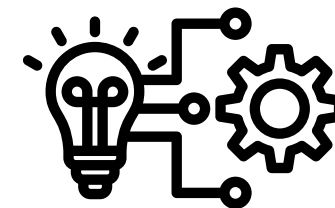


ENGINEERING DESIGN PROCESS:

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ACROSS THE CURRICULUM

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# CONTENT BY:

Billie Carlton

Nicole Dainty

Cherrie Lemon

Sophia Sprunger

Mary Vandergraff

Purdue University

EDCI 52004



“

“WE ARE CONTINUALLY FACED BY GREAT  
OPPORTUNITIES BRILLIANTLY DISGUISED AS  
INSOLUBLE PROBLEMS.”

*Lee Iacocca, American engineer and automobile executive*



# ENGINEERING DESIGN CHALLENGE



# DESIGN CONTEXT: OUTDOOR TEACHER SPACE

*Your school has an outdoor picnic area where teachers can eat in peace, or go to grade papers at their plan time.*

*But, rainy days make this space less usable!*





*Your objective: Design and build a cantilever.*

*Cantilever: A structure that is only anchored at one end and extends outward.*





Think-Pair-Share

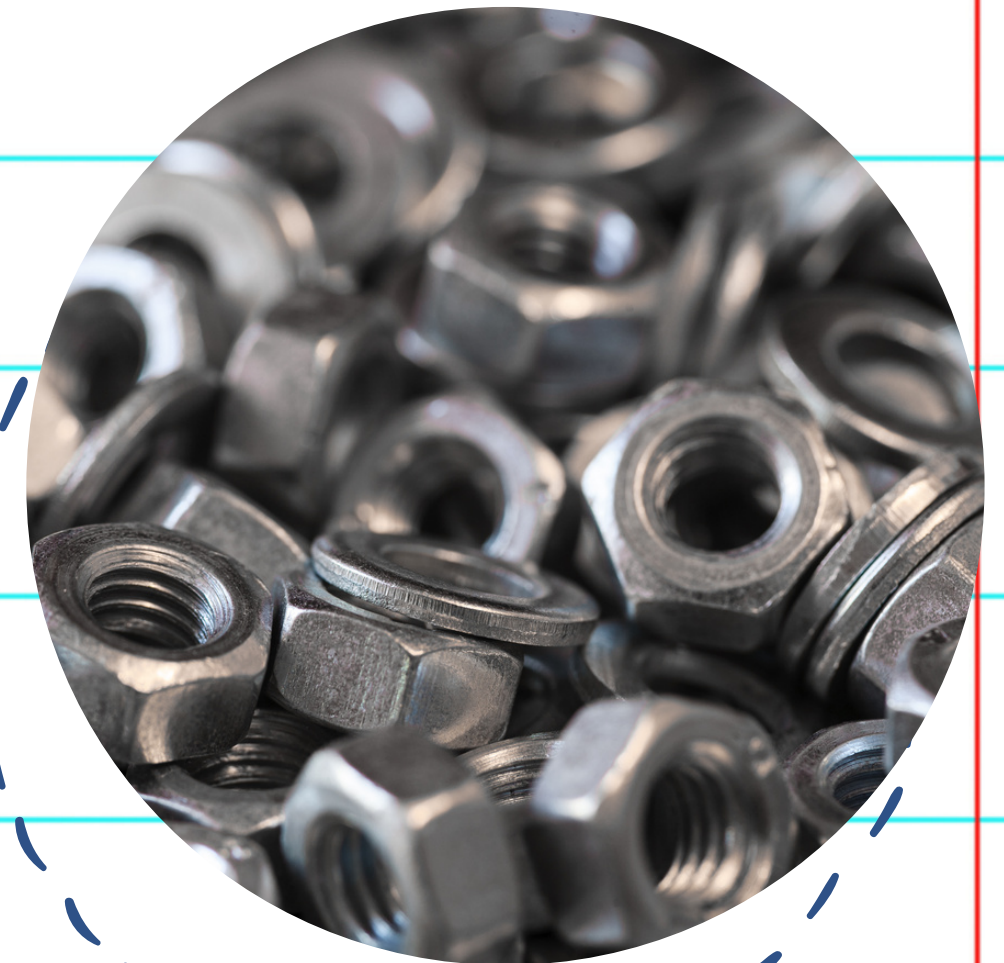
What questions would you ask to get the info you need to start on your design process?

