STEAM ON!

A Collection of STEAM Activities

FOUNDATIONS
FOR A BRIGHTER FUTURE

foundationsinc.org | Mount Laurel, NJ 08054 | info@foundationsinc.org

This collection of engaging STEAM activities is designed for educators working with middle and high school students; however, they can be adapted based on the developmental needs of your learners. Feel free to modify and apply them as appropriate to best suit your youth. Each activity is hands-on, lists materials to complete each project and incorporates challenge questions to foster critical thinking, creativity and problem-solving skills. Ideal for youth development programs, the content encourages exploration across science, technology, engineering arts and mathematics.

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Lemon Battery and Limelight

Grade Level: 4th-6th grade
Subject Areas: Science
Duration: 50 minutes
Objectives:

- Create a battery using lemons
- Understand the basics of electrical circuits and electrochemistry
- Highlight the potential of everyday objects in generating electricity

Materials:

- 4 Lemons
- 3 Alligator Clipped Wires
- 4 Galvanized Nails
- 4 Copper Pennies
- 1 LED Light
- 1 Piece of Sandpaper
- Small Knife or Sharp Cutting Tool

Introduction: Display a small LED light powered by a lemon or lime battery setup and explain to youth how these things can be observed. Explain that batteries create electricity using chemical energy. Share that the citric acid that is in lemon juice acts as an electrolyte which enables a chemical reaction with the metal.

Instruction:

1. Roll each lemon on a table or hard surface with the palm of your hand.
2. Sand each penny.
3. Sand the flat top of each nail.
4. Cut a slot in each lemon about the diameter of the penny.
5. Insert one sanded penny into the slot cut in each lemon.
6. Insert one sanded nail into each lemon at a location separate from the penny.
7. Connect the LED light from each nail to a penny in a different lemon.
8. Connect these free electrodes to the corresponding leads of your LED.

Group Activity: Arrange youth in groups of 3-5. Using alligator clips, connect the copper to a lemon to a nail to another lemon. Add another clip to the zinc nail of the last lemon and connect the two loose ends of alligator clips to the LED light.

Challenge Questions:

1. Does the size of the lemon affect the amount of electricity?

2. What things are needed for a lemon battery to produce electricity?

Slime Solar System

Grade Level: 4th-6th grade
Subject Areas: Science
Duration: 50 minutes
Objectives:

- Understand that the solar system consists of 8 planets orbiting the sun along with smaller bodies like moons and asteroids.
- Recognize that gravity is the force that holds the solar system together.
- Determine that our solar system is part of the Milky Way galaxy, which is one of billions of galaxies in the universe.

Materials:

- Borax Powder
- 8 Bowls
- Water
- White Lotion
- Clear Glue
- Solar System Picture or Model
- Styrofoam Balls in Various Sizes
- Food Coloring Liquids in White, Yellow. Orange, Red, Green, Blue, and Brown (Colors May Have to be Combined for Desired Outcome)

Introduction: Introduce the activity with images or a short video clip about the solar system. Guide a brief discussion on the solar system by asking the group "What makes each planet in our solar system special?" Engage with the group on follow-up topics about planet sizes, color variations, and unique features. Explain how the activity will allow them to create their own slime planets as a model of the solar system.

Instructions:

1. Mix ½ cup of Glue, ¼ cup of Lotion and food coloring in each bowl.
2. Mix 5 cups of water and 5 teaspoons of Borax Powder in a separate bowl.
3. Pour borax liquid into each bowl with food coloring.
4. Stir until the slime forms (add more Borax if slime is too sticky).
5. Carefully stretch the slime over each Styrofoam ball using colors for planet design.
6. Use pipe cleaners as rings around the planets that have rings.

Group Activity: Each youth reflects on their experience with building the slime solar system and shares one fact about the solar system.

Challenge Questions:

1. How do scientists classify whether an object is a planet?
2. What objects other than planets do you think exist in our solar system?

Articulated Hand

Grade Level: 6^{th}-7th
Subject Areas: Engineering, Technology
Duration: 50 minutes
Objectives:

- Identify how different parts of your hand work together
- Understand the tendons used for stretching the hand and straightening the fingers run through the back of the hand to the tips of the fingers

Materials:

- Straws
- Cardboard
- String
- Sticky Tape
- PVA Glue
- Glitter
- Felt Tips

Introduction: Pose a question to the group, "How do your fingers move to grab or hold something?" Allow the group to share their input and guide the conversations around bones, tendons, and muscles. Share that the movement in hands and fingers are controlled by two sets of tendons. Display an articulated hand and detail how this activity is related to how joints and tendons work collaboratively to move fingers.

Instructions:

1. Place your hand on a piece of thin cardboard (like a cereal box) and draw around it
2. Cut this out to make your hand shape
3. Use a cutting board or several layers of newspaper and use a ruler and a pair of scissors to gently score lines where you want the fingers and thumb to bend. This will be where you can see the "creases" in your own fingers
4. The "bones" are straws cut into sections. Lay a straw along each finger and cut it into small pieces that fit inside the score lines.
5. You will need 3 short pieces for each finger and a longer piece that reaches almost to the wrist, for the palm of the hand.
6. Use sticky tape to stick all the straw pieces in place.
7. Cut 5 lengths of thick thread or fine string (fine enough to thread though the straws) that is roughly twice the length of the hand. Thread each piece from the wrist to the fingertip through the straw pieces on each finger – it's fiddly but it should slip through easily.

8. When all 5 strings are in place carefully tie knots in the fingertip ends. Put a dot of glue on the knots or tape down to the top of the fingertip straws so they don't move.
3. To make your articulated hand even more amazing and unique you can decorate it with felt tip markers and glitter.

Group Activity: Organize a rock, paper, scissors challenge using the articulated hand. Allow two youth to stand in front of the group using their articulated hand to play a game of rock, paper, scissors. Rock beats scissors. Scissors beat paper. Paper beats rock.

Challenge Questions:

1. How many bones are in each of your fingers?
2. Is it more difficult to create an articulated hand that can grip a pencil or one that could lift a large box?

DIY Projector

Grade Level: 6^{th}-8th
Subject Areas: Engineering
Duration: 25 minutes
Objectives:

- Learn how light travels, bends and focuses using lenses
- Observe how the lens flips an image during projection and learn why this happens

Materials:

- Sturdy Cardboard Box (ex. Shoe box)
- Magnifying Lens
- Small, Flat Mirror
- Smartphone or Tablet
- Scissors
- Ruler
- Hot Glue Gun
- Projector Screen or a Dark, Reflective Surface
- LED Flashlight

Introduction: Start with a group question "How does light help to project pictures or videos onto the screen?" Explain that light is directed through a series of lenses as well as mirrors in order to magnify and clarify the image onto a large surface. Continue to discuss lenses, lights, and magnification. Display a finished projector and share how this activity will explore the relationship between light and lenses and how it creates projection.

Instructions:

1. Create an open-face box by removing any unnecessary flaps or lids.
2. Mark the dimensions of your smartphone or tablet on one side of the box using the ruler to ensure accurate measurements.
3. Using the scissors, carefully cut out the opening so that it fits the device.
4. On the opposite side, measure the diameter of the magnifying lens.
5. Carefully cut a hole for the lens.
6. On the same side as the lens hole, mark the position for the mirror.
7. Cut open a space for the mirror to fit into.
8. Ensure all openings are smooth and the items fit into their space.
9. Optional- Decorate the exterior of the box.

Group Activity: In groups of 3-4, youth present their projector with an image of their art work, challenge each group to persuade the audience to purchase this piece of art.

Challenge Questions:

1. How does the light in the interior of the box affect the image quality?
2. How can you improve the brightness or sharpness of the projection?

DIY Speaker

Grade Level: 6^{th}-8th
Subject Areas: Engineering, Science
Duration: 30-45 minutes
Objectives:

- Learn how sound travels, how speakers produce sound, and the role of vibrations in audio technology
- Relate the DIY speaker to real-world technologies like headphones, phones, and Bluetooth speakers

Materials:

- Permanent Marker
- 3 Toilet Paper Rolls
- Scissors
- Hot Glue Gun
- Smartphone
- Measuring Tape

Introduction: Begin by asking the group "How do you think speakers turn electrical signals into sounds that we hear?" to understand their knowledge about sound and technology. Emphasize that speakers are able to transform electrical signals into sounds by creating mechanical vibrations that create sound waves. Display a finished DIY speaker. Remind the group that this activity will increase their understanding of the way that sound is amplified through vibrations.

Instructions:

1. Measure the bottom of the smartphone.
2. Draw the measured dimensions of the Smartphone onto one toilet paper roll and cut it out.
3. Cut one end of the other two toilet paper rolls diagonally.
4. Using tape, attach the slanted ends to each side of the toilet paper roll that has the slot for the Smartphone.

Group Activity: Using a smartphone, observe how the speaker vibrates and how the sound changes using different materials to amplify or dampen the sound.

Challenge Questions:

1. What could improve the speaker's sound quality?
2. How do vibrations turn into sounds?

Make Your Own Kazoo

Grade Level: 6^{th}-8^{th} Grade
Subject Area: Engineering
Duration: 45-60 minutes
Objectives:

- Understand how sound is produced
- Learn how sound is modified through vibrations
- Explore relationship between air movement and sound production

Materials:

- Toilet Paper Roll
- Wax Paper
- Rubber Bands
- Scissors
- Markers
- Stickers

Introduction: Begin with a brief discussion on sound and vibrations. Ask "How do musical instruments like flutes or trumpets produce sounds?" Share that musical instruments like flutes or trumpets produce sounds through the vibration of air columns by blowing air across the mouthpiece or opening which causes the air column to vibrate. Display a finished kazoo.

