://www.youtube.com/watch?v=5uY02WntEuY

6 SIMPLE MACHINES



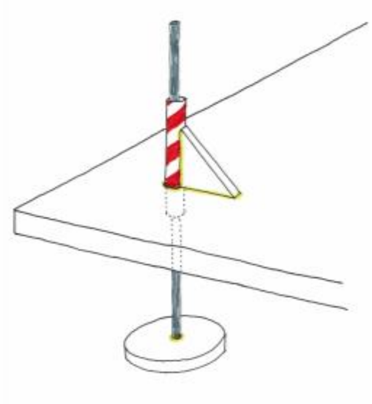
SHOEBOX ROVER

YOUR MACHINE SYSTEMS

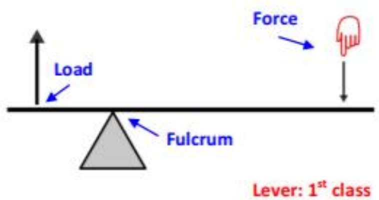
1. Automata Instrument Mount - Cameras & Communications
2. Locomotion System
3. Robotic Arm
4. Sample Collector
5. Pulley Arm
6. Ramp & Mini Instrument
7. Drill Arm
8. Other Science & Engineering Instruments

GLOSSARY

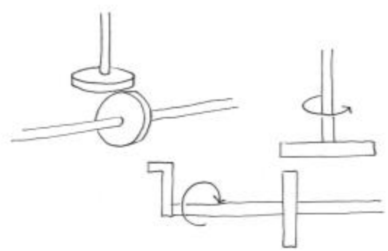
MISSIONMakers
Engineering

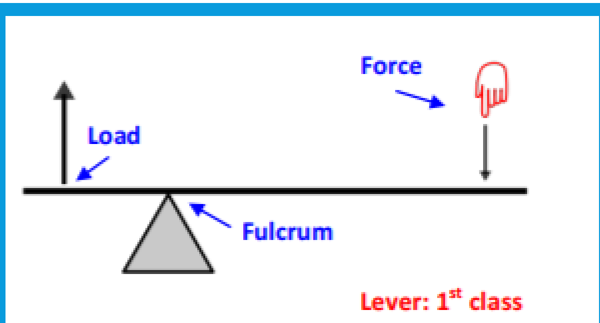


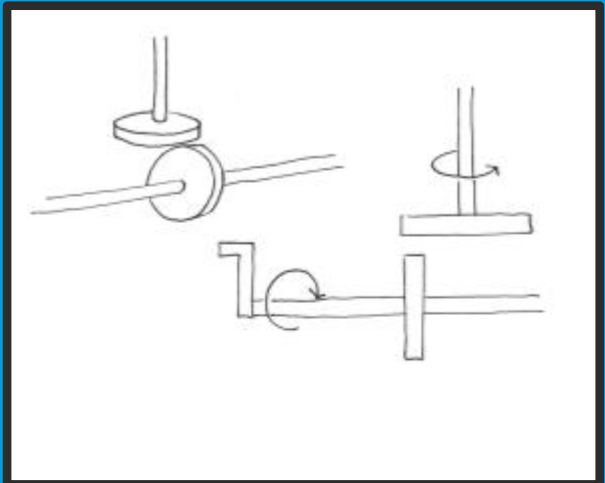
- Axle – a rod or spindle that passes through one or more wheels, allowing them to turn
- Horizontal – parallel to the ground or horizon
- Vertical - at right angle to the ground or horizon
- Automaton (automata) – a machine that can move by itself, without the need for human control
- Bearing – a part of a machine that supports and reduces the friction between moving and stationary machine parts
- Chassis – the outer structural body of a machine
- Friction – the force that slows down an object when it moves across another object or surface
- Force – a push or pull on an object that happens only when two objects interact
- Fulcrum – the point at which a lever is balanced and can pivot
- Lever – a simple machine with a bar that moves at a fixed point (fulcrum), that can lift or move an object (load) at one end when pressed down with force on the other end.



- Load – the weight of an object being moved by a simple machine
- Inclined plane – a simple machine is a flat surface set at an angle between horizontal and vertical, and to change the force needed to move an object.
- Wedge – a triangle-shaped simple machine made of two inclined planes, with the function of splitting one or more objects, holding an object in place, or lifting an object.
- Wheel – a circular object with bars (spokes) connecting the center with the outer edge. It can move across a surface easily, and when connected to a bar at the center, can make an object move.
  - Drive wheel –the wheels that are connected to and move in response to the power source
  - Motion wheel - ??? not in "dictionary" ("wheels in motion")







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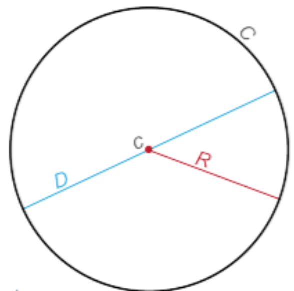
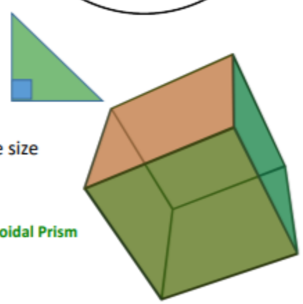
GEOMETRY TERMS

MISSIONMakers
Geometry

Circumference (C) – the distance around the outer boundary of a circle
Diameter (D) – a straight line that passes through the center of a circle from one side to the other
Radius (R) – a straight line that connects the center of a circle to the outer edge



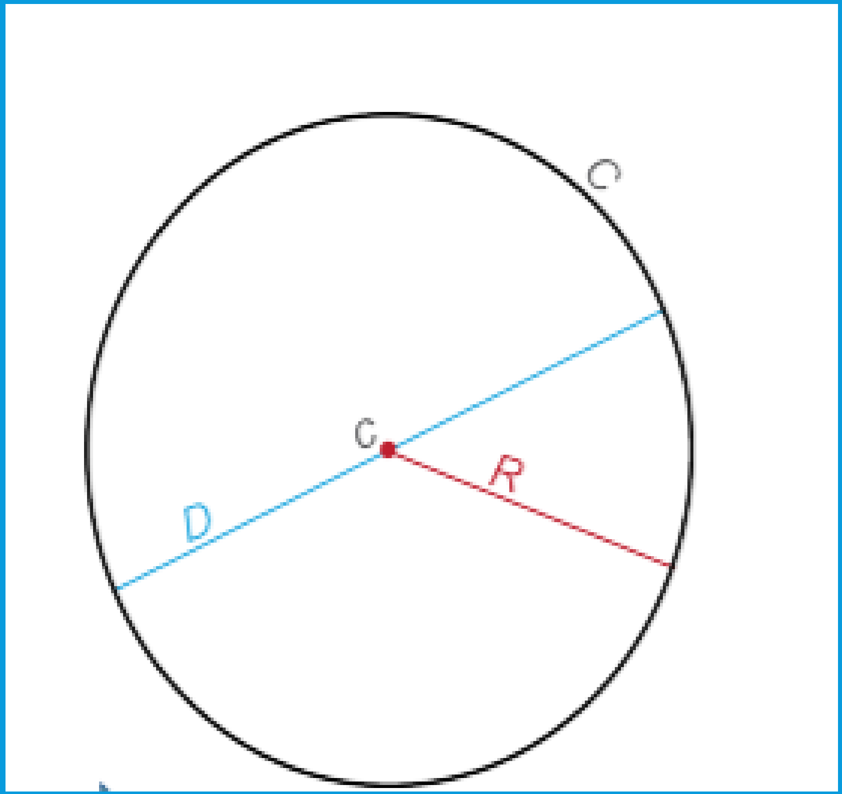
Triangle (Right) – a 2D shape with three straight lines and three angles, one of which is 90 degrees (right angle).
Cube – a box shape made of six equal-sized squares
Prism – a 3D shape with two parallel bases that are the same size and shape, and parallelogram sides



