SOLIDWORKS

DESIGN PROJECTS

TEACHER GUIDE

3DEXPERIENCE



KINETIC SCULPTURE

DASSAULT SYSTEMES

INTRODUCTION/GENERAL GUIDELINES

Welcome to the Design Projects Teacher Guide for kinetic sculptures. This activity presents a wide range of possibilities for the instructor. The individual components are simple enough for beginners to learn the basics of designing with CAD and the result is a model that can be used to explore aspects of motion design & planning. This project is suitable for individuals and teams to eventually design and build their own kinetic sculptures.

It is recommended that you have a completed model to pass around the class during the Presentation. As an instructor, you have several resources at your disposal:

1. **Overview PDF**
    - The initial document that introduces the project providing a brief overview.
2. **Teacher Guide**
    - This document contains information that corresponds to the sections of the Presentation PowerPoint (see below). Each section discussed in this guide provides further details on how you can use the PowerPoint.
    - Also included are additional ideas you may want to use to enhance the activity in the classroom or adjust it for different skill levels.
3. **Student Guide**
    - This document is intended for students and provides basic guidelines for the activity such as deliverables, tips for creating the individual components and 3D printing guidelines.
4. **Presentation PowerPoint**
    - The PowerPoint is used to introduce the project to the class.
    - Feel free to customize any part of the presentation such as history, design concepts or any STEM related materials.
5. **Video**
    - The video is located on YouTube, and is intended to provide an overall approach to how the model could be created in CAD.
    - You may want to watch it together with the students in class.
    - LINK TO YOUTUBE VIDEO
6. **Step-by-Step Course**
    - This is where every step of the design process is demonstrated with short easy to follow procedures and video clips as well as overall videos showing the entire process.
    - LINK TO STEP-BY-STEP

BACKGROUND

This section is intended to provide students with an introduction to kinetic sculptures. This particular design takes uses a simple scotch & yoke mechanism with a linkage to create the flapping motion. There are other types of mechanisms that convert rotational motion to linear motion. You may want to look these up online and have further discussions regarding them.

It is important to understand the different parts of this mechanism. Basic sculpture construction terminology is highlighted using the project itself to make the connection to the design project.

Also included in this section is a slide for the discussion of key design terms.

- **Design Intent** – It is always best to have a clear definition of how a product should look, function and feel to the user. This is referred to as form, fit and function. Spend some time discussing this vital step in the process of designing a solution to a problem.

- **Additive Manufacturing** – This refers to the process of creating a 3D object by adding material layer by layer. 3D printing is a specific form of additive manufacturing.

- **DFM/DFAM (Design for Manufacturing, Design for Additive Manufacturing**) - In addition to Design Intent, the concepts of DFM/DFAM are equally important. When designing anything, the question, "How will this be made?", should be considered. This particular project is designed to be 3D printed. As such, it is important that students understand the capabilities of the machine you have available.

- **Nesting -** In manufacturing, nesting refers to laying out cutting patterns on raw material to minimizing waste during manufacturing processes, such as laser cutting. In 3D printing, it is the process of laying out parts to fit on the bed of the 3D printer to print several components at one time. It is important to discuss how parts should be prepared for manufacture, specifically 3D printing.

COMPONENT DESIGN

This section contains slides for each of the components. The purpose of this section is to discuss how Design Intent and DFAM is to be applied to each part.

For detailed dimensions and step by step instructions for the parts, refer to the STEP-BY-STEP, in the **ADDITIONAL RESOURCES** section below.

3D PRINTING

This section provides an opportunity to discuss the specific ways the individual components will be oriented and prepared for 3D printing on whatever machines are available to the students in the classroom.

Each component in this project is designed to be a perfect fit, but most printers are not completely accurate. It is recommended that teachers print test components and determine the proper tolerances and relay that information to students before they start designing.

It is recommended that you develop classroom procedures for using machines and a method for keeping account of materials used. One thing you may want to do is have the students calculate the cost of each project. The way the components are designed and oriented on the 3D printer will have an impact on this. This can also be an opportunity to discuss sustainability, being mindful of the environmental impact we have when designing and making things.