*Your objective: Design and build a cantilever.*

*Cantilever: A structure that is only anchored at one end and extends outward.*

# KNOWN PARAMETERS

- System will be modeled with popsicle sticks and hex nuts.





Load



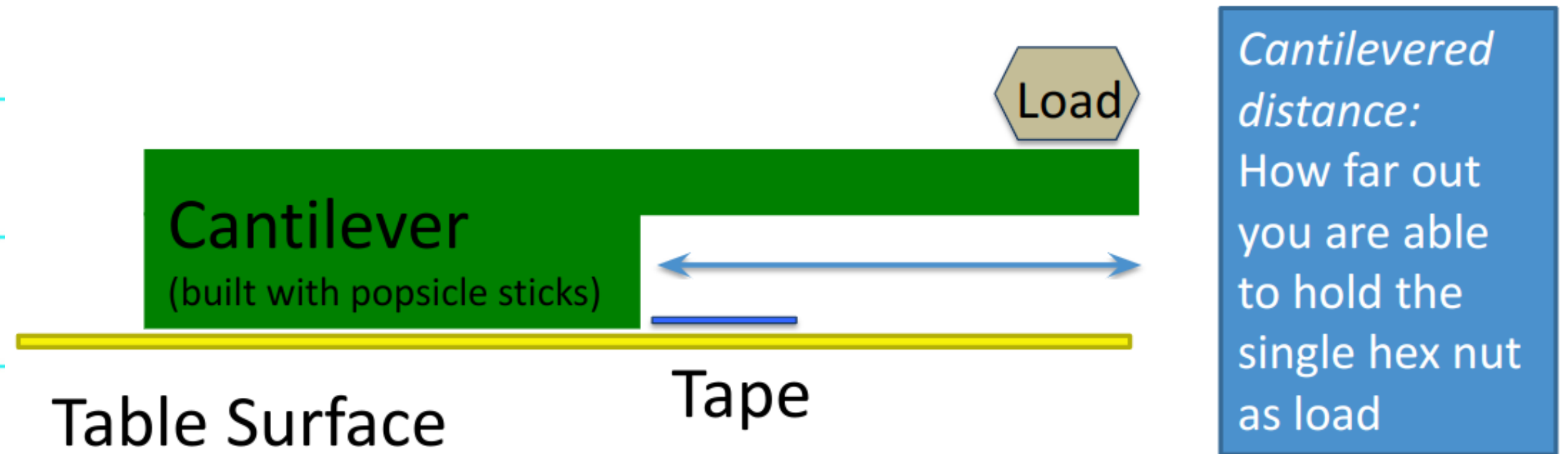
Cantilever  
(built with popsicle sticks)

Table Surface

Tape

# KNOWN PARAMETERS

- Initial design requirement: maximize the cantilevered distance for one hex nut as load





# KNOWN PARAMETERS

- *Time constraint will be imposed.*
- *Each popsicle stick and counterweight has a cost.*