Instructions:

1. Decorate the toilet paper roll with markers or stickers.
2. Cut a square of wax paper and stretch it over one end of the toilet paper roll.
3. Secure the wax paper tightly with a rubber band.
4. Use scissors to make a small hole near the open end of the toilet paper roll.
5. To test the kazoo, hold the open end to your mouth and hum or sing.

Group Activity: Form a "kazoo orchestra" and have youth play simple songs together. In groups of 4-5 youth, create a short musical performance using the kazoos. Allow each group to take turns performing for the rest of the class.

Challenge Questions:

1. Why does the wax paper vibrate when humming into the kazoo?
2. How does the size of the hole affect the sound of the kazoo?

Marble Run Wall

Grade Level: 6th-8th Grade
Subject Area: Engineering
Duration: 60-75 minutes
Objectives:

- Explore the concepts of gravity, friction, and energy transfer through a hands-on activity
- Develop problem-solving and engineering skills by designing and testing a marble run

Materials:

- Trifold Board
- Marbles or Small Balls
- Paper Towel Rolls
- Toilet Paper Rolls
- Pool Noodles (Cut in Half)
- Painter's Tape
- Scissors
- Small Boxes, Cups, or Containers (to Catch Marbles)
- Rulers
- Measuring Tape
- Sticky Notes or Paper (for Planning)

Introduction: Show a video of a marble run wall and ask, "What forces are at work?" and "How do you think the design impacts how the marble moves?" Explain that the marble will travel from the top of the marble wall to the bottom. Discuss how the laws of gravity are pulling the marble down and how friction slows it.

Instructions:

1. Arrange students in groups of 3-5.
2. Sketch the marble run design on paper.
3. Attach tubes to other materials to the vertical surface using tape.
4. Predict the outcome of the marble run wall to determine if the marble will complete the course.
5. Test the marble after assembling each section.

Group Activity: Groups take turns demonstrating their marble runs to the class while timing how long it takes the marble to travel from the top to bottom.

Challenge Questions:

1. Why does the marble speed up when it moves down steeper sections of the run?
2. What materials or design features helped slow the marble down?

Wind Powered Car

Grade Level: 6^{th}-8^{th} Grade
Subject Area: Engineering
Duration: 60-75 minutes
Objectives:

- Demonstrate how wind energy can be harnessed and converted into mechanical motion to propel vehicles.
- Navigate concepts of energy transfer, force, and aerodynamics

Materials:

- Cardboard, Foam Board, or Plastic Bottle (for the Body of the Car)
- Bottle Caps or CDs
- Axels
- Paper, Cardstock, or Fabric (for Sail Materials)
- Tape
- Glue
- Rubber bands
- Scissors
- Hole Punch
- Balloons
- Fan or Hairdryer (to Mimic Wind)
- Measuring Tape (Test Distance)

Introduction: Begin a discussion introducing wind power and renewable energy. Show a short video of a wind turbine and ask, "How do wind turbines generate energy?" and "How can wind turbines generate energy?"

Instructions:

1. Divide youth into groups of 3-5.
2. Youth plan the design of their wind powered car.
3. Cut the body of the car from cardboard.
4. Attach straws as axles to the bottom of the body of the car using tape or glue.
5. Slide the bottle caps or CDs onto the axles so that they spin freely.
6. Cut the sail out from paper, cardstock, or fabric.
7. Attach the sail to the car using straws as supports.

Group Activity: Set up a racetrack and have groups test their cars, measuring the distance that each car travels using wind from the fan or hairdryer.

Challenge Questions:

1. What helps the wind powered car move farthest?

2. Why do some cars move straighter or faster than others?

Chromatography

Grade Level: 6^{th}-8^{th} Grade
Subject Area: Engineering, Art
Duration: 60-75 minutes
Objectives:

- Apply science and art to create visually engaging designs with chromatography
- Realize how the concept of solubility is related to chromatography
- Analyze the results of the chromatography experiment

Materials:

- Coffee Filter or Paper Towels
- Water-Based Markers
- Permanent Marker
- Pencils
- Small Clear Cups
- Scissors
- Rulers
- String or Clothespin (to Hang Papers for Drying)
- Water
- Rubbing Alcohol

Introduction: Begin with an opening discussion, what happens when two colors of paint are mixed? Can the colors be "unmixed"? Share that some paint mixtures can be separated, even if the paint appears as one color by separating individual particles from their blends and reverting them back to their original colors.

Instructions:

1. Cut the coffee filters into 5-6 strips about 3 inches long.
2. Draw a small design or a dot using water-based markers about 1 inch from the bottom center of the paper.
3. Have each youth choose between 2-3 different colored markers. On each strip of paper, make a small dot with the chosen markers at least 1 inch apart.
4. Pour a small amount of either water or rubbing alcohol into separate small clear cups.
5. Place the bottom of the paper in water or rubbing alcohol and observe.
6. Using string or clothespin, hang the dry chromatography sheet for display.

Group Activity: In small groups of 3-5, allow youth to share why they chose certain colors for this project and detail how the colors separated while displaying their chromatography sheet.

Challenge Questions:

1. Did all the pigments move at the same speed?
2. How does the type of marker, whether water based or permanent, affect the results?

Designing Floor Plans

Grade Level: 6^{th}-8^{th} Grade
Subject Area: Mathematics, Art, Engineering
Duration: 60-75 minutes
Objectives:

- Understand the role of architects and the significance of floor plans in building designs
- Understand spatial reasoning by organizing spaces within a layout
- Use measurement to design a simple floor plan

Materials:

- Graph Paper (1/4-Inch Grid or Architectural Grid Paper)
- Pencils and Erasers
- Rulers
- Colored Pencils
- Markers
- Example of Floor Plans
- Projector or Whiteboard for Visuals

Introduction: Explain that architects are professionals that plan, design and oversee construction of buildings and introduce that floor plans display the level of rooms in a building.

Instructions:

1. Think about your dream home.
2. Sketch the outline of the place. Draw the walls using a ruler.
3. Indicate where the doors and windows will go in each room.
4. Include simple furniture using shapes and symbols.
5. Label each room and measure the dimensions of each room.
6. Designate a different color for each room in the floor plan.
7. Decorate and design the floor plans.

Group Activity: Allow youth to present their designs and floor plans to class where each group will explain their layout choices and the challenges that they faced.

Challenge Questions:

1. How did you decide where to place doors and windows?
2. If you could add more rooms and features, what would you add and why?

Boomwhackers

Grade Level: Grades 6-12
Subject Areas: Arts
Duration: 60 minutes
Objectives:

- Identify specific boomwhacker notes to play the melody of selected song
- Collaborate in small groups to learn and perform the song.
- Develop listening skills and improve timing through ensemble playing.

Materials:

- Set of Boomwhackers (Diatonic Set Recommended)
- Sheet Music or a Simple Melody Chart for Selected Songs with Corresponding Boomwhacker Colors
- Metronome or Rhythm App (Optional)

Introduction:

1. **Engage Students:**
   - Begin with a discussion about melodies and how they can be played using boomwhackers.
   - Introduce a familiar song that can be played with boomwhackers.
2. **Demonstration:**
   - Play the melody of the familiar song on the boomwhackers to demonstrate how it sounds.

Instruction:

1. **Introducing the Song:**
   - Share a melody chart that includes the notes and corresponding boomwhacker colors.
   - Explain the structure of the song, highlighting its repetitive nature.
2. **Assigning Notes:**
   - Assign each student a specific note (or boomwhacker color) based on the melody chart.
   - Review the corresponding note names and pitches for the assigned boomwhackers.
3. **Rhythm Practice:**
   - Clap the rhythm of the song together as a class, emphasizing timing and rests.

Group Activity 1

1. **Song Preparation:**

- Choose a few simple songs (e.g., "Twinkle Twinkle Little Star," "Mary Had a Little Lamb," "Happy Birthday," etc.).
- Write down the melody or provide a simple version of the song, showing which boomwhacker colors correspond to each note (see page 8).
- Practice playing the song together with the class (or as a demonstration).

2. **Song Performance and Guessing Game:**
    - Split the class into small groups (2-4 students).
    - Assign each group a song and have them practice playing it on boomwhackers.
    - Groups will perform their song for the class without revealing the title.
    - The rest of the class must guess the song being played based on what they hear.
    - After each performance, give hints if needed (e.g., “It’s a popular nursery rhyme” or “It’s a birthday song”).
3. **Variation:**
    - If you have more time, let groups perform the song in different variations (e.g., slowing down, playing quietly, or adding different dynamics).

Group Activity 2:

1. **Form Groups:**
    - Divide the class into small groups of 4-5 students, assign each group a familiar song without the sheet music, and ensure each group has the full range of boomwhacker notes needed for their assigned song.
2. **Learning the Song:**
    - Each student plays their assigned note as the group figures out how to play the melody together.
    - Encourage groups to work collaboratively to align their notes and understand how they fit into the song.
3. **Rehearsal:**
    - Allow time for groups to practice the song multiple times. Walk around to assist groups, providing feedback on timing and accuracy.

Performance:

1. **Group Presentations:**
    - Have each group perform their song for the class.
    - Encourage students to listen actively and provide positive feedback after each performance.
2. **Reflection:**

- After each performance, discuss what went well and what they learned about teamwork and music.

Challenge Questions:

1. What happens to the sound of the boomwhacker when you change the way you strike it?
2. How might different techniques (like tapping softly or hitting harder) affect the pitch or tone?
3. What musical elements (like the melody, rhythm, or dynamics) helped you identify the tune?
4. How can you make sure that your group stays in sync while playing a song on boomwhackers?