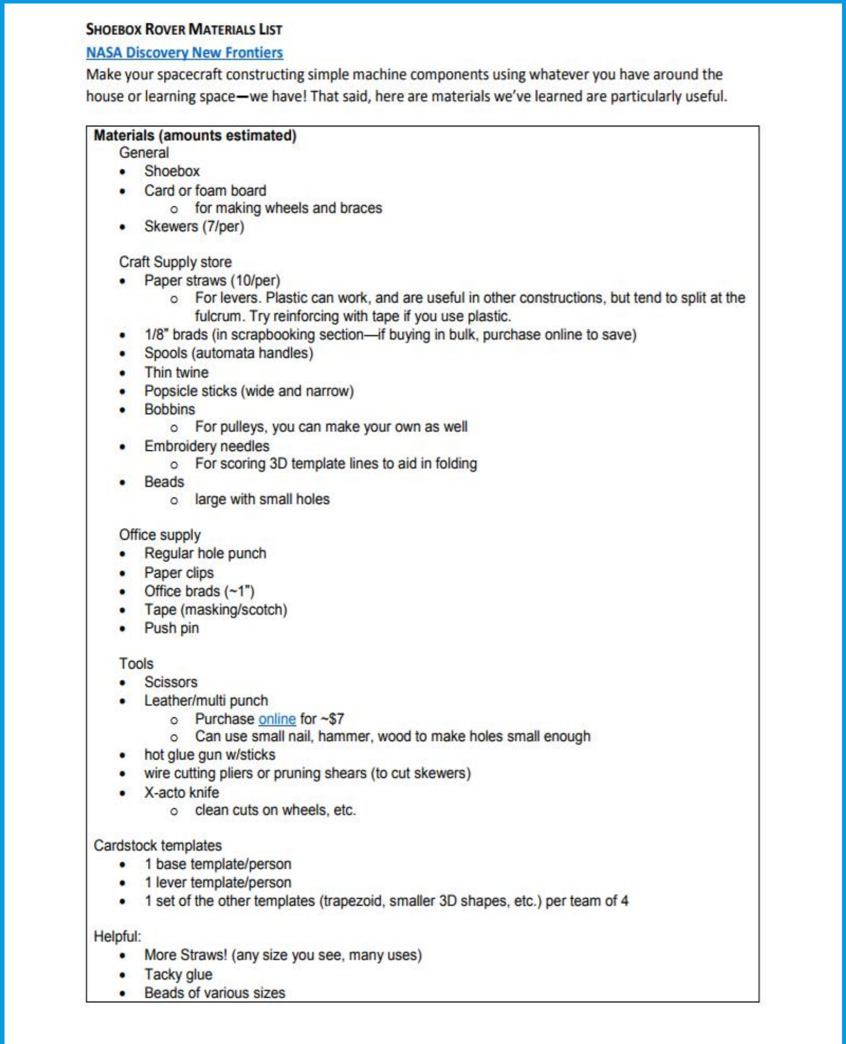
Cube = Cuboidal Prism

Trapezoid – a four-sided 2D shape with two parallel sides.
Parallel – objects, surfaces or lines that are always the same distance apart so they never meet, or intersect
Perpendicular – objects, surfaces or lines that are at right angles to each other
Ratio – the relationship between the quantities of two things

I think many of these math words should have a diagram. One circle diagram could have many labels.



MATERIAL LIST



SHOEBOX ROVER MATERIALS LIST

NASA Discovery New Frontiers

Make your spacecraft constructing simple machine components using whatever you have around the house or learning space—we have! That said, here are materials we've learned are particularly useful.

Materials (amounts estimated)

General
- Shoebox
- Card or foam board
  - for making wheels and braces
- Skewers (7/per)

Craft Supply store
- Paper straws (10/per)
  - For levers. Plastic can work, and are useful in other constructions, but tend to split at the fulcrum. Try reinforcing with tape if you use plastic.
- 1/8" brads (in scrapbooking section—if buying in bulk, purchase online to save)
- Spools (automata handles)
- Thin twine
- Popsicle sticks (wide and narrow)
- Bobbins
  - For pulleys, you can make your own as well
- Embroidery needles
  - For scoring 3D template lines to aid in folding
- Beads
  - large with small holes

Office supply
- Regular hole punch
- Paper clips
- Office brads (~1")
- Tape (masking/scotch)
- Push pin

Tools
- Scissors
- Leather/multi punch
  - Purchase online for ~$7
  - Can use small nail, hammer, wood to make holes small enough
- hot glue gun w/sticks
- wire cutting pliers or pruning shears (to cut skewers)
- X-acto knife
  - clean cuts on wheels, etc.

Cardstock templates
- 1 base template/person
- 1 lever template/person
- 1 set of the other templates (trapezoid, smaller 3D shapes, etc.) per team of 4

Helpful:
- More Straws! (any size you see, many uses)
- Tacky glue
- Beads of various sizes

https://drive.google.com/file/d/1Zw1aodxgdvdjQ3P1-hz3oNAEOvwuVCDe/view

SHOEBOX ROVER GUIDE: TABLE CARDS

https://informal.jpl.nasa.gov/museum/sites/default/files/ResourceLibrary/ShoeboxRoverTableCards_PrintVersion.pdf

SHOEBOX Rover

You are a born engineer! Human beings have always found ways to help us work and explore. Our earliest machines were simple, but key to our survival. A spoon, a hammer, an arrow. As technology evolved, we invented more complex machines. Plows, wheelbarrows, bicycles. Eventually, we designed machines that perform amazing jobs. Now we even explore the outer edges of our solar system. Yowza!

SHOEBOX ROVER
Explore cool NASA inventions. Build engineering skills. Get your hands dirty. Work in a team. Have fun! How? Design your own Shoebox Rover. What do you need? Curiosity. Time. Craft materials:

- Explore
- Create
- Collaborate
- Problem-solve
- Build a Rover!

SIMPLE MACHINES

It all starts with six simple machines. Levers, wedges, screws, pulleys, wheels and axles, and inclined planes. Combine these simple machines and do more complex jobs! Every NASA spacecraft uses simple machines in its design.

THE SIX SIMPLE MACHINES
- Levers
- Wedge
- Screw
- Pulley
- Wheels & Axle
- Inclined Plane

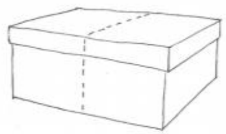
GO! The Spacecraft Bus

What's life's home base? Our body! The skeleton offers structure. Skin gives protection. Outside, sensors gather information. Eyes, ears, nose, tongue, skin. Inside, we process. We take in food & oxygen & water for energy. Our brain is mission control.

Think of a spacecraft like a robot. A human-like robot, going places hard for humans to visit. It needs a lot of the same things. The spacecraft body is often referred to as a "bus" or a "chassis." Its structure is the skeleton. It carries all the working parts of the mission, from engine to camera to satellite dish. It protects instruments from the harsh space environment.

An explorer robot's shape and construction depends on its mission. Where is it going? What questions does it hope to answer?

1 GETTING STARTED:
A shoe box will be your rover bus. It will house your mechanical parts & instruments.



- Collect all materials
- Construct your box if necessary
- Use templates or measure to find the center line around the top and bottom as shown.