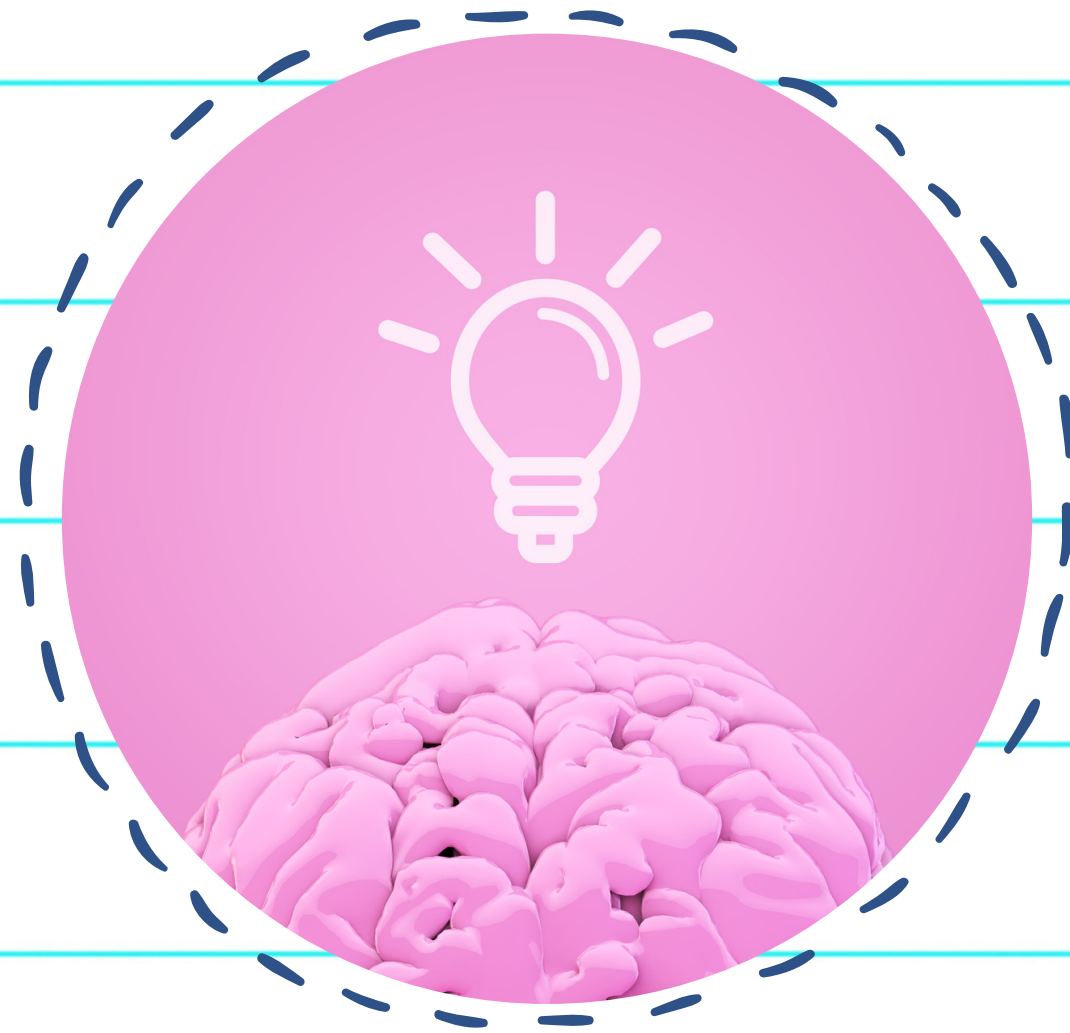


Hex nuts on the “base structure” side of the tape can be used as counterweights.