Twinkle, Twinkle Little Star

Tubes Needed: CDEFGA

C	C	G	G	A	A	G
F	F	E	E	D	D	C
G	G	F	F	E	E	D
G	G	F	F	E	E	D
C	C	G	G	A	A	G
F	F	E	E	D	D	C

Mary Had a Little Lamb

Tubes Needed: CDEG

E	D	C	D	E	E	E
D	D	D	E	G	G	
E	D	C	D	E	E	E
E	D	D	E	D	C	

Happy Birthday

Tubes Needed: CDEFGAC^{i}

C	C	D	C	F	E	
C	C	D	C	G	F	
C	C	C^{i}	A	F	E	D
A	A	A	F	G	F	

Row, Row, Row Your Boat

Tubes Needed: CDEFGC^{i}

C	C	C	D	E	E	D
E	F	G				
C^{i}	C^{i}	C^{i}	G	G	G	E
E	E	C	C	C	G	F
E	D	C				

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High School Level Activities

These activities go beyond surface-level learning, offering deeper engagement and more involved experiences that challenge students to think critically, collaborate and apply their knowledge in meaningful ways. Designed to spark curiosity and encourage hands-on exploration. Each activity pushes students to analyze, problem-solve, and connect concepts to real-world applications. While tailored to high school learners, the following activities can be adjusted to fit different developmental levels, ensuring an enriching experience for all students.

Engineering a Water Filtration System

Grade Level: 9-12
Subject Areas: Engineering, Science
Duration: 1.5 hours
Objectives:

- Understand the importance of water filtration in providing clean drinking water.
- Identify the key principles involved in water filtration (mechanical filtration, absorption, and chemical treatment).
- Design, build, and test a simple water filtration system.
- Evaluate the effectiveness of their water filtration systems based on water quality tests.

Materials:

- Empty Plastic Bottles (2 Per Group)
- Scissors (for Cutting Plastic Bottles)
- Cotton Balls
- Sand (Fine and Coarse)
- Gravel
- Activated Charcoal (Optional)
- Coffee Filters or Paper Towels
- Dirty Water (Prepared Ahead of Time Using Dirt, Small Pebbles, and Food Coloring)
- Clear Cups or Beakers for Collecting Filtered Water
- Measuring Cups or Spoons for Sand and Gravel
- Funnel (Optional)
- Rubber Bands or Tape
- pH Testing Strips (Optional)
- Gloves (Optional)
- Timer or Stopwatch
- Markers for Labeling

Introduction:

- Begin by discussing the importance of clean water and how access to clean drinking water is essential for health and survival.
- Talk about different methods of water treatment, such as filtration, boiling, and chemical treatment.
- Explain the basic principle behind water filtration: removing impurities, suspended particles, and harmful microorganisms to make the water safe for consumption.

- Introduce the concept of mechanical filtration (removal of large particles), adsorption (binding of pollutants), and chemical treatment (disinfection, such as with chlorine).

Instruction:

1. Water Filtration Process Overview:
    - Explain the key layers in a typical filtration system:
        - Cotton balls (or a similar material): Helps to trap large particles and debris.
        - Activated charcoal: Adsorbs chemicals and contaminants, improving the water's clarity and odor.
        - Sand: Filters smaller particles from the water.
        - Gravel: Traps larger debris while allowing smaller particles to pass through.
    - Discuss how different materials in a filtration system work together to purify water.
2. Demonstrate:
    - Show students a sample filtration system (either a pre-made system or use the materials available) to explain how the filtration layers will be arranged in their designs.
    - Emphasize that the water will pass through each layer, getting progressively cleaner as it moves from top to bottom.
3. Safety Precautions:
    - Remind students not to drink the water after filtering, as the filtration system is for demonstration purposes. Emphasize the importance of using proper water treatment methods for actual drinking water.

Activity:

1. Group Work - Design and Build:
    - Divide the students into small groups (3-4 students per group). Provide each group with the materials listed.
    - Instruct students to design and build their water filtration system by cutting the bottom off of the plastic bottles and using the materials provided to layer the filtration medium (cotton balls, sand, gravel, activated charcoal, etc.).
    - Their system should include at least three layers, with cotton balls at the top, followed by sand, gravel, and/or charcoal in whatever configuration they choose. The goal is to make the water as clear and clean as possible after passing through the layers.
2. Test the Filtration System:

- Prepare a "dirty" water sample ahead of time by mixing dirt, food coloring, and small pebbles in water to simulate polluted water.
- Have each group pour the dirty water through their filtration system into a clean container.
- Allow the water to pass through the filtration layers and observe the clarity of the filtered water in the receiving cup or beaker.

3. Measure Effectiveness (optional):
    - If pH strips or other testing materials are available, test the pH of both the unfiltered and filtered water to assess the effectiveness of the filtration system.
    - Alternatively, students can assess the clarity of the water by eye and compare it to the original dirty water sample.

Challenge Questions:

1. What modifications could you make to improve the efficiency of your filtration system?
2. How might your filtration system work in a real-world situation where clean water is scarce?
3. What additional materials could be added to remove harmful microorganisms from the water?
4. How does the filtration system compare to real-life water treatment methods used in cities or rural areas?

Exploring Pigments

Grade Level: 9-12
Subject Areas: Science, Art
Duration: 1 hour
Objectives:

- Understand the chemical properties of pigments and how they are used in creating colors.
- Learn how to mix primary colors to create secondary and tertiary colors.
- Experiment with adding black and white to create tints and shades.
- Explore the science behind the creation and use of pigments in different artistic mediums.

Materials:

- Primary Color Paints (Red, Yellow, Blue)
- White and Black Paint
- Watercolor or Regular Paper
- Paintbrushes
- Palette or Mixing Surface
- Small Containers for Mixing Paint
- Optional: Pictures of Different Pigments (Both Natural and Synthetic) or a Pigment Color Wheel

Introduction:

- Begin by introducing the concept of pigments. Explain that pigments are substances that impart color to materials by reflecting light at specific wavelengths.
- Discuss the difference between a pigment and a dye: pigments are generally insoluble in the medium, while dyes dissolve in their solvents.
- Briefly go over how pigments are used in art materials like paints, and the historical significance of natural pigments (e.g., ochre, lapis lazuli) vs. synthetic pigments.
    - Ask students to think about the colors they use in their artwork and where those colors come from. You might ask: "Where do you think colors in paints come from? How do artists get different colors? What happens when we mix colors together?"

Instruction:

1. **Color Mixing**:
    - Explain the basic color theory: primary colors (red, blue, yellow) cannot be created by mixing other colors, while secondary colors (green, orange, purple) are made by mixing primary colors.

- Demonstrate how to mix colors on the palette. Start by mixing red and yellow to make orange, blue and yellow to make green, and red and blue to make purple.
- Discuss tertiary colors (yellow-orange, red-orange, red-purple, blue-purple, blue-green, yellow-green) and demonstrate how to create them.

2. **Adding Black and White**:
    - Explain how adding white to a color creates a tint (a lighter version of the color), while adding black creates a shade (a darker version of the color).
    - Demonstrate by adding white and black to various primary and secondary colors and show the students how it affects the overall color. This will give them insight into creating lighter and darker versions of colors.

3. **Scientific Insight**:

    - Briefly explain the science behind pigment mixing: when two pigments are mixed, the result depends on how the pigments absorb and reflect light. For example, when red and yellow mix, the resulting orange color is due to the combined light wavelengths of both pigments.

Activity:

1. **Mixing Colors**:
    - Give each student or group a set of primary paints (red, yellow, and blue), white, and black paint.
    - Ask students to experiment with mixing the primary colors to create secondary and tertiary colors on their palette.
    - Students should also experiment with adding black or white to their colors to create tints and shades, and document their observations (e.g., what happens when more black is added to a color).

2. **Create a Color Wheel**:
    - Have students paint their own color wheel on their paper, showing primary, secondary, and tertiary colors.
    - They can either paint the color wheel as a circle or make a linear gradient that demonstrates color transitions.
    - Encourage students to use black and white to create tints and shades around their color wheel.

Group Activity:

1. **Discussion of Pigments**:
    - Once students have created their color wheels or color mixes, break them into small groups to share their results.

- Ask students to discuss:
    - Which colors were the hardest to mix?
    - How did the addition of black and white affect the hues they created?
    - What did they notice about the brightness or dullness of colors when mixing?
- Optionally, show examples of natural vs. synthetic pigments and discuss their historical and modern uses in art.

Challenge Questions:

1. Why do you think artists use specific pigments in their work? How might the chemical properties of a pigment affect its use in different art forms?
2. How do you think color mixing in art compares to color mixing in science (e.g., in light mixing vs. pigment mixing)?
3. What happens if you mix too many pigments together? Why do you think this occurs from a chemical perspective?

Solar Oven Design

Grade Level: 9-12
Subject Areas: Science, Engineering
Duration: 1.5 - 2 hours
Objectives:

- Understand the basic principles of solar energy and how it can be harnessed for practical applications.
- Design and build a simple solar oven using low-cost materials.
- Explain how solar ovens use the sun's energy to generate heat and cook food.
- Evaluate the efficiency of their solar oven by testing its ability to cook food.

Materials:

- Cardboard Boxes (Larger Box and Smaller Box for Oven)
- Aluminum Foil
- Black Construction Paper
- Clear Plastic Wrap or Plastic Bags (for the Oven Window)
- Duct Tape or Masking Tape
- Scissors
- Glue
- Ruler
- Thermometer (Optional)
- Small Food Items to Cook (e.g., S'mores Ingredients, Nachos, Cookies, or Thin Slices of Vegetables)
- Markers or Stickers for Decorating
- Reflective Materials (Optional, e.g., Shiny Metal Trays, Mirrors)
- Optional: Reflective Insulation or Foam Board (for Better Insulation)

Introduction:

- Begin by explaining the concept of solar energy: energy that comes from the sun and can be harnessed for various uses, including electricity generation, heating, and cooking.
- Briefly discuss renewable energy sources and why solar energy is important for sustainable living. Mention how solar ovens are an environmentally friendly alternative to conventional cooking methods that use fossil fuels.
- Introduce the idea of a solar oven: A solar oven uses the sun's rays, reflected and concentrated, to generate heat inside the oven and cook food. Solar ovens are often used in regions with abundant sunlight and where access to electricity or conventional fuels is limited.