Note: Remember, the lid will be slightly larger than the box when you make your measurements.

https://drive.google.com/file/d/1_iE1FRY8L269Nv4WigAjWkZdE8IQdnj1/view

TEMPLATES

- **Box Marking Templates**

  - Box Side Marking Template

  - Box Top Marking Template

- **Shape Templates**

  - Combined Shapes *(print 1/maker if you want to limit materials or budgets)*

  - Lever Practice Templates

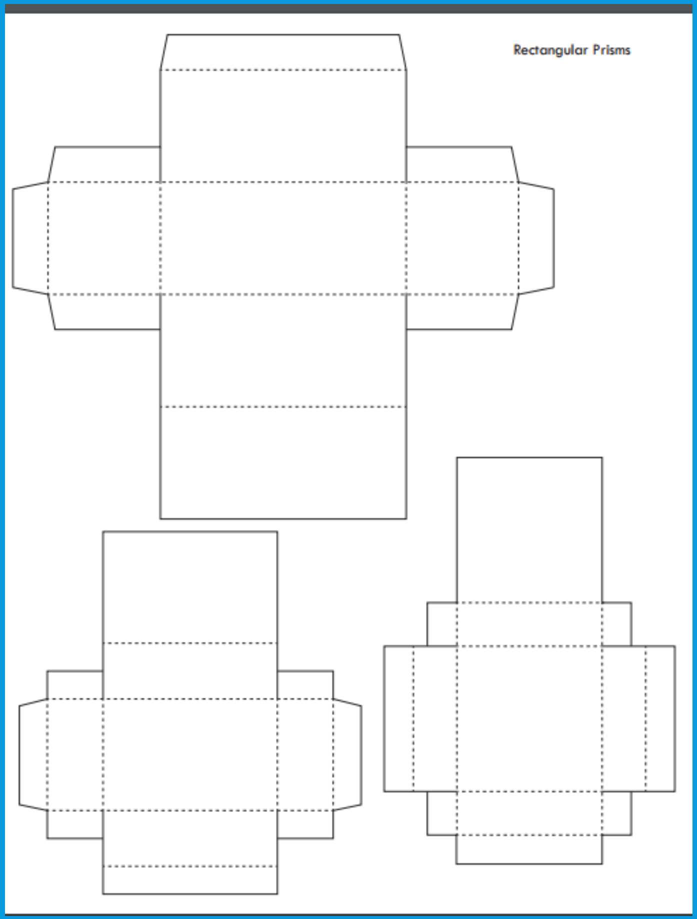
  - Antenna

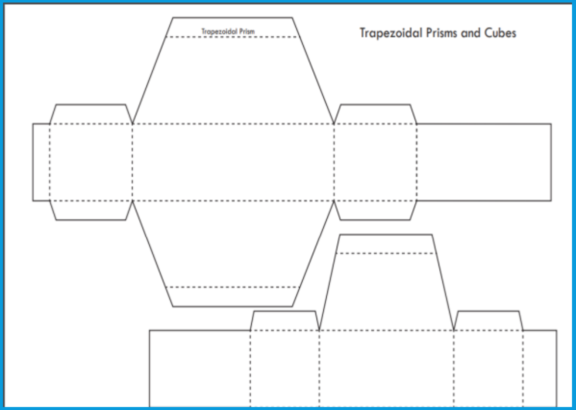
  - Large Rectangular Prisms

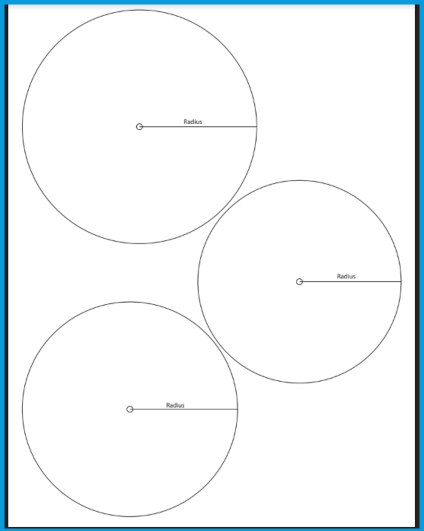
  - Small Rectangular Prisms

  - Cube & Trapezoidal Prisms

  - 5 mm Grid







VIDEOS

HTTPS://WWW.YOUTUBE.COM/PLAYLIST?LIST=PLMDOIKYGMI-ZEVTSFWWUEDIWJYEHGAPRT

EDUCATOR VIDEO

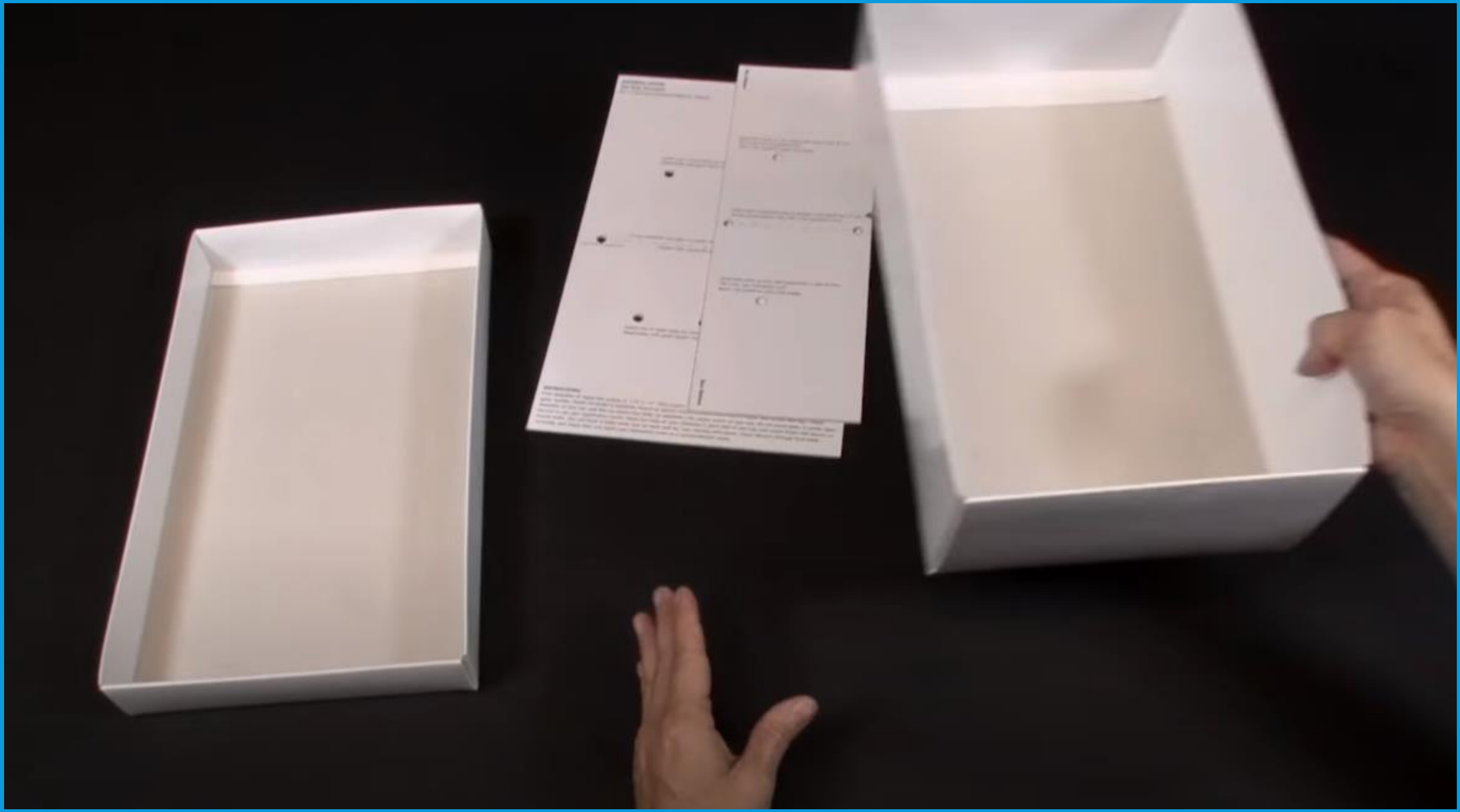
https://www.youtube.com/watch?v=zZEp_3f6K4k&list=PLmdoikyGMi-ZeVTSfWwUedIWjYehgAPRt&index=2&t=0s

12 SHORT VIDEOS TO GUIDE SIMPLE MACHINE ROVERS

https://www.youtube.com/watch?v=g9fSp_BoWSw&index=4&list=PLmdoikyGMi-ZeVTSfWwUedIWjYehgAPRt

- **Maker Videos on YouTube**
  Instructable Videos to Guide Making & Provide Inspiration
  - Getting Started: Mark Your Shoebox
  - Wheels & Axles: Locomotion
  - Making Automata: Drive Motion
  - Make a Simple Lever Arm
  - Make a Scissor Lever
  - Make a Complex Lever
  - 2D to 3D Shapes: Make Instruments
  - Rover Cameras
  - Make a Wedge Shovel Arm
  - Make a Swivel Mount
  - Make a Simple Pulley
  - Make a Complex Pulley

MISSIONMAKERS SHOEBOX ROVER – GETTING STARTED: SHOEBOX MEASUREMENTS



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DESIGN CHALLENGE: ROVER

- Design a rover that will travel in a straight line from the starting line past the finish line.
- Redesign the rover to improve their performance and solve any "mechanical" problems that crop up.
- Must incorporate a minimum of 4 simple machine functional instruments.