Table Surface

Tape



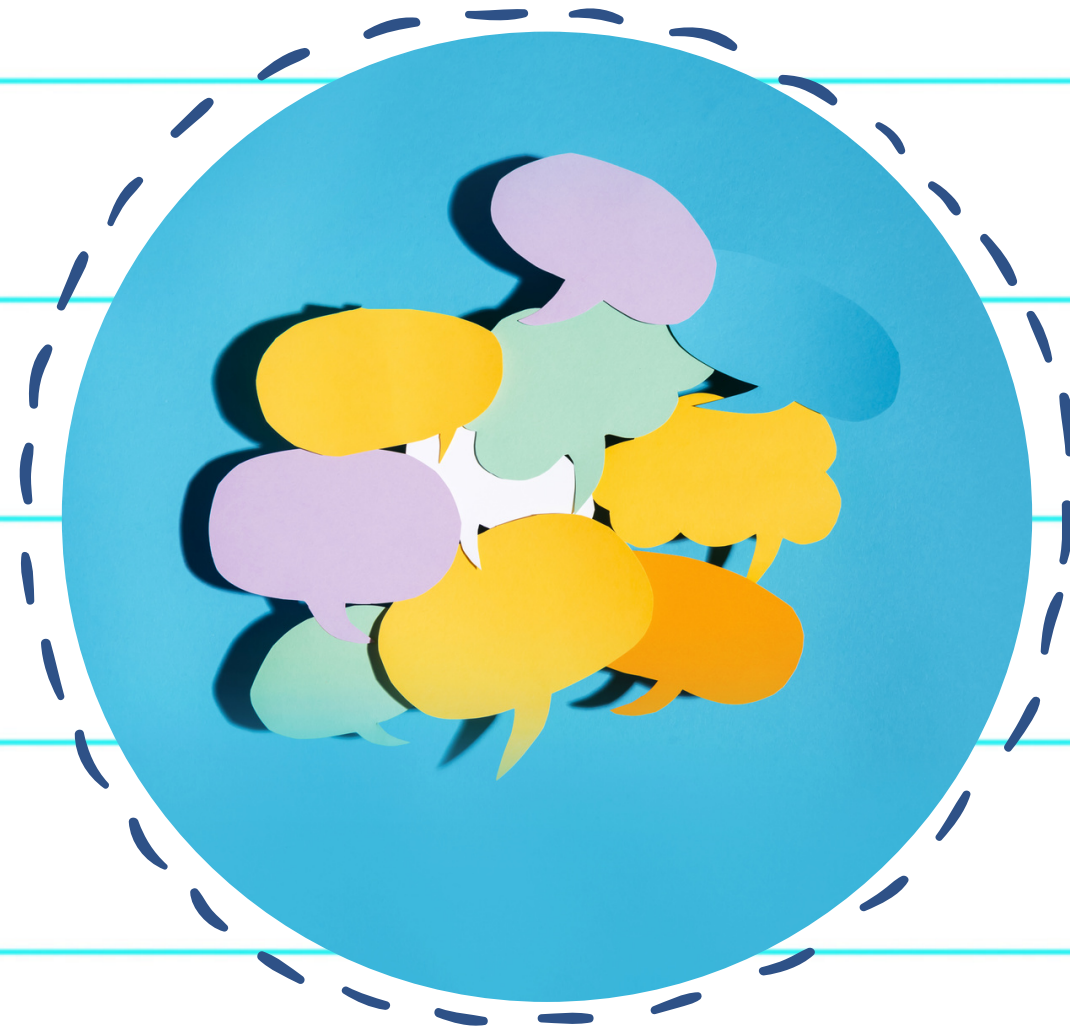
# TIME TO BRAINSTORM!