- Ask students: “How do you think a solar oven works? What materials do you think would be good for absorbing and reflecting heat? How would you design a solar oven that could get hot enough to cook food? What challenges might you face when using only the sun’s energy to cook food?”

Instruction:

1. **Principles of Solar Energy and Oven Design**:
   - Solar Energy Absorption: The oven uses dark-colored materials (like black construction paper) to absorb the sun’s rays, which converts the sunlight into heat.
   - Reflection and Concentration: Reflective materials (like aluminum foil) are used to reflect and concentrate the sunlight onto the oven's cooking surface.
   - Insulation: To retain the heat inside the oven, clear plastic or glass is used to cover the oven and trap heat inside.
   - Key Variables: The efficiency of the solar oven depends on several factors:
     - The angle of the oven relative to the sun.
     - The quality of the materials used (e.g., reflective surfaces, insulation).
     - The amount of sunlight available.
2. **Demonstration**:
   - Show students a sample solar oven or images of different solar oven designs. Explain how each component contributes to the oven’s ability to capture and retain heat.
   - Optionally, you could demonstrate a basic setup with a small box and aluminum foil to highlight how the reflective surfaces can direct sunlight into the oven.

Activity:

1. **Group Work – Design and Build the Solar Oven**:
   - Divide students into small groups (3-4 students per group) and provide each group with the materials needed to create their solar oven.
   - Instruct students to follow these steps:
     1. Construct the Oven Box: Use the larger cardboard box as the base and the smaller box as the internal structure. Cut the top of the larger box to create an opening for the reflective materials.
     2. Create Reflective Surfaces: Line the inside of the larger box with aluminum foil to reflect sunlight onto the cooking area inside the smaller box. If possible, use reflective materials like mirrors or shiny trays for better concentration of light.
     3. Add a Dark Absorbing Surface: Line the bottom of the smaller box with black construction paper to absorb heat.

4. Seal the Oven: Cover the top of the smaller box with clear plastic wrap or plastic bags to allow sunlight in while trapping the heat inside. Ensure that there are no gaps where heat could escape.
5. Insulate: If desired, add extra insulation around the oven to prevent heat loss.

2. **Testing the Solar Oven**:
   - Once the ovens are built, place them outside in direct sunlight and use thermometers to check the temperature inside the oven.
   - Put food (e.g., s'mores ingredients, nachos, or thin vegetables) inside the oven to test if it can cook.
   - Allow the oven to cook for about 20-30 minutes and monitor the temperature and cooking progress.

Challenge Questions:

1. What modifications could you make to your solar oven to increase its efficiency? (e.g., better insulation, more reflective surfaces)
2. How could you adapt this solar oven design to cook larger meals or work in different weather conditions?
3. What are the environmental benefits of using solar energy to cook food compared to traditional methods that rely on fossil fuels?
4. How does the concept of a solar oven relate to larger energy issues, like sustainability and reducing carbon footprints?

Homemade Lava Lamp

Grade Level: 9-12
Subject Areas: Science, Engineering
Duration: 60 minutes
Objectives:

- Understand the principles of density and immiscible liquids.
- Demonstrate the effect of chemical reactions that create movement in a liquid.
- Explore how gas bubbles affect liquid motion in a lava lamp.
- Design and create a homemade lava lamp that demonstrates the properties of liquids and gases.

Materials:

- Clear Plastic Bottles or Glass Jars (1 Per Group)
- Vegetable Oil
- Water
- Food Coloring (Any Color)
- Alka-Seltzer Tablets (or Effervescent Tablets)
- Flashlights (Optional, for Enhancing the Lava Lamp Effect)
- Funnels (Optional, for Easier Pouring)
- Measuring Cups or Spoons
- Rulers
- Paper Towels or Cloth (for Clean-Up)

Introduction:

- Ask students if they've ever seen a lava lamp and how it works. Discuss the colorful, moving blobs inside the lamp and explain that the movement is a result of chemical reactions and the behavior of liquids of different densities.
- Explain that the basic principles behind a lava lamp include:
  - Density: Liquids with different densities do not mix easily, and the denser liquid will sink to the bottom while the less dense liquid rises.
  - Chemical Reaction: Alka-Seltzer creates bubbles that help move the liquids inside the lamp.
- Ask the class what they think would happen if you mixed oil with water. Discuss how these two substances don't mix due to their different densities.

Instruction:

1. **How Lava Lamps Work**:
   - **Density**: Oil is less dense than water, so when you pour oil into a container, it will float above the water.

- **Alka-Seltzer Reaction**: The effervescent tablets release carbon dioxide gas when mixed with water, forming bubbles that cause the oil to rise and fall, creating the "lava lamp" effect.
- **Gas**: The gas bubbles form and move upward through the oil, pushing the oil upward, and then they pop, allowing the oil to sink again.

2. **Safety**:
   - Discuss the safety of using Alka-Seltzer tablets and the importance of handling liquids carefully. Explain that the experiment is safe as long as the materials are used appropriately.

Activity:

1. **Group Work – Creating the Lava Lamp**:
   - Divide students into small groups (3-4 students per group).
   - Provide each group with the materials listed.
   - Instruct students to:
     1. Fill the plastic bottle or jar about 2/3 full of vegetable oil.
     2. Fill the rest of the container with water, leaving a little space at the top.
     3. Add a few drops of food coloring (to make the water more visible).
     4. Break an Alka-Seltzer tablet into smaller pieces and drop them into the container.
     5. Observe the reaction and watch the "lava" effect as bubbles move through the liquid.
     6. Optionally, use a flashlight to illuminate the container and enhance the effect.
2. **Observation and Recording**:
   - Have students observe the effects and note how the oil and water interact and how the bubbles cause the movement.
   - Encourage them to discuss how long the lava lamp effect lasts and what happens when the bubbles pop.
3. **Extension**:
   - Ask students to experiment with using different amounts of oil or water, different food colors, or breaking up the Alka-Seltzer tablet in different sizes to see how it affects the motion.

Challenge Questions:

1. What would happen if you added more Alka-Seltzer?
2. How could you change the materials (other oils, different liquids) to create a different effect in your lava lamp?

3. Why do you think the bubbles rise and then fall back down?
4. How could you improve your lava lamp to make the effect last longer?

Invisible Ink

Grade Level: 9-12
Subject Areas: Science, Art
Duration: 60 minutes
Objectives:

- Understand how acids and bases work to create invisible ink.
- Experiment with different types of homemade invisible ink.
- Use heat to reveal secret messages.
- Explore the concept of chemical reactions and how they can be applied creatively.

Materials:

- Lemon Juice or Baking Soda Solution (for Ink)
- Watercolor Paints or a Heat Source (like a Lamp or Iron)
- Cotton Swabs or Brushes
- Paper (Preferably Thicker, like Construction Paper or Card Stock)
- Small Bowls (for ink solutions)
- Optional: UV Light (for a Different Type of Invisible Ink Effect)
- Light-Colored Markers or Pens (optional, for Revealing Messages)

Introduction:

- Begin by asking students if they've ever seen or used invisible ink. Discuss how invisible ink has been used in history for secret messages, spy communication, and in art.
- Explain that invisible ink works through chemical reactions that make a substance either invisible or very faint until it is exposed to heat or another chemical.
- Introduce the two common types of invisible ink:
  - Acid-based (e.g., lemon juice) that becomes visible when heated.
  - Base-based (e.g., baking soda solution) that is revealed by a pH indicator or a specific revealing chemical.

Instruction:

1. **Chemical Reactions in Invisible Ink**:
   - Explain that lemon juice contains citric acid, and when it is written on paper, it is invisible because it is a weak acid. When heated, it reacts with the paper, darkening it in the areas where the lemon juice was applied, revealing the message.

   - For baking soda, explain that it is a base, and when it reacts with an acid (like vinegar), it will cause a change in color when exposed to a pH indicator or heat.

2. **Safety**:

- Discuss safety guidelines when using heat (e.g., careful use of irons or lamps) and handling chemicals.

Activity:

1. **Group Work – Creating Secret Messages**:
    - Divide students into small groups and provide them with materials.
    - Assign each group to create a secret message using one of the invisible ink types:
        1. Lemon Juice Invisible Ink: Use a cotton swab to write a message on paper with lemon juice.
        2. Baking Soda Invisible Ink: Mix baking soda with a small amount of water to create a solution. Use a cotton swab to write a message on the paper.
    - Allow the messages to dry.
2. **Revealing the Message**:
    - Once the messages are dry, ask students to carefully heat their paper using a heat source (a lamp or iron set to low heat).
    - Alternatively, use a UV light to reveal messages written with other invisible ink types (like a special ink that is visible under UV light).
3. **Observation and Recording**:
    - Have students observe the changes in the paper and record how the messages are revealed. Discuss why heating or using a UV light causes the hidden writing to become visible.

Challenge Questions:

1. How does the chemical composition of lemon juice make it invisible when first written, and how does heat or another agent reveal it?
2. What role does acidity play in the visibility of the ink after heating?
3. How could you test different types of invisible ink (e.g., lemon juice, baking soda solution, vinegar) to determine which one is the most effective for hiding messages?
4. What variables in the experiment (e.g., the type of paper, the amount of ink, or the heat source) would you manipulate to see the differences in how well the ink is revealed?

Sound Waves and Music

Grade Level: 9-12
Subject Areas: Science, Engineering, Arts, Mathematics
Duration: 1.5 - 2 hours
Objectives:

- Understand the properties of sound waves including frequency, amplitude, and wavelength.
- Explore how different types of musical instruments produce sound and how they use resonance.
- Understand the relationship between pitch and frequency, and the role of harmonic frequencies in music.
- Apply mathematical principles (ratios and frequency) to create a simple musical instrument.
- Use hands-on engineering and experimentation to design and test a musical instrument.