LET'S GET STARTED

Materials

- Cardboard boxes
- straws
- sticks
- Misc. building materials
- 4-wheels
- Masking tape and Duck tape
- tools
- measuring tape/ ruler

THE PLATFORM (BUS)

A box (shoebox will work or something similar).

It will house your mechanical parts & instruments.

Construct your box if necessary

GETTING STARTED

The Bus

- **Collect all materials**
- **Use templates or measure.**

The wheels: adding motion

- Rotating parts allow an instrument on a NASA spacecraft to take advantage of its position.
- You will make two moving instrument mounts— for your rover.
- Use wheels and axles inside the shoebox to transfer movement.

WHEELS RESOURCE

https://www.enasco.com/p/Wheels-Set%2BSB48139M

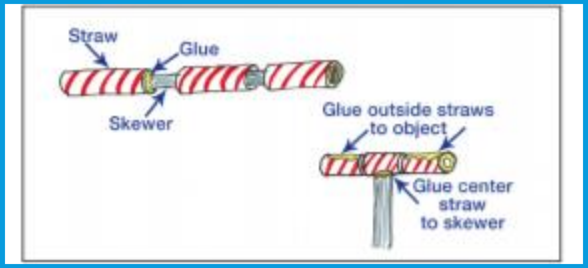
WHEELS AND AXLE
MOUNTS FOR OTHER INSTRUMENTS

SWIVEL MOUNT

Punch a hole on rover where instrument is wanted Punch hole in the center of a cardboard circle (wheel mount) Connect with large brad at top (axle) Glue instrument to wheel, leaving it free to move on the axle

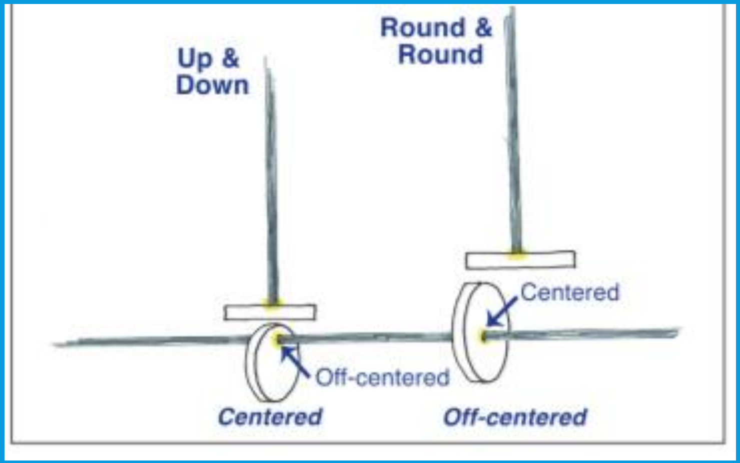
HINGES:

A hinge is a movable joint made with an axle and bearing attached to two separate objects. This allows them to pivot and turn. Paper or small stir straws can be used for your bearings.

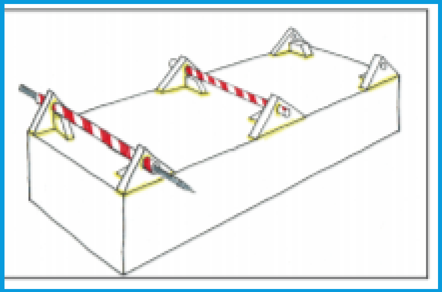


WHEELS AND AXLE

- CHOOSE YOUR MOVEMENTS:
- Look at the sketch to understand where to place the axle on the drive wheel for the desired movement.

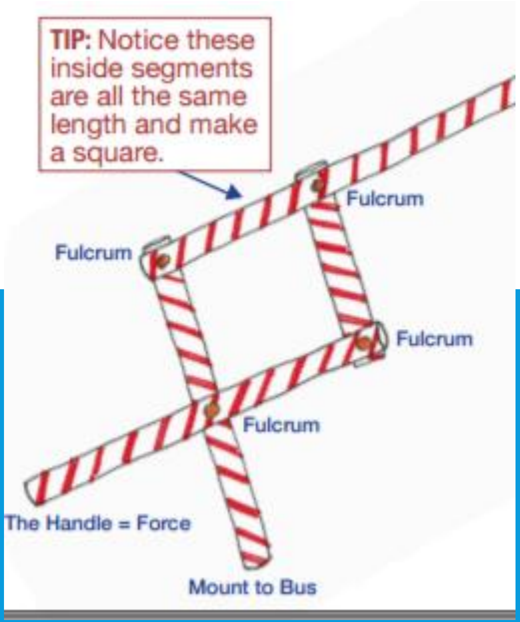


- **PUTTING IT ALL TOGETHER**



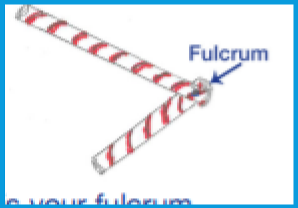
- **TEST MOVEMENT**

LEVERS



EXPLORE LEVERS

Make a lever out of two straws: Put a dot of glue in one end of each & squish Punch a small hole at the end Connect with a small brad—this is your fulcrum Make another! How might two levers combine to make a robotic arm?



3 PARTS OF A LEVER

- FULCRUM: The pivot point of a lever.
- FORCE: The effort applied to a lever to make it move and lift a load.
- LOAD: The weight or object you are trying to lift or move with the lever.

ADD A ROBOTIC ARM: PIVOT, TURN AND TOUCH

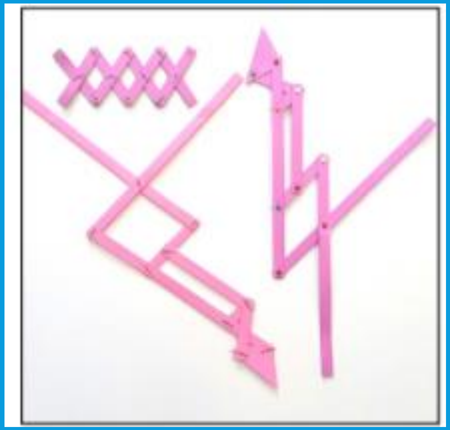
What work do you want it to do?

Collect soil or air or liquid samples?

Move an instrument?

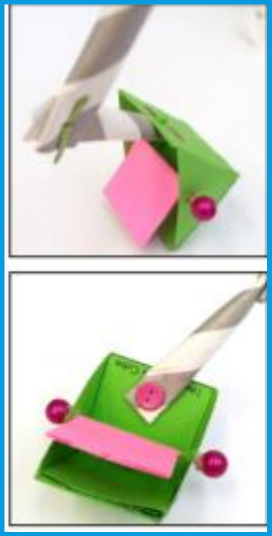
Or solar panels, a drill, a secret hatch?

Its purpose will help you decide the best design.



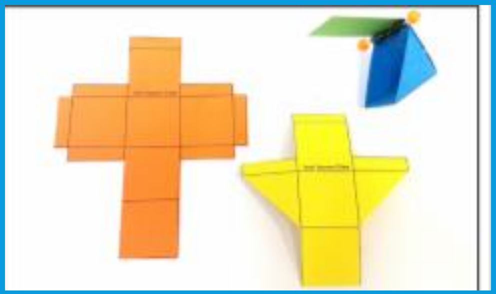
WEDGES

- Wedges in the form of nose cones, fins, wings and heat shields are used in spacecraft to make them aerodynamic.
- Their angled shape helps them cut through the atmosphere.
- Projectiles, from spears to jets to rockets, use wedges to assist with flight.