CLASS DISCUSSION

Included in this section are a couple questions to get the conversation started. The intent here is for you to tailor the discussion to suit your specific course goals and students needs. Some ideas may include:

- What types of linkages could be used to turn the spinning motion into different movements?
- How does friction in the moving parts affect the overall efficiency and smoothness of the sculptures motion?
- What are some other ideas for a hand-cranked kinetic sculpture? (e.g., walking animals, flapping birds, blooming flowers, bouncing figures, jumping frogs, swimming fish, orbiting planets)
- How might material choices or part tolerances impact the performance of a hand-powered mechanism?

PROJECT TASKS (ASSESSMENT CRITERIA)

Depending on the goals of the class, at a minimum students should be able to accomplish the following tasks.

1. Create the following sculpture components in CAD:
    - Butterfly Wings
    - Head and Tail
    - Flower
    - Stem
    - Cam
    - Link and Yoke
    - Pin and Stopper
    - Axle
    - Crank
2. Create a working, moving assembly of the sculpture in CAD.
3. Print the physical components on a 3D printer.
4. Assemble the sculpture.

Some other possibilities for assessment may be in the following categories:

- **SUSTAINABILITY** – How much waste is generated in the manufacturing process?
- **ASSEMBLY** – With no adhesives or fasteners, does the model hold together on its own?
- **MANUFACTURABILITY** – Do the components fit within the parameters of the 3D printer?
- **PERFORMANCE** – How well does it showcase motion considering factors like smoothness, consistency, and responsiveness to wind?

ADDITIONAL RESOURCES

LINK TO DOCUMENTS

LINK YOUTUBE

LINK TO STEP-BY-STEP

The following sections do not correspond to the PowerPoint, and are included here for added benefit.

ADVANCED OPTIONS

For more experienced students, you can challenge them with more advanced concepts and tasks that encourage creativity, engineering principles, and real-world application. Below are some ideas that could be suitable for this level:

Advanced Mechanism Designs

- **Complex Linkage Systems:** Challenge students to incorporate cams, followers, or multi-link mechanisms to create more intricate motions, such as opening petals, or moving parts that interact in sequence.
- **Gear Integration:** Have students design gear systems to adjust the speed or direction of motion transferred from the crank input to different parts of the sculpture.

Simulation and Performance Analysis

- **Motion Simulations:** Students can use CAD simulation tools to analyze how different, linkage lengths, or gear ratios affect movement efficiency and speed.
- **Performance Testing:** Encourage students to build prototypes, test them through manual cranking, and collect data on parameters such as rotation speed, stability, and smoothness of motion for comparison and optimization

Team-based Design Projects

- **Team-based Design Projects:** Assign students to teams where each member focuses on a different aspect of the sculpture, such as motion kinematics, artistic design, mechanism efficiency, or structural integrity
- **Interdisciplinary Enhancements**: Combine mechanical design with electronics by challenging students to add LED lighting, sound elements triggered by movement, or add a motor with adjustable speed to replace manual cranking. This opens opportunities to integrate basic circuitry or Arduino programming for interactive designs.

By including these advanced design elements, students will be pushed to develop critical thinking skills and a deeper understanding of engineering concepts.

EDUCATIONAL CONCEPTS

A kinetic sculpture design and construction project is an excellent way to integrate multiple STEM concepts. Here are some potential teaching approaches:

SCIENCE

- Examine kinematics by analyzing position, velocity, and acceleration of moving parts over time.
- Investigate torque, friction, and rotational dynamics and how they impact motion.

TECHNOLOGY

- Teach students to use 3D modeling software to design components with both artistic and mechanical functions.
- Demonstrate how 3D printers work, from slicing software to the actual printing process.
- Discuss additive manufacturing principles and how they differ from traditional methods.
- Emphasize the importance of DFAM, Designing for Additive Manufacturing, by minimizing waste through smart design.

ENGINEERING

- Explore how cams, gears, and linkages translate crank input into controlled mechanical motion.
- Challenge students to incorporate different types of movement using a variety of mechanisms.
- Introduce collision detection and failure analysis to identify and resolve weak points in assemblies.
- Encourage iterative design and creative problem-solving to improve motion efficiency and alignment.

MATHEMATICS

- Apply geometric principles in designing effective linkages and motion paths.
- Calculate angles, lengths, and proportions for accurate CAD modeling and proper assembly fit.
- Analyze rotational speed, distances, and motion output to compare design performance.