Materials:

- Rubber Bands (Variety of Sizes)
- Small Boxes (Wooden or Cardboard)
- Plastic Tubes, Straws, or Pipes (for Wind Instruments)
- String (Variety of Lengths)
- Scissors
- Tape or Glue
- Tuning Forks (Optional)
- Markers
- Protractors or Rulers (for Measuring and Adjusting Lengths)
- Smartphones with Sound Meter Apps (Optional, to Measure Frequencies)
- Worksheet for Notetaking and Observations

Introduction:

- Start with a question: "What makes a sound high or low? How does a musical instrument create sound?"
- Introduce the concept of sound as a vibration that travels through a medium (usually air) in the form of sound waves.
    - Explain frequency: the number of vibrations (or cycles) per second, measured in Hertz (Hz). Higher frequencies produce higher pitches, and lower frequencies produce lower pitches.
    - Amplitude: relates to how loud or soft a sound is (larger amplitude = louder sound).

- Wavelength: the distance between two consecutive peaks of a wave. Shorter wavelengths correspond to higher frequencies, and longer wavelengths correspond to lower frequencies.
- Discuss resonance: how certain frequencies resonate with an object, amplifying the sound (as with a guitar body or a speaker).

Link to Music:

- Briefly introduce how sound waves are used in musical instruments to produce specific notes (frequencies).
- Explain that the frequency of sound produced by an instrument is related to factors like:
  - String length (shorter strings vibrate faster, producing higher pitches).
  - String tension (tightened strings vibrate faster).
  - Resonance of the instrument (like the body of a guitar).
- Introduce the mathematical relationships in music:
  - An octave is a 2:1 ratio in frequency (for example, doubling the frequency gives a pitch one octave higher).
  - A perfect fifth is a 3:2 ratio, and a major third is a 5:4 ratio, both of which are essential for harmonic music.

Instruction:

1. **The Physics of Sound and Music**:
   - Vibration and Frequency: Demonstrate sound waves using a tuning fork or a vibrating string (pluck a guitar string or use a stretched rubber band).
     - Explain how the vibration of an object creates waves in the air, which are perceived as sound by our ears.
   - Pitch and Frequency: Show how increasing the frequency raises the pitch and decreasing the frequency lowers the pitch.
     - Strike a tuning fork and observe its vibration. You can compare different tuning forks with varying frequencies.
     - Arrange assorted rubber bands from thinnest to thickest around a small empty cardboard box (like a tissue box). Pluck each rubber band and observe the pitch of the sound produced. Try changing the tension by pressing down on the rubber bands with a ruler or pencil and plucking them again. Compare the sounds of the thicker vs. thinner rubber bands and tighter vs. looser bands.

2. **Mathematical Patterns in Music**:
   - Explain how musical intervals are based on ratios of frequencies:
     - An octave (e.g., 440 Hz ➻ 880 Hz) is a 2:1 ratio.

    - A perfect fifth (e.g., 440 Hz ↠ 660 Hz) is a 3:2 ratio.
    - A major third (e.g., 440 Hz ↠ 550 Hz) is a 5:4 ratio.
- Discuss how these ratios form the basis of harmony in music and how these mathematical relationships can be heard in chords.

Activity:

1. **Group Work: Engineering a Simple Musical Instrument**
    - Divide students into small groups (3-4 students per group).
    - Provide materials for each group to build a string instrument (e.g., rubber bands and a box), a wind instrument (e.g., straw flute), or a percussion instrument (e.g., balloon drum).
    - Each group should:
        1. Design an instrument that produces a recognizable pitch or sound.
        2. Use the mathematical principles of pitch and frequency to adjust their instruments:
            - For string instruments, students can adjust the tension or length of the rubber bands.
            - For wind instruments, they can adjust the length of the straw or pipe.
            - For percussion instruments, they can vary the tension or surface area of the drum.

2. **Building the Instruments**:
    - **String Instrument** (e.g., rubber band guitar):
        - Use a box or container as the body of the instrument. Stretch rubber bands of varying thicknesses over the box and adjust their length and tension to produce different pitches.
    - **Wind Instrument** (e.g., straw flute):
        - Cut straws into various lengths. Have students blow through them to produce different pitches and experiment with the length of the straw.
    - **Percussion Instrument** (e.g., balloon drum):
        - Stretch a balloon over a cup or container to create a drum. Students can adjust the tightness of the balloon to change the pitch of the drum.

3. **Testing and Tuning**:
    - After building their instruments, have students test them by producing sound.
    - Use tuning forks or a sound meter app (aka tuner) to compare the pitch produced by their instrument with the expected frequency.
    - Encourage students to adjust their instruments to produce different pitches (e.g., higher or lower notes) by altering the tension or length.

4. **Analyzing Sound**:
   - Have students record their observations of the pitch and sound quality produced by different instruments.
   - Discuss the differences in how each instrument produces sound and how frequency relates to the pitch of the note produced.

Challenge Questions:

1. How do different materials affect the sound produced by musical instruments?
2. What would happen to the pitch if you added more tension to a string instrument or shortened a wind instrument?
3. How does the length of the air column in a wind instrument affect the pitch of the sound?
4. How could you modify your instrument to produce a wider range of notes or a different type of sound?

Mathematical Patterns in Nature

Grade Level: 9-12
Subject Areas: Science, Mathematics
Duration: 1.5 to 2 hours
Objectives:

- Identify and understand mathematical patterns and symmetry found in nature.
- Explore the Fibonacci sequence and its relationship to natural patterns (e.g., flower petals, pinecones, shells).
- Understand fractals and how they appear in natural structures such as trees, coastlines, and snowflakes.
- Apply mathematical concepts (geometry, ratios) to analyze and replicate patterns in nature.
- Recognize how math is used in understanding growth patterns, structures, and symmetry in biological systems.

Materials:

- Graph Paper
- Rulers and Protractors
- Colored Pencils or Markers
- Examples of Natural Patterns (e.g., Photos of Flowers, Shells, Pinecones, Trees, etc.)
- Access to Computers or Devices with Internet (Optional for Research)
- Copies of the Fibonacci Sequence (Can be Printed or Written on the Board)
- Printed Examples of Fractals (Mandelbrot Set, Coastlines, etc.)
- A Variety of Real-World Examples of Nature (Plants, Leaves, Pinecones, Shells, etc.)

Introduction:

- Start the activity by asking:
    - "Have you ever noticed patterns in nature, like the spiral arrangement of sunflower seeds or the way tree branches grow?"
    - "What do you think makes these patterns so consistent across different natural forms?"
- Introduce the idea that mathematical patterns are all around us in the natural world. These patterns are not only beautiful but often follow specific mathematical rules that can be identified and understood.
- Discuss the importance of symmetry and geometry in nature, including the occurrence of mathematical relationships like the Fibonacci sequence, fractals, and symmetrical shapes.

Instruction:

1. **Fibonacci Sequence in Nature**:

- Introduce the Fibonacci sequence:
    - It begins as: 0, 1, 1, 2, 3, 5, 8, 13, 21, 34...
    - Each number is the sum of the two preceding numbers.
- **Real-world examples of the Fibonacci sequence**:
    - Flowers: The number of petals on many flowers follows the Fibonacci sequence (e.g., lilies have 3 petals, daisies have 34, 55, or 89).
    - Pinecones: The spirals on pinecones often follow Fibonacci numbers.
    - Seashells: The shape of many seashells follows the golden spiral, related to the Fibonacci sequence.
    - Fruit and vegetables: The arrangement of seeds in fruits like apples, the branching of trees, or the arrangement of leaves (phyllotaxis) often follows Fibonacci numbers.
- **The Golden Ratio**:
    - Introduce the golden ratio (approximately 1.618), which is derived from the Fibonacci sequence. This ratio is often seen in natural structures (e.g., the shape of galaxies, hurricanes, and the growth patterns of plants).

2. **Fractals in Nature**:
    - **Fractals**: Introduce the concept of fractals as repeating geometric patterns at various scales.
        - Examples in nature:
            - Trees and branches: The way branches split from trunks follows a fractal pattern.
            - Coastlines: The jagged edges of coastlines can be modeled as fractals.
            - Snowflakes: The formation of snowflakes follows a fractal pattern due to the symmetry and repeated division.
        - **Mandelbrot set**: Show a visual example of a fractal (Mandelbrot set) and explain how it is self-similar—meaning each smaller part of the fractal looks similar to the whole.

Activity:

1. **Group Activity 1: Exploring Fibonacci in Nature**
    - Students will research and identify examples of Fibonacci sequences in nature.
    - Divide the class into small groups (3-4 students per group).
    - Provide each group with examples of real-world Fibonacci patterns (e.g., photos of flowers, pinecones, sunflower seeds, shells).

- **Task**:
    - Each group will analyze their examples and calculate the Fibonacci numbers they see in the pattern. For example, they may count the number of spirals on a pinecone or the petals on a flower.
    - Use graph paper to sketch out a few patterns (like a sunflower or pinecone) and identify the Fibonacci sequence in the structure.
    - **Discussion**: How does the Fibonacci sequence appear in nature? What advantages does this pattern provide to the organism (e.g., optimizing seed arrangement, maximizing space for growth)?

2. **Group Activity 2: Exploring Symmetry and Fractals**
    - Students will explore fractals and symmetry in natural structures.
    - Provide examples of fractals and symmetry in nature (e.g., branches, snowflakes, coastlines, leaves, etc.).
    - **Task**:
        - Each group will select a natural object (such as a leaf or tree branch) and examine its structure for symmetry or fractal-like properties.
        - Use rulers and protractors to measure angles, distances, or branching patterns.
        - Sketch their observations and discuss the type of symmetry (e.g., bilateral symmetry, rotational symmetry) or fractal patterns found in the object.
        - Discuss how fractals or symmetry help plants and animals optimize space, resources, or growth.