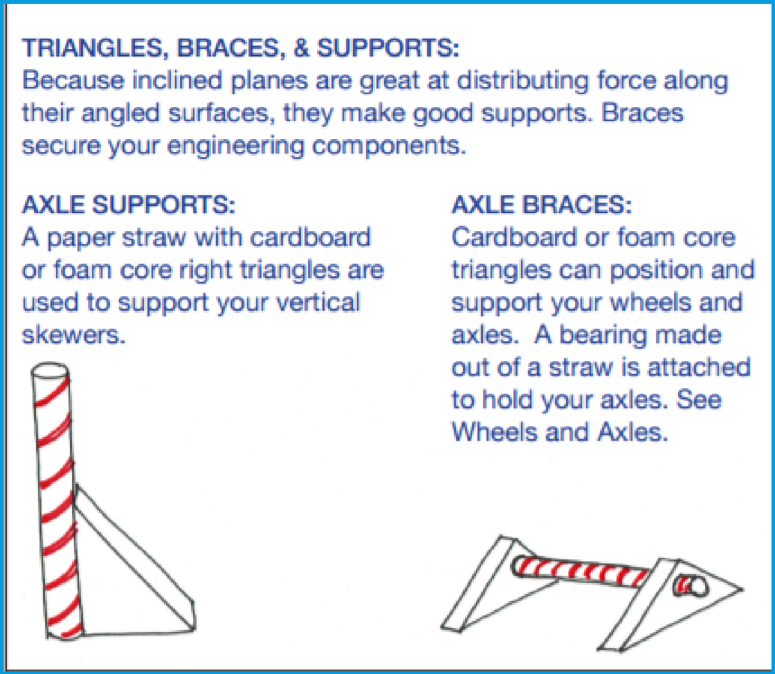
TO MAKE A SHOVEL: IDEA

- TO MAKE A SHOVEL
  Choose a 3D template:
- Cut the side squares at a diagonal (see yellow template)
- Remove the last end square
- Fold and glue tabs Add a hinged cover.
- Use a stir straw as a bearing and a paper clip for an axle.



INCLINED PLANES

- The inclined plane's angled surface is key to its usefulness.
- It reduces the force needed to lift a load straight up by distributing it over distance.
- But there is a trade-off. The greater the slope of an inclined plane, the shorter the distance you have to go. But it takes more effort to get there.



MOVE AND BRACE

DESIGN CHALLENGE:
Design an inclined plane ramp for your rover.
Be creative!

Ideas:

- A trap door that opens down to make a ramp to deploy a mini rover
- Create a system to push your instrument out the trap door with a retractable arm or lever

1 MAKE A MINI TOOL:
Design a mini instrument for your ramp. Our mini rover is housed in a secret compartment. It has a prism body and paper straw cameras. Stir stick bearings, paper clip axles, and beads are the wheels. There's even a lever latch!

SCREWS

- Landers and rovers have simple and complex machines to do the job of a geologist.
- Spirit and Opportunity used an instrument called the Rock Abrasion Tool (RAT) which was the first instrument to drill into the interior of another planet.
- Curiosity has a more sophisticated drill system that works in tandem with a suite of instruments and on-board lab to analyze the Martian surface.

DESIGN CHALLENGE:
Design an instrument that uses a screw.

Consider:

- The science data you want to collect
- The work you want your arm to do

You can use the insides of an old glue stick or Chapstick for the screw itself, as well as screws from the family toolbox.

1 DESIGN A DRILL:
For our example, take apart an old glue stick and use the screw and threaded cap parts.

- Glue a skewer axle to the end of the screw
- Make a straw bearing
- Glue the bearing and the threaded cap to a popsicle stick
- Spin your stick and the screw will move up and down!

Glue threaded cap of glue stick to popsicle stick

PULLEYS

DESIGN CHALLENGE:

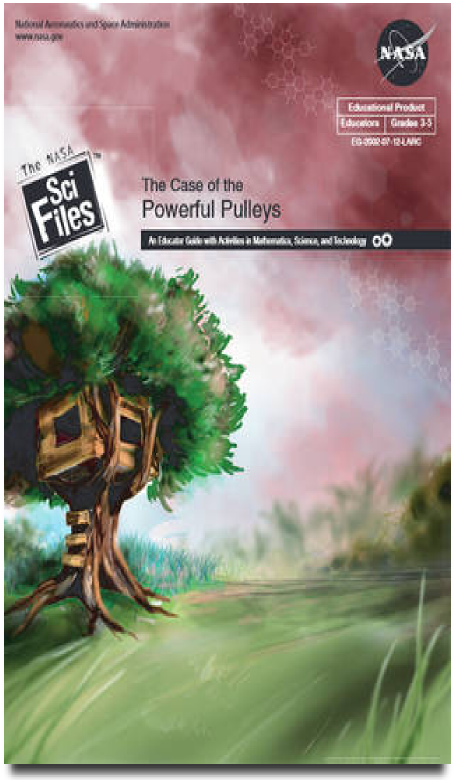
Your challenge is to design a pulley system for your rover to do a task. Think about what type of instrument you would like it to lift and move. Experiment with one or more pulleys.

Our World: Simple Machines - Here and In Space

Description

Simple machines are all around us and help make our work easier. When simple machines are combined, a compound machine is created. Learn about NASA's compound machine, the lunar crane, and the simple machines it contains to make work easier in Our World.

https://nasaeclips.arc.nasa.gov/video/ourworld/our-world-simple-machines-here-and-in-space



The Case of the Powerful Pulleys Unit

Product Type: Educator Guides, Lesson Plans/Activities, Multimedia
Audience: Educators
Grade Levels: K-4, 5-8
Publication Year: 2002
Product Number: EG-2002-07-12-LARC
Subjects: Energy Heat and Magnetism, Forces and Motion, General Science

Jacob, one of the Treehouse Detectives, has broken his foot. He is eager to get back into the treehouse and join his friends, but the cast on his foot prevents him from climbing the ladder. Using problem-based learning, the rest of the gang investigates the world of simple machines and physical science and "pulls" together to get everyone into the treehouse.

Follow the Treehouse Detectives in four video segments as they learn about simple machines, force, energy, work and the world of engineering to discover that "pulling" Jacob up into the treehouse is not as simple as they thought. Use the lessons and the questions in the videos to reinforce the concepts discussed in each segment.

Components:
Cover, Program Overview and Standard [4.75MB PDF file]
Video Segment 1 and Lessons
Video Segment 2 and Lessons
Video Segment 3 and Lessons
Video Segment 4 and Lessons

https://www.nasa.gov/stem-ed-resources/case-powerful-pulleys-activities-guide.html

SEGMENT 1 -LESSONS

Inert Inertia

Purpose To understand the basic concept of inertia

Background Sir Isaac Newton was an English physicist and mathematician who studied the properties of force and motion. He developed three laws of motion known as Newton's Laws. Newton's First Law of Motion states that an object at rest will remain at rest, and an object in motion will remain in motion at a constant velocity unless an unbalanced force acts upon it. This tendency of objects to either remain at rest or in motion is called inertia.

Materials
- 1-m wooden board
- various assortment of books
- medium-sized toy car
- 1 large washer
- meter stick
- science journal

Procedure
1. Stack two or three books on a flat surface and place one end of the board on top of the books to create a ramp so that one end is approximately 10 cm from the surface.
2. Measure the height of the ramp and record in data chart.
3. Use a thick book, like a dictionary, to form a wall at the bottom of the ramp. See diagram 1.
4. Place the large washer on top of the car.
5. Put the car at the top of the ramp and release it, making sure that you do not push the car.
6. After the car hits the wall, measure the distance from the car to where the washer landed and record this distance in the data chart.
7. Repeat steps 4-6 for two additional trials.
8. Raise the ramp an additional 5 cm and record height in data chart.
9. Repeat steps 4-7.
10. Repeat steps 8-9 by raising the ramp again.
11. Find the average distance (cm) that the washer traveled at each height.
12. Discuss your findings and conclusions.