Discussion and Reflection:

1. **Class Discussion**:
    - Ask each group to present their findings. For example:
        - What Fibonacci patterns did you find, and how do they relate to the function or structure of the object?
        - How did the symmetry or fractal patterns help the plant or animal?
    - Discuss how these mathematical patterns help organisms in nature:
        - Why is it beneficial for a plant to follow the Fibonacci sequence in its growth?
        - How do fractals in natural objects like trees or coastlines maximize surface area or optimize energy efficiency?
2. **Real-World Applications**:
    - Discuss how mathematical patterns in nature are not just for beauty—they can be used in technology, architecture, and design. Examples might include:

- Architectural designs that mimic natural forms.
- Fractal antennas used in communication devices.
- Optimizing crop patterns or designing more efficient structures by mimicking natural patterns.

Challenge Questions:

1. How might the Fibonacci sequence help plants or trees in terms of space and light optimization?
2. In what ways could fractals be applied in modern technology or engineering?
3. What advantages might symmetrical structures provide for animals or plants in terms of survival or reproduction?
4. Can you think of any examples where fractals or the Fibonacci sequence are used in human design or technology?

Paper Airplane Physics

Grade Level: 9-12
Subject Areas: Science, Engineering
Duration: 1.5 to 2 hours
Objectives:

- Understand and apply the four forces of flight: lift, weight, thrust, and drag.
- Explore how different design choices affect the flight of a paper airplane (e.g., wing shape, plane size, fold techniques).
- Measure the flight distance, flight time, and flight stability of paper airplanes.
- Use the scientific method to hypothesize, test, and analyze their results in controlled experiments.
- Understand the real-world application of flight principles in aircraft design and engineering.

Materials:

- Printer Paper (Standard 8.5" x 11")
- Rulers and Protractors
- Stopwatch (or Smartphone Timer)
- Measuring Tape
- Markers or Pens
- Paperclips
- Paper Airplane Template Sheets (Optional)
- Graph Paper (for Data Recording)
- Calculator

Introduction:

- Start with a question: "Have you ever wondered what makes an airplane stay in the air? What forces act on an object when it flies?"
- Explain the four forces of flight: Lift (the upward force that counteracts gravity and allows the plane to stay in the air), Weight (the force of gravity pulling the airplane toward Earth), Thrust (the forward force that propels the airplane through the air), Drag (the air resistance that slows the airplane down).
- Introduce aerodynamics as the study of how objects move through the air and how their shape affects flight.
- Explain that students will create and test paper airplanes to explore how design impacts flight performance (distance, speed, and stability).
- Discuss how different paper airplane designs are similar to real-life aircraft designs, where engineers optimize shape and materials to control the forces acting on the plane.

Instruction:

1. **Explanation of Forces in Paper Airplanes**:
    - Break down the four forces and how they relate to paper airplanes:
        - Lift: A well-designed paper airplane with a good wing shape can generate lift through air pressure differences above and below the wings.
        - Weight: If the paper airplane is too heavy (e.g., with too many folds or a paperclip), it may not stay aloft long enough.
        - Thrust: The force applied when throwing the airplane. The harder you throw, the more thrust is applied.
        - Drag: The resistance encountered as the airplane moves through the air. The smoother and more streamlined the airplane, the less drag it encounters.
2. **Paper Airplane Design Variations**:
    - Wing Shape: The shape and size of the wings affect the lift and stability. Larger wings typically create more lift but might also increase drag.
    - Body Shape: A long and streamlined body reduces drag, allowing for longer flights.
    - Weight Distribution: Adding weight (like paperclips) to the nose or back of the plane can affect the plane's stability and direction.
    - Folding Techniques: Small changes in how the paper is folded can alter the plane's aerodynamics significantly.
3. **Design Hypothesis**:
    - Encourage students to make a hypothesis about how certain changes to their paper airplane design will affect its flight. For example:
        - "If I make the wings wider, the airplane will fly farther."
        - "If I add a paperclip to the front, the plane will fly straighter."

Activity:

1. **Paper Airplane Design and Creation**:
    - Have students create their first paper airplane based on their own design.
    - Design Variations: Students will create different airplanes, such as:
        - A basic dart design with narrow wings.
        - A wide-wing glider design.
        - A sleek, long design for speed.
    - Optional: Provide templates or allow students to design their own planes from scratch.

2. **Flight Testing**:
    - Set up a testing area: Ensure there is a long, clear space for the planes to fly.
    - Testing Procedure:
        - Measure the flight distance: Mark where each airplane lands.
        - Record the flight time: Use a stopwatch to measure how long the plane stays in the air (if relevant).
        - Test flight stability: Observe whether the plane flies in a straight line or spirals, dips, or loops. Record observations on the plane's stability.
3. **Data Collection and Recording**:
    - Create a data table to record the results of the tests. Students should measure:
        - Distance flown (in feet or meters).
        - Time aloft (in seconds).
        - Stability rating (1-5, with 1 being very unstable and 5 being very stable).
    - Test each design at least 3 times and take the average of the results for each plane.
4. **Adjustments and Iteration**:
    - After testing the first round of planes, students should analyze the data and adjust their designs.
        - For example:
            - If the plane with the narrow wings didn't fly far, students might try making the wings wider to create more lift.
            - If a plane flew too high or looped, students might add a paperclip to the nose to adjust the center of gravity.
    - Encourage students to modify their designs, hypothesize again, and test the new plane.

Challenge Questions:

1. How does wing shape affect the lift and drag on an airplane?
2. Why do airplanes have a pointed nose, while paper airplanes often have flat noses?
3. How would the weight distribution of the airplane change the flight path?
4. How could you reduce drag while maintaining lift? What design elements would you change?

Making a Kaleidoscope

Grade Level: 9-12
Subject Areas: Science, Art, Engineering
Duration: 1.5 to 2 hours
Objectives:

- Understand the principles of light reflection and symmetry.
- Learn how mirrors can be used to create repeating patterns and optical illusions.
- Build their own kaleidoscope using simple materials.
- Experiment with different objects to create interesting effects inside the kaleidoscope.
- Explore real-world applications of optics and symmetry in art and design.

Materials:

- Cardboard Tube (e.g., a toilet paper roll or paper towel roll)
- 3 Small Mirrors (Preferably Flexible Mirror Sheets or Thin Acrylic Mirrors, About 3–4 Inches in Length)
- Glue Gun or Strong Adhesive
- Scissors
- Decorative Materials (e.g., Colorful Beads, Sequins, Small Pieces of Glass, Plastic Jewels, Or Colored Plastic Wrap)
- Transparent Plastic Sheet or Clear Plastic Film
- Tape
- Ruler
- Pencil
- Craft Paper, Washi Tape, or Decorative Wrapping Paper (Optional for Decoration)
- Safety Scissors (if needed)
- Protractor (Optional, for Understanding Angles)

Introduction:

- Start by asking students:
    - "What do you know about kaleidoscopes?"
    - "Have you ever wondered why the patterns inside a kaleidoscope are so beautiful and repetitive?"
- Introduce the concept of reflection:
    - Explain that a kaleidoscope works by reflecting light in such a way that it creates a symmetrical pattern that repeats as you turn the device.
    - Discuss the importance of angles of reflection and symmetry in producing these patterns.
- Briefly explain the materials and concepts involved: mirrors, light reflection, and how changing the objects inside the kaleidoscope can affect the patterns.

Instruction:

1. **How a Kaleidoscope Works**:
    - Explain that the magic of a kaleidoscope lies in the angles at which the mirrors are placed.
    - When light reflects off the mirrors inside the kaleidoscope, it bounces between the mirrors at a precise angle, creating repeating, symmetrical patterns.
    - A typical kaleidoscope has three mirrors set at **60-degree angles** to each other.
    - The pattern of objects inside the kaleidoscope is reflected multiple times, forming intricate designs.
2. **Overview of the Materials**:
    - Show the materials students will be using to build their kaleidoscope, such as the cardboard tube, mirrors, decorative items, and plastic film.
    - Demonstrate how to carefully attach the mirrors to the tube in a triangular configuration to reflect the light.

Activity:

1. **Preparation**:
    - Give each student (or group) the materials listed above.
2. **Building the Kaleidoscope**:
    Students will follow these steps to construct their kaleidoscope.
    - Step 1: Cut the Mirrors:
        - Using a ruler, students should cut three mirrors (or mirror sheets) to approximately 4 inches in length. The width of the mirrors should be just wide enough to fit inside the cardboard tube.
        - Safety Tip: Make sure students are careful with the mirrors and scissors, as they may have sharp edges.
    - Step 2: Prepare the Tube:
        - Take the cardboard tube (e.g., toilet paper roll) and measure and mark the area where the mirrors will be placed. Use a pencil and ruler to measure the length of the tube, ensuring the mirrors will fit snugly inside.
    - Step 3: Position the Mirrors:
        - Attach the three mirrors inside the tube at a 60-degree angle to each other.
        - Glue the edges of the mirrors to the inner surface of the tube, ensuring the reflective sides face inward. The mirrors should meet at one point and form a triangular tunnel inside the tube.
        - You can use a protractor to measure and confirm the angle between the mirrors, though this is optional.

- Step 4: Create the Object Chamber:
  - On one end of the tube, cut a small hole (about 1.5 inches in diameter) for the object chamber.
  - The object chamber is where students can place colorful beads, sequins, or small objects that will create patterns when reflected.
  - Attach a piece of clear plastic over the hole to form the object chamber. Secure the edges with tape. This will help keep the objects inside while still allowing light to pass through.
- Step 5: Add Decorative Objects:
  - Students can add small colorful objects like beads, sequins, or tiny glass pieces to the object chamber. These objects will reflect and create vibrant, symmetrical patterns when looked at through the kaleidoscope.
- Step 6: Close the Kaleidoscope:
  - On the opposite end of the tube, cover the hole with a clear piece of plastic or plastic wrap (this will be the viewing end).
  - Secure the plastic in place with tape or glue.

3. **Final Adjustments**:
   - Allow students time to decorate their kaleidoscopes with craft paper, stickers, or other materials to personalize the design.
   - Ensure that the mirrors are securely glued, and the object chamber is properly sealed.

Experimentation and Exploration:

1. **Exploring Patterns**:
   - Once the kaleidoscopes are assembled, encourage students to look through their kaleidoscopes and turn the object chamber to observe the repeating patterns that appear.
   - Experiment with different objects inside the object chamber to see how the patterns change. Discuss why the patterns might look different based on the objects or the way they are arranged.
2. **Group Sharing**:
   - Ask students to share their kaleidoscopes with the class, explaining how they created their patterns and any design elements they added.
   - Ask them questions like:
     - "What do you notice about how the objects inside the kaleidoscope reflect?"
     - "How do the angles of the mirrors influence the patterns you see?"

Challenge Questions:

1. How does the reflection of light inside a kaleidoscope create the changing patterns?
2. What role do the mirrors, and the angle of reflection play in producing these symmetrical images?
3. How can you calculate the number of symmetrical patterns or sections in a kaleidoscope based on the angles of the mirrors?
4. What happens to the pattern if you change the angle between the mirrors?

Making Paper

Grade Level: 9-12
Subject Areas: Science, Art
Duration: 1.5 to 2 hours
Objectives:

- Understand the basic process of papermaking.
- Learn about the history and importance of paper in various cultures.
- Apply their knowledge to make recycled paper without the use of a traditional papermaking screen.
- Demonstrate creativity by adding natural fibers or other materials to enhance the texture of the paper.
- Discuss the environmental benefits of recycling paper and using sustainable materials in the papermaking process.

Materials:

- Old Paper (Newspaper, Scrap Paper, or Used Office Paper)
- Water
- A Large Bowl or Basin for Soaking Paper
- A Blender (to Create Pulp)
- A Kitchen Towel or Several Layers of Paper Towels
- Rolling Pin or Smooth Object for Flattening
- Food Coloring (Optional)
- Natural Fibers (Optional, e.g., Dried Flowers, Grass, or Leaves)
- Scissors
- A Clean Surface (Like a Plastic or Wax Paper Sheet) for Drying the Paper
- A Sponge (Optional for Squeezing Out Excess Water)
- Rubber Gloves (Optional for Handling Paper Pulp)

Introduction:

- Start with a brief discussion about the history and importance of paper by asking: "What is paper made from? Where do we use paper in our daily lives?", "Did you know that paper was originally made by hand in ancient China around 2,000 years ago?"
- Explain how traditional papermaking involved using natural fibers like wood, cotton, and bamboo to create pulp, and then forming sheets by pressing the pulp into shape.
- Explain to the students that today they will be recycling old paper to make new sheets of paper by hand, without the use of a screen. This will help them understand the papermaking process, its environmental benefits, and how they can use sustainable practices at home or in the classroom.

Instruction:

1. **Papermaking Process Overview**:
    - Step 1: Shredding and soaking paper.
        - Break down old paper into small pieces, which will be soaked in water to break down the fibers.
    - Step 2: Blending the paper into pulp.
        - Once the paper is soaked, use a blender to create a smooth, pulpy mixture.
    - Step 3: Forming the paper.
        - Without a screen, students will press and roll out the paper pulp on a flat surface, shaping it into a thin sheet.
    - Step 4: Drying the paper.
        - After forming the sheet, students will lay it on a clean surface to dry.
2. **Safety and Cleanliness**:
    - Remind students that they should use gloves if they prefer to avoid getting their hands wet or if they have sensitive skin.
    - Encourage them to keep their workspace clean, as paper pulp can be messy.

Activity:

1. **Preparation**:
    - Have students gather into small groups and distribute the necessary materials:
        - A few sheets of old paper for recycling.
        - Water.
        - A large bowl, blender, and towel.
2. **Step-by-Step Procedure**:
    - Step 1: Tear the Paper:
        - Students should tear their old paper into small pieces (about 2-inch squares). You can have them use newspaper, old office paper, or scrap paper for this step.
        - The torn paper will be placed in the large bowl and covered with water. Let the paper soak for about 10-15 minutes.
    - Step 2: Blend the Paper:
        - Once the paper is soaked and softened, transfer the paper into a blender with enough water to cover the paper. Blend the paper and water mixture until it forms a smooth pulp. This may take about 2-3 minutes, depending on the blender's power.
    - Step 3: Create the Paper Sheet:
        - After blending, the pulp should be a smooth, thick consistency. Students will spread the pulp evenly on a flat surface, such as plastic or wax

paper. Use a spoon or spatula to spread the pulp out into a thin layer, shaping it into a rectangular or circular form.
    - If students want to add texture or color to their paper, they can mix in natural fibers like dried flowers, grass, or leaves. They can also add food coloring to the pulp to create colorful paper.
  - Step 4: Flatten the Paper:
    - After spreading the pulp, students will use a rolling pin (or smooth object) to press out the excess water and flatten the pulp into a smooth, even sheet.
    - They can use a sponge to gently press out more water, which helps the paper dry faster.
  - Step 5: Dry the Paper:
    - Once the pulp has been flattened, students will carefully lift their paper and place it on a clean, dry surface (like a towel or wax paper). Allow the paper to dry completely, which may take a few hours to a day depending on the thickness of the sheet.
3. **Creative Element**:
  - If desired, students can add creative elements to their paper, such as textured materials (e.g., dried flowers, glitter, or leaves). Encourage them to think about how this paper could be used (for example, in a craft project or handmade card).

Challenge Questions:
1. How does the process of pulping fibers change their physical properties, and why is this important for the paper-making process?
2. What role does water play in separating and breaking down the fibers?
3. How did the transition from hand-made paper to industrial paper mills affect the economy and society?
4. What innovations were made to improve the efficiency of paper production?

Color Changing Cabbage

Grade Level: 9-12
Subject Areas: Science
Duration: 1.5 to 2 hours
Objectives:

- Understand the concept of pH and how pH affects the color of certain substances.
- Learn how anthocyanins (a pigment found in cabbage) can be used as a pH indicator.
- Conduct an experiment to test the pH of different substances using cabbage juice.
- Explain the acid-base reactions that cause color changes in cabbage juice.
- Apply their knowledge of pH indicators to real-world scenarios, such as testing household substances.

Materials:

- 1 Small Head of Red Cabbage (or Several Leaves from a Red Cabbage)
- Blender or Food Processor
- Strainer or Cheesecloth
- Clear Plastic Cups or Beakers (at least 6-8)
- Different Household Substances to Test (e.g., Vinegar, Baking Soda Solution, Lemon Juice, Soap, Soda, Water, Etc.)
- Water
- Stirring Sticks or Spoons
- Droppers or Pipettes
- pH Scale Chart (Optional, for Reference)
- Safety Goggles (Recommended)
- Apron
- Gloves (Optional)

Introduction:

- Ask students: "What do you know about acids and bases?", "Can you name any substances that are acidic or basic?"
- Introduce the concept of pH: pH is a scale used to measure how acidic or basic a substance is, ranging from 0 (very acidic) to 14 (very basic), with 7 being neutral (like water).
- Explain the role of pH indicators: pH indicators are substances that change color depending on the pH of the solution they are in.
- Introduce anthocyanins, the pigments found in red cabbage, which can change color in response to different pH levels (acidic or basic environments).
- Tell students that today, they will extract the juice from red cabbage and use it as a natural pH indicator to test the acidity or basicity of various household substances.

- Explain that this experiment will demonstrate how acids and bases affect the color of the cabbage juice.

Instruction:

1. **How Red Cabbage Changes Color**:
    - Explain the chemistry behind the color change in cabbage juice.
    - Acidic solutions (e.g., vinegar, lemon juice) will turn the cabbage juice red or pink.
    - Neutral solutions (e.g., water) will keep the cabbage juice purple.
    - Basic solutions (e.g., baking soda, soap) will turn the cabbage juice green or yellow.
    - Show a pH scale and discuss how different pH values correlate with different colors in the cabbage juice.

2. **How to Make Cabbage Juice**:
    - Step-by-step instructions on how to make cabbage juice:
        1. Chop up the cabbage into small pieces.
        2. Blend the cabbage with water until it forms a puree.
        3. Strain the puree through a fine mesh strainer or cheesecloth to extract the juice.
        4. The juice should appear purple, which is the natural color of the anthocyanin pigment in the cabbage.
3. **Safety Precautions**:
    - While the experiment is relatively safe, remind students to wear safety goggles and an apron when handling liquids to avoid accidental splashes and stains.
    - Encourage careful handling of substances, especially if using vinegar or baking soda solutions.

Activity:

1. **Preparation**:
    - Give each student group the following:
        - A small container of cabbage juice (prepared in advance).
        - Several small cups or beakers filled with different test solutions (e.g., vinegar, lemon juice, water, baking soda solution, soap, soda, etc.).
        - Stir sticks or spoons for mixing.
        - Droppers or pipettes to add cabbage juice to each solution.

2. **Conducting the Experiment**:
    - Students will use droppers to add cabbage juice to each of the test substances. They should observe and record the color change.
    - For each test, students should record:

- The name of the substance being tested.
- The color change observed after adding cabbage juice.
- The pH category (acidic, neutral, or basic) of the substance based on the color change.