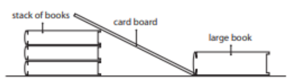


Diagram 1

Data Chart

WASHER WILL TRAVEL				
Height of Ramp (cm)	Distance Trial 1 (cm)	Distance Trial 2 (cm)	Distance Trial 3 (cm)	Average Distance (cm)

Conclusion
1. Describe what happened to the washer when the car hit the wall.
2. Why do you think it happened?
3. Explain the relationship between the height of the ramp and the distance the washer traveled.
4. What is the relationship between inertia and the speed of the car at the bottom of the ramp?
5. Define inertia in your own words.
6. Explain how Jacob unfortunately encounters inertia on his scooter.
7. Using what you now know about inertia, explain why it is necessary to wear seat belts in a vehicle.

Extension If the heights of the ramps were the same for all groups, have students share their data as a class and find a class average for each trial. Create a graph showing the relationship between the height of the ramp and the distance the washer traveled. Use washers of different weights and repeat experiment.

Lessons:

Inert Inertia [106KB PDF file]

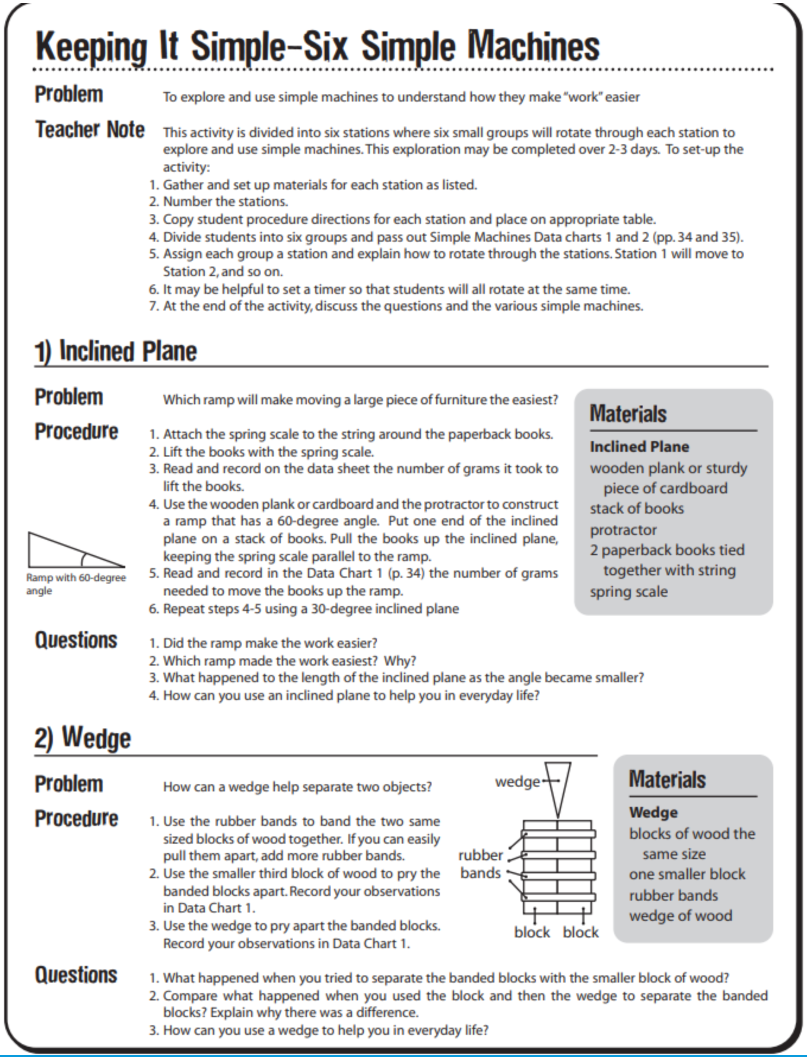
Forcing the Issue of Force [454KB PDF file]

Stop in the Name of Energy [149KB PDF file]

Newton Has the Joules [69KB PDF file]

Answer Key [204KB PDF file]

SEGMENT 2- LESSONS



Keeping It Simple–Six Simple Machines

Problem To explore and use simple machines to understand how they make "work" easier

Teacher Note This activity is divided into six stations where six small groups will rotate through each station to explore and use simple machines. This exploration may be completed over 2-3 days. To set-up the activity:

1. Gather and set up materials for each station as listed.
2. Number the stations.
3. Copy student procedure directions for each station and place on appropriate table.
4. Divide students into six groups and pass out Simple Machines Data charts 1 and 2 (pp. 34 and 35).
5. Assign each group a station and explain how to rotate through the stations. Station 1 will move to Station 2, and so on.
6. It may be helpful to set a timer so that students will all rotate at the same time.
7. At the end of the activity, discuss the questions and the various simple machines.

1) Inclined Plane

Problem Which ramp will make moving a large piece of furniture the easiest?

Procedure

1. Attach the spring scale to the string around the paperback books.
2. Lift the books with the spring scale.
3. Read and record on the data sheet the number of grams it took to lift the books.
4. Use the wooden plank or cardboard and the protractor to construct a ramp that has a 60-degree angle. Put one end of the inclined plane on a stack of books. Pull the books up the inclined plane, keeping the spring scale parallel to the ramp.
5. Read and record in the Data Chart 1 (p. 34) the number of grams needed to move the books up the ramp.
6. Repeat steps 4-5 using a 30-degree inclined plane

Ramp with 60-degree angle

Materials

Inclined Plane
wooden plank or sturdy piece of cardboard
stack of books
protractor
2 paperback books tied together with string
spring scale

Questions

1. Did the ramp make the work easier?
2. Which ramp made the work easiest? Why?
3. What happened to the length of the inclined plane as the angle became smaller?
4. How can you use an inclined plane to help you in everyday life?

2) Wedge

Problem How can a wedge help separate two objects?

Procedure

1. Use the rubber bands to band the two same sized blocks of wood together. If you can easily pull them apart, add more rubber bands.
2. Use the smaller third block of wood to pry the banded blocks apart. Record your observations in Data Chart 1.
3. Use the wedge to pry apart the banded blocks. Record your observations in Data Chart 1.

wedge
rubber bands
block block

Materials

Wedge
blocks of wood the same size
one smaller block
rubber bands
wedge of wood

Questions

1. What happened when you tried to separate the banded blocks with the smaller block of wood?
2. Compare what happened when you used the block and then the wedge to separate the banded blocks? Explain why there was a difference.
3. How can you use a wedge to help you in everyday life?

Lessons:
[Popcorn, Get Your Popcorn Up Here!] [161KB PDF file]
[Keeping It Simple -- Six Simple Machines] [377KB PDF file]
[Answer Key] [249KB PDF file]

Keeping It Simple (continued) Six Simple Machines

3) Wheel and Axle

Problem

Does a larger handle on a screwdriver make work easier?

Procedure

1. Observe the screwdrivers and determine which part of the screwdriver is the wheel and which part is the axle. Discuss and record in Data Chart 1 (p. 34).
2. First, use the screwdriver with the smaller handle. Turn the screwdriver until about half the screw is inserted into the wood. Observe and rate the amount of force needed to turn the screw into the wood.
3. Use the second screwdriver to finish inserting the screw into the wood. Observe and rate the amount of force used. Record.
4. Compare the amount of force used in steps 2 and 3.

Materials

Wheel and Axle

two screwdrivers that are the same length but have different sized handles
piece of wood
6 screws (1 for each group)

Questions

1. Which screwdriver made it easier to insert the screw into the wood?
2. Explain you answer.
3. How can you use a wheel and axle in everyday life?

4) Screw

Problem

To understand that the pitch of a screw determines the difficulty of turning the screw

Procedure

Each group should use a new set of predrilled holes.

1. Observe each screw and nail and note any differences in Data Chart 2 (p. 35).
2. Place screw A in one of the predrilled holes.
3. Use the line drawn on top of the screw to count the number of turns it takes using the screwdriver to insert the screw entirely into the block of wood.
4. Record the number of turns in your data chart. Observe the amount of force used and record.
5. Repeat steps 2-4 with screw B.
6. Using just your hands, try to insert the nail into the wood. Use the line drawn on top of the nail to help you count the number of turns.
7. Record the number of turns and your observations in the data chart.
8. Compare and contrast inserting the nail, Screw A, and Screw B.

Materials

Screw

block of soft wood with 12 predrilled holes
6 nails (1 for each group)
6 sets of 2 wood screws with different pitch but equal length (pitch is the distance between the treads or ridges)
1. use permanent marker and draw a line across the top of each screw and nail
2. use tape to label screws A (larger pitch) and B (smaller pitch)

screwdriver
goggles

Questions

1. How did the nail work in relation to the two screws?
2. Did you find one screw works better than the other?
3. What was the difference between the screws?
4. Which one needed more turns? Why?
5. How can screws make a difference in everyday life?

Keeping It Simple (concluded) Six Simple Machines

5) Lever

Problem

How does moving the fulcrum affect the amount of force needed in a lever system?

Procedure

1. Place the dictionary 26 cm from the edge of the table.
2. Place one end of the ruler under the dictionary so that the 1-cm mark is covered.
3. Place the fulcrum under the ruler at the 24 cm mark.
4. Attach the spring scale to the ruler so that it is hanging downward. Gently pull on the spring scale until you just begin to lift the dictionary. See diagram 1.
5. Read and record in Data Chart 2 (p. 35) the number of grams used.
6. Keeping the 1-cm side of the ruler underneath the dictionary, move the fulcrum to the 15-cm mark. Repeat steps 4-5.
7. Repeat step 6, using 6 cm as the fulcrum's position.

Materials

Lever

30-cm ruler
dictionary
small object such as a pencil or base 10 block for fulcrum
spring scale

Questions

1. Did the number of grams used to lift the dictionary change when you moved the fulcrum? How?
2. If you wanted to lift a heavy load, where should you place the fulcrum?
3. How can you use levers to help you in everyday life?

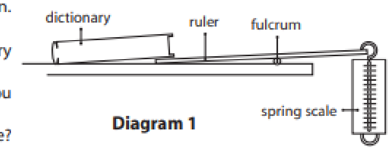


Diagram 1

6) Pulley

Problem

How do pulleys make work easier?

Procedure

1. Use the spring scale to lift the weight off the floor or desk. Read and record the number of grams.
2. Attach the pulley to the ring stand.
3. Attach one end of the string to the weight.
4. Loop the other end through the pulley and attach the spring scale to the end of the string. See diagram 1.
5. Pull down on the spring scale to measure how many grams are needed to lift the weight and record in Data Chart 2 (p. 35).
6. Using a second pulley, construct the pulley system below. See diagram 2.
7. Pull up on the spring scale to lift the weight. Read and record grams in the data chart.

Materials

Pulley

two single pulleys
ring stand
500 g weight
80 cm of string
spring scale

Questions

1. Was there a difference between not using a pulley and using one pulley?
2. What was the difference between using one pulley and using two pulleys?
3. Why would anyone want to use just one pulley?
4. How can pulleys help you in everyday life?

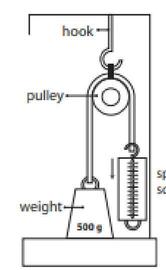


Diagram 1

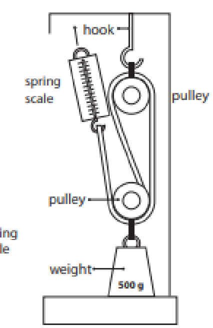


Diagram 2

Keeping It Simple Data Chart 1

Inclined Plane

Inclination in degrees	Grams
0 °	
30 °	
60 °	

Questions:

1. ______________________________
2. ______________________________
3. ______________________________

Wedge

Object	Rate Observed Force
Small block	
Wedge	

Questions:

1. ______________________________

____

2. ______________________________

____

3. ______________________________

____

Wheel and Axle

On a screwdriver, the wheel is the _________ and the axle is the _________.

Screwdriver	Rate the Observed Force
Small-handled screwdriver	
Large-handled screwdriver	

Questions:

1. ______________________________

____

2. ______________________________

____

3. ______________________________

____

Keeping It Simple Data Chart 2

Screw

Observations (compare and contrast nail, screw A, and Screw B).

Screw	Number of Turns	Rate Observed Force
Nail		
Screw A		
Screw B		

Compare and contrast the insertion of screws A and B and the nail.

Questions:

1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

5. ______________________________

Lever

Position of Fulcrum	Grams
24 cm	
15 cm	
6 cm	

Questions:

1. ______________________________

2. ______________________________

3. ______________________________

Pulley

Number of Pulleys	Grams
0	
1	
2	

Questions:

1. ______________________________

2. ______________________________

3. ______________________________

4. ______________________________

SEGMENT 3- LESSONS

Powerful Pulleys

Purpose To understand that pulleys reduce the amount of force needed to lift an object

Materials (per group)

two double pulleys
string
pennies
cup with attached string
clamp and poles from which to hang the pulley system
500 gram mass (weight)
balance
calculator

Procedure

1. Use a balance to find the mass of the bottom pulley system and the attached weight, which is called the load. Record the mass in the chart below.

Object	Mass
Load (Mass of pulleys + 500 g)	

2. Attach the string to the hook on the bottom pulley.
3. Loop the string over the top pulley and attach the cup to the string.
4. Hang the weight from the hook on the bottom pulley. (See Diagram 1)
5. Begin placing pennies in the cup, continuing until the cup balances the weight without anyone having to hold it.
6. Continue placing pennies in the cup until the cup moves. Note: If the cup begins to move and then stops, give the cup a little downward tap. If the cup resumes its motion and moves a good distance, don't add any more pennies. If the cup moves only a few cm and then stops again, you will need to add another penny or two until it moves with a little tap.
7. Place the cup with pennies on the mass balance and record its mass to the nearest gram. The mass of the pennies plus the cup is called the total mass.
8. Repeat steps 5-7 for three more trials and record results in data chart (p. 44). Before each trial, remove 5 or 6 pennies from the cup.
9. Find the average mass for the four trials and record in the data chart. Your answer should be to the nearest gram.
10. To repeat the experiment using 2 strings, attach the string to the top pulley, go around one bottom pulley and one top pulley and then attach the cup to the string. See diagram 2.
11. Now repeat steps 5 through 9 to determine the mass required to lift the load, when it is supported by 2 strings.
12. To find the mass required when using 3 strings, attach the string to the bottom pulley, go around one top pulley, bottom pulley, and the top pulley. See diagram 3.
13. Repeat steps 5 through 9.
14. To find the mass required using 4 strings, attach the string to the hook on the top pulleys and go around one bottom, followed by a top pulley, then the other bottom pulley, and finally the remaining top pulley. See diagram 4.
15. Repeat steps 5 through 9.