3. **Test a Variety of Substances**:
    - Allow students to test a variety of substances. Some possible options include:
        - Vinegar (acidic)
        - Baking soda solution (basic)
        - Lemon juice (acidic)
        - Water (neutral)
        - Soda (acidic or slightly basic)
        - Soap solution (basic)
        - Milk (neutral)
4. **Observations and Data Recording**:
    - As students perform the tests, encourage them to carefully observe the colors that develop.
    - Ask them to record the color changes in their data tables and correlate these with their knowledge of the pH scale.

Challenge Questions:

1. Why does cabbage juice turn red when it reacts with an acidic substance, and green when it reacts with a basic substance?
2. Can you think of other natural substances that might be used as pH indicators?
3. How would you explain the color change of cabbage juice in terms of molecular chemistry?
4. How might you modify this experiment to test the pH of substances that are not commonly found in household products?

Designing a Dream House

Grade Level: 8-12
Subject Areas: Math, Art, Engineering
Duration: 1.5 - 2 hours
Objective:

- Understand the application of geometry concepts such as area, perimeter, volume, and angles in real-world scenarios, specifically in architecture.
- Design a floor plan of a house using geometric principles.
- Create a 3D model of their house using geometric shapes and measurements.
- Calculate the area and perimeter of different rooms and the total volume of their house.
- Work collaboratively to solve problems related to space, structure, and measurements.

Materials:

- Graph Paper (or Design Software Such as SketchUp)
- Rulers and Compasses
- Pencils, Erasers, and Colored Pencils or Markers
- Scissors and Glue (for 3D models)
- Cardboard or Foam Board (optional For Building 3D Models)
- Protractors (Optional, for Measuring Angles)
- Calculators (Optional, for Quick Calculations)

Introduction;

- Begin by discussing how geometry is fundamental in architecture and engineering.
- Explain that architects use geometric principles to create designs for buildings, ensuring they are functional and aesthetically pleasing.
- Introduce the concepts of area, perimeter, volume, and angles as they apply to real-life architecture, such as floor plans, walls, and windows.
- Show some examples of famous buildings (e.g., the Eiffel Tower, Sydney Opera House, or Frank Lloyd Wright's designs) and explain how geometry played a role in their construction.
- Discuss how understanding space, dimensions, and measurements are essential for both aesthetic and structural integrity.

Activity:
Step 1: Brainstorm and Plan

1. Group Discussion:
    - Divide the class into small groups (2-4 students).
    - Have students brainstorm what type of house they would like to design, considering the following questions:

- How many rooms will the house have?
- What shapes will the rooms be? (Rectangular, square, circular?)
- How will they organize spaces (e.g., living areas, bedrooms, bathrooms)?
- What architectural features will they include (e.g., windows, doors, stairs)?

2. Design Elements:
    - Each student should sketch an outline of their house on graph paper, focusing on:
        - The floor plan of the house (rooms, doors, windows).
        - Using geometric shapes (rectangles, squares, triangles) for different rooms.
        - Determining the dimensions of each room (length and width) and calculating the area of each room.
3. Instructional Tip:
    - Remind students that the scale they use on the graph paper should be consistent. For example, each square on the graph paper could represent 1 square meter, 1 foot, or another unit of measurement.

Step 2: Create the Floor Plan

1. Designing the Floor Plan:
    - Using graph paper, students will draw the layout of their house with their chosen dimensions for each room.
    - Students should label rooms (e.g., Kitchen, Living Room, Bedroom) and include dimensions (length and width).
    - As students work, encourage them to think about the functionality of the space. For example, if they are creating a living room, consider the size needed for furniture and movement.
    - Students should also calculate the area of each room (Area = length × width) and label it on the plan.
2. Perimeter and Volume:
    - Once the floor plan is complete, ask students to calculate the perimeter of their house (Perimeter = sum of all the sides of the house).
    - For rooms with different heights (like a two-story house), students will need to calculate volume (Volume = length × width × height). Provide different dimensions for height (e.g., 8 feet for standard rooms or 12 feet for a taller living room).

Step 3: Create the 3D Model

1. Building the 3D Model:
    - After completing the floor plan, students will move on to creating a 3D model of their house.
    - Using materials like cardboard or foam board (optional), students will build basic geometric shapes to represent the walls, floors, and roof of the house.
    - If using graph paper, students can draw perspective views of the house's 3D structure.
    - Emphasize using geometric principles for the 3D shapes:
        - Rectangles and squares for walls and floor plans.
        - Triangular prisms for roofs.
2. Reflection on Design:
    - Ask students to reflect on the process: How did they apply their knowledge of geometry to solve design challenges? Did they need to adjust their original plan to make the house functional?

Challenge Questions:

1. How can the use of different geometric shapes (triangles, squares, circles) impact the structural integrity and aesthetic appeal of your dream house design?
2. What role does symmetry play in achieving balance and harmony in architecture?
3. How do the angles in your architectural design (e.g., roof slopes, window placements) influence both the aesthetics and the stability of your house?
4. How do you use geometry to ensure that these angles are both visually appealing and structurally sound?

Jellybean Stop Motion Video

Grade Level: 9-12
Subject Areas: Art, Technology
Duration: 2 hours
Objectives:

- Understand the principles of stop-motion animation and how it creates the illusion of movement.
- Create a stop-motion video using jellybeans as characters or props.
- Demonstrate creativity and storytelling through their animation project.
- Work collaboratively in small groups to plan and execute a short animation.
- Gain hands-on experience using basic video editing tools to produce a final video.

Materials:

- Jellybeans (or Other Small Objects to Animate)
- Camera or Smartphone (With Camera Capabilities)
- Tripod or Stand to Stabilize the Camera (Optional but Recommended)
- Computer with Video Editing Software (e.g., iMovie, Windows Movie Maker, or Free Online Tools)
- Animation Software or Apps (Optional: Stop Motion Studio App, or Other Stop-Motion Apps)
- Paper and Markers for Drawing Backgrounds or Creating Scenes
- Small Props (e.g., Additional Items Like Paper, Pencils, Fabric, or Small Toys for the Background or Interactions)
- Ruler or Measuring Tape (Optional, for Precise Placement)
- A Flat, Stable Surface (Like a Desk or Table) for Animation Setup

Introduction:

- Begin by discussing stop-motion animation and asking: "Have you ever seen a stop-motion movie, like Wallace & Gromit, Nightmare Before Christmas or Chicken Run?"
- Explain how stop-motion works: taking a series of individual photos of objects in slightly different positions and stringing them together to create the illusion of movement.
- Show an example of a stop-motion video or briefly explain the history of stop-motion animation (e.g., famous early stop-motion films like Gumby or The Nightmare Before Christmas).
- Explain the basic steps: Planning (decide on the story or action you want to animate), Setting up the Scene (arrange jellybeans and props in the starting positions), Photography (take multiple photos of the jellybeans in small movements), Editing (combine the photos into a video to create the illusion of movement).

Activity:

1. **Brainstorm and Plan**
    - Divide students into small groups (3-4 students per group).
    - Each group should brainstorm a simple story or action to animate. Possible ideas include:
        - A jellybean walking across a table.
        - Jellybeans dancing or interacting.
        - Jellybeans forming a shape or object.
        - Jellybeans having a conversation (though only the "actions" will be shown).
    - Tips for planning:
        - Keep the story short and simple.
        - Focus on smooth, gradual movements so that the animation looks fluid.
        - Plan any props, backgrounds, or additional items needed for the scene.
    - Have students sketch or write a basic storyboard to outline their sequence of movements. This helps them visualize how the jellybeans will move and what the end result will look like.
2. **Set Up the Scene**
    - Students should arrange their background (can be drawn on paper or use simple props).
    - Place the jellybeans in starting positions.
    - Tip: The key to successful stop-motion animation is to keep everything in the same spot as much as possible. Use a tripod or steady surface to keep the camera fixed in place throughout the shoot.
    - Discuss the importance of lighting: Ensure that the scene is well-lit, and the light remains consistent throughout the animation process.
3. **Capture the Animation**
    - Students will now take a series of photos. Each photo should feature the jellybeans in a slightly different position from the last photo.
        - Tip: For smooth animation, move the jellybeans very small amounts between each shot. This will result in smoother, more fluid movement.
    - Students should aim for at least 15-30 photos for a 5-10 second animation. More photos will create smoother movement.
    - Encourage them to experiment with the positions of the jellybeans and props to see how different actions create different effects.
    - Remind students to keep the camera still for consistency.
4. **Edit the Animation**

- Once all the photos are taken, students can move to the editing stage.
    - Using video editing software (i.e., iMovie, Windows Movie Maker, or Stop Motion Studio app), students can import the photos and arrange them in sequence.
    - Students will need to set the timing between frames (usually 0.1 to 0.2 seconds per photo) to control the speed of the animation.
- Add any final touches:
    - Music or sound effects (optional).
    - Text or credits (optional).

Discussion and Sharing

1. **Class Presentation**:
    - Have each group present their stop-motion video to the class.
    - After each video, ask students to discuss the following:
        - What was the story or action in the video?
        - How did the animation come out? Was the movement smooth or jerky?
        - What challenges did they encounter during the project?
        - How did they solve those challenges?
2. **Reflection**:
    - Ask students to reflect on the following questions:
        - "How does stop-motion animation compare to traditional animation or computer-generated imagery (CGI)?"
        - "What was the most difficult part of creating a stop-motion animation?"
        - "How can you improve the fluidity and realism of stop-motion animations?"

Challenge Questions:

1. How can the positioning and movement of jellybeans in your stop-motion animation affect the illusion of fluid motion?
2. How does frame rate affect the pacing and smoothness of your final video?
3. How can you use the shapes, colors, and arrangements of jellybeans to convey a story or emotion in your video?
4. How do visual details like background and lighting influence the mood of your animation?