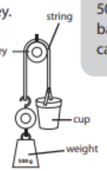


Diagram 1

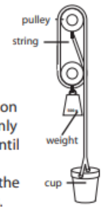


Diagram 2

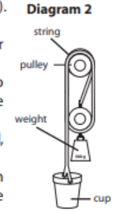


Diagram 3

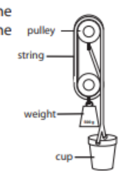


Diagram 4

Lessons:

[Powerful Pulleys](#) [99KB]
[Load-Lifting Lever](#) [95KB]
[Creative Gears](#) [59KB]
[Answer Key](#) [199KB]

Data Chart: Total Mass

Number of Strings	Trial 1	Trial 2	Trial 3	Trial 4	Average Total mass
Example:	212 Grams	213 Grams	211 Grams	212 Grams	212 Grams (212 + 213 + 211 + 212) ÷ 4
1 String					
2 Strings					
3 Strings					
4 Strings					

16. Share your results with the rest of the class and find the class average to the nearest gram.

Group Averages for Total Mass

	1 String	2 Strings	3 Strings	4 Strings
Group 1				
Group 2				
Group 3				
Group 4				
Group 5				
Group 6				
Class Average				

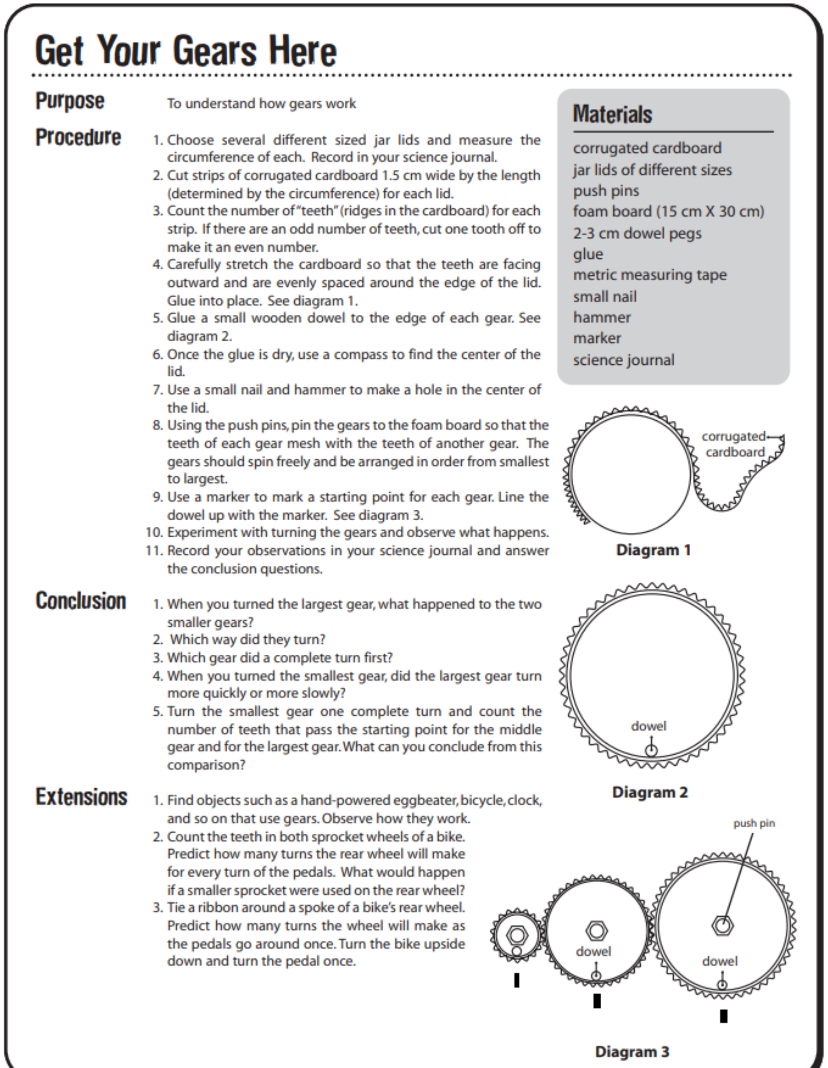
Conclusion:

1. Was the total mass required to move the pulley always less as the number of strings increased?
2. The theory states that the total mass required to lift the load with a pulley system can be found by dividing the load by the number of strings supporting the bottom pulley. Use a calculator to divide the load (Load = mass of bottom pulleys + 500 grams) by the number of strings in each experiment. Record the actual average total mass required to lift the load for each. Find the difference between the two numbers and record.

Number Strings	Load ÷ Number of Strings	Actual Total Mass	Difference
Example: 1	523 ÷ 1 = 523 g	554g	31g
1			
2			
3			
4			

How do you explain the differences between your class's experimental values for Total Mass and the values listed above for Load ÷ Number of Strings?

SEGMENT 4- LESSONS



Get Your Gears Here

Purpose To understand how gears work

Procedure

1. Choose several different sized jar lids and measure the circumference of each. Record in your science journal.
2. Cut strips of corrugated cardboard 1.5 cm wide by the length (determined by the circumference) for each lid.
3. Count the number of "teeth" (ridges in the cardboard) for each strip. If there are an odd number of teeth, cut one tooth off to make it an even number.
4. Carefully stretch the cardboard so that the teeth are facing outward and are evenly spaced around the edge of the lid. Glue into place. See diagram 1.
5. Glue a small wooden dowel to the edge of each gear. See diagram 2.
6. Once the glue is dry, use a compass to find the center of the lid.
7. Use a small nail and hammer to make a hole in the center of the lid.
8. Using the push pins, pin the gears to the foam board so that the teeth of each gear mesh with the teeth of another gear. The gears should spin freely and be arranged in order from smallest to largest.
9. Use a marker to mark a starting point for each gear. Line the dowel up with the marker. See diagram 3.
10. Experiment with turning the gears and observe what happens.
11. Record your observations in your science journal and answer the conclusion questions.

Materials

corrugated cardboard
jar lids of different sizes
push pins
foam board (15 cm X 30 cm)
2-3 cm dowel pegs
glue
metric measuring tape
small nail
hammer
marker
science journal

Diagram 1

Conclusion

1. When you turned the largest gear, what happened to the two smaller gears?
2. Which way did they turn?
3. Which gear did a complete turn first?
4. When you turned the smallest gear, did the largest gear turn more quickly or more slowly?
5. Turn the smallest gear one complete turn and count the number of teeth that pass the starting point for the middle gear and for the largest gear. What can you conclude from this comparison?

Diagram 2

Extensions

1. Find objects such as a hand-powered eggbeater, bicycle, clock, and so on that use gears. Observe how they work.
2. Count the teeth in both sprocket wheels of a bike. Predict how many turns the rear wheel will make for every turn of the pedals. What would happen if a smaller sprocket were used on the rear wheel?
3. Tie a ribbon around a spoke of a bike's rear wheel. Predict how many turns the wheel will make as the pedals go around once. Turn the bike upside down and turn the pedal once.

Diagram 3

]**Lessons:**

[Get Your Gears Here] [126KB]
[Fighting Force of Friction] [125KB]
[Simply Words] [72KB]
[Answer Key] [405KB]

Simply Words

Word Bank

inclined plane	screw	wedge	pulley	wheel and axle	fulcrum	load
force	lever	kinetic	potential energy	crank	winch	work
gears	teeth	machine	compound	friction	push	pull
apparatus	system					

I	N	C	L	I	N	E	D	P	L	A	N	E	A	P	P	A	R	A	T	U	S
S	N	M	O	S	P	S	M	F	I	B	A	B	E	H	U	G	U	Y	I	N	I
G	A	C	A	M	O	R	P	D	O	V	C	A	C	X	L	R	O	L	M	D	T
I	B	F	D	E	P	E	R	I	A	K	M	E	I	C	L	I	P	E	O	E	P
P	N	S	A	A	I	O	M	B	N	H	T	I	H	B	E	L	C	H	T	R	O
F	H	E	D	L	T	I	U	A	I	R	A	U	X	S	Y	L	I	S	H	R	T
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C	J	I	L	I	E	S	N	M	D	C	J	I	L	P	L	L	E	U	D	O	N
B	L	S	T	Y	I	D	J	T	Y	B	L	S	T	U	T	A	G	O	R	F	T
Z	A	I	E	H	E	R	G	E	H	Z	A	I	E	S	I	R	V	A	I	M	I
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I	G	W	I	N	C	H	E	N	N	Y	N	I	K	K	I	N	Y	I	R	P	V
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From: 06:00 PM - 07:00 PM ET
Present by: Susan Kohler
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