*Take a few minutes to sketch a few ideas.*

*One per post-it note.*

*Don't discuss with table yet!*



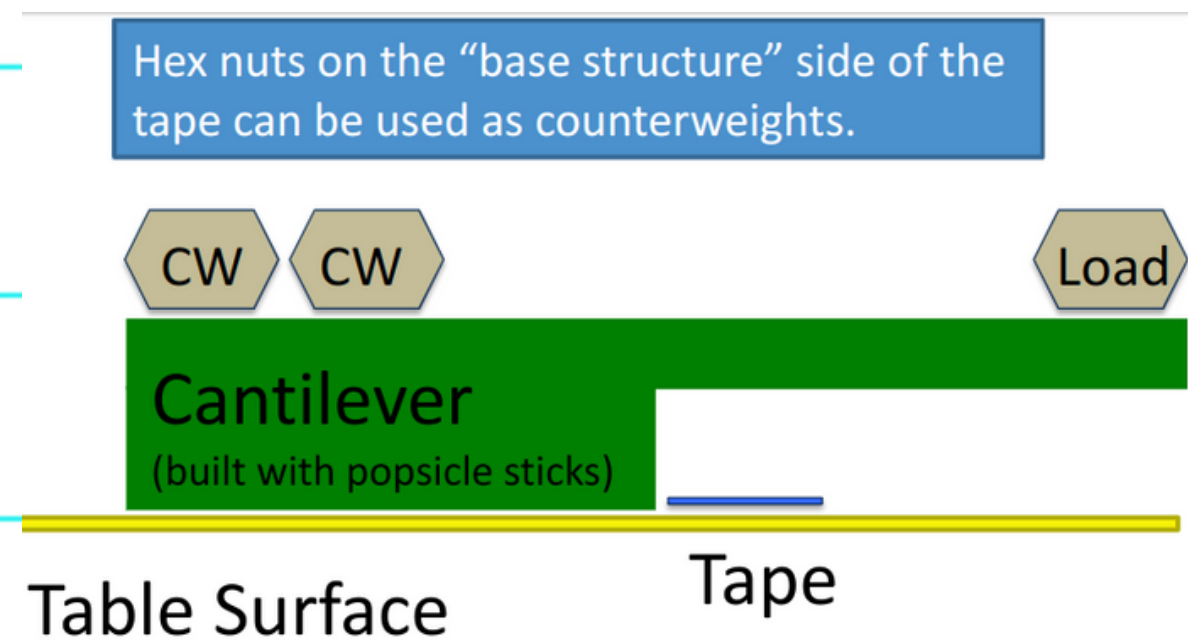


# DISCUSS YOUR IDEAS

*Share ideas with your team at your table.*

*Work together to come up with a plan.*

# BUILD YOUR PROTOTYPE



- Build your picnic cover cantilever to support a one hex nut load above the table surface at a distance beyond the tape line.
- Each team will start with 45 popsicle sticks and 15 hex nuts as materials.
- You can request additional materials.
- You will have \_\_\_\_\_ minutes to build.
- Next we'll take measurements and record data.



# ANALYSIS

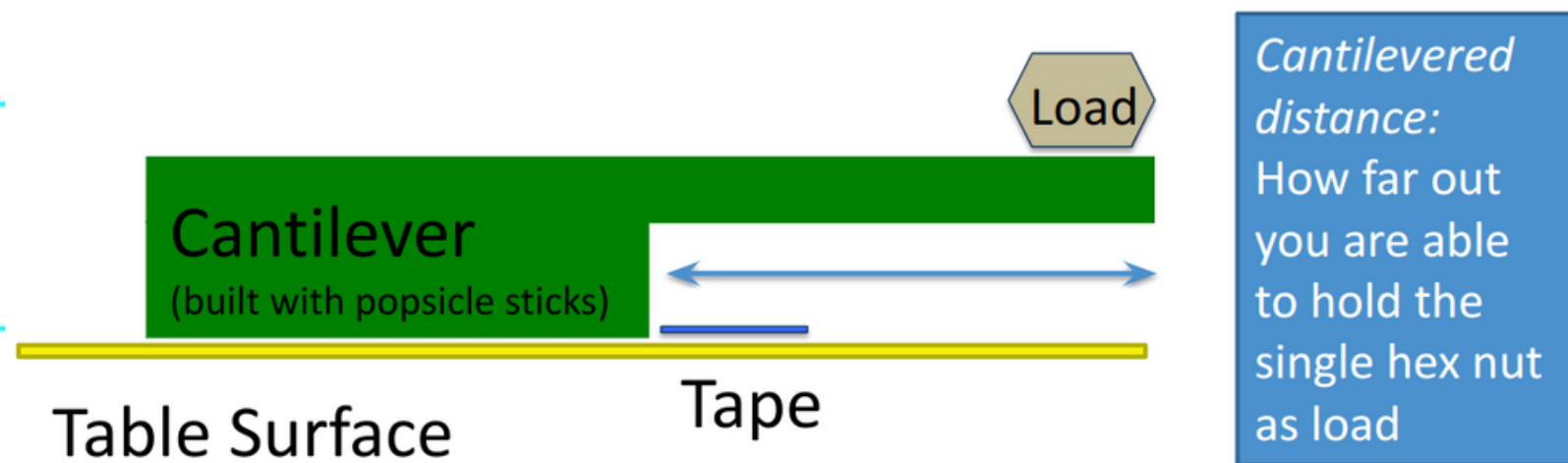
Record on the half sheet of paper:

Number of large popsicle sticks

Number of small popsicle sticks

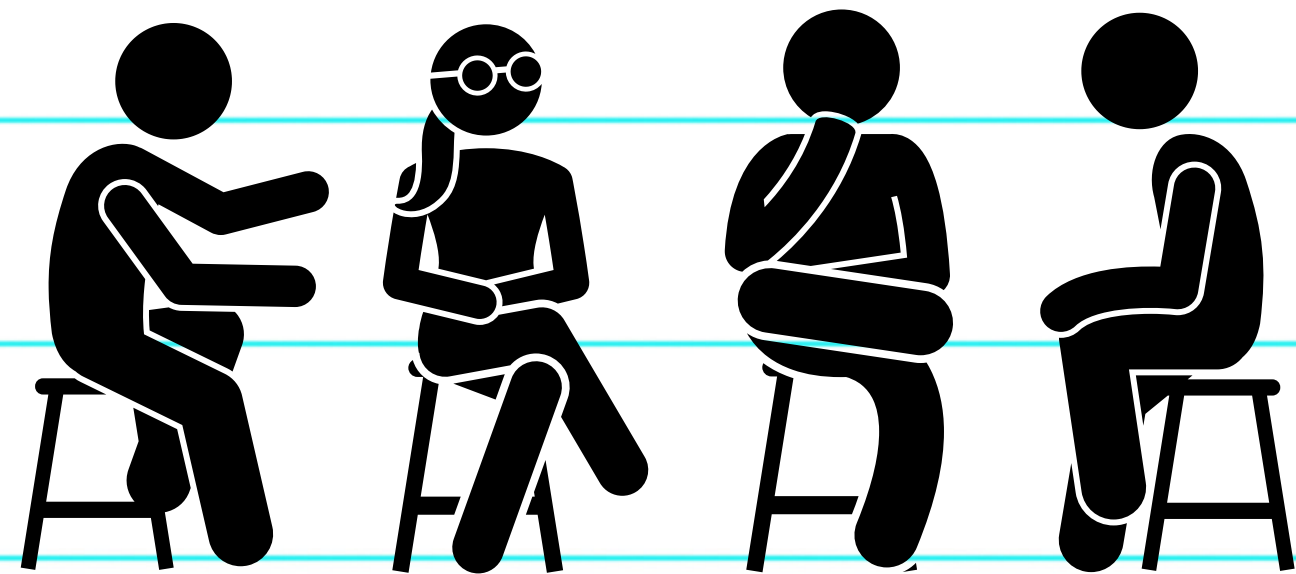
Number of hex nuts used as counterweights

Cantilevered distance (cm)



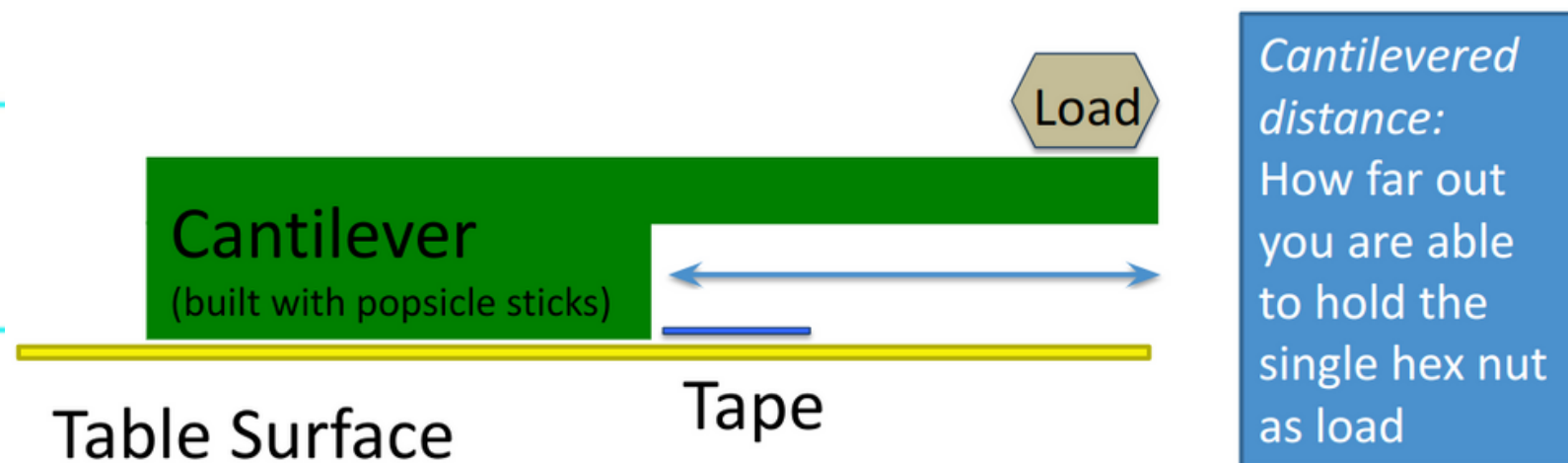


# REFLECT



- What would you do to improve your cantilevered distance?  
(Could your design hold one hex nut further out?)
- What would you do to improve your design to hold more cantilevered hex nuts?

# BUILD: PART 2



- Build a cantilever to support a load consisting of as many hex nuts as possible above the table surface at a distance beyond the tape line.

- You can request more materials.

- You will have \_\_\_\_\_ minutes to build, and then we'll take measurements and record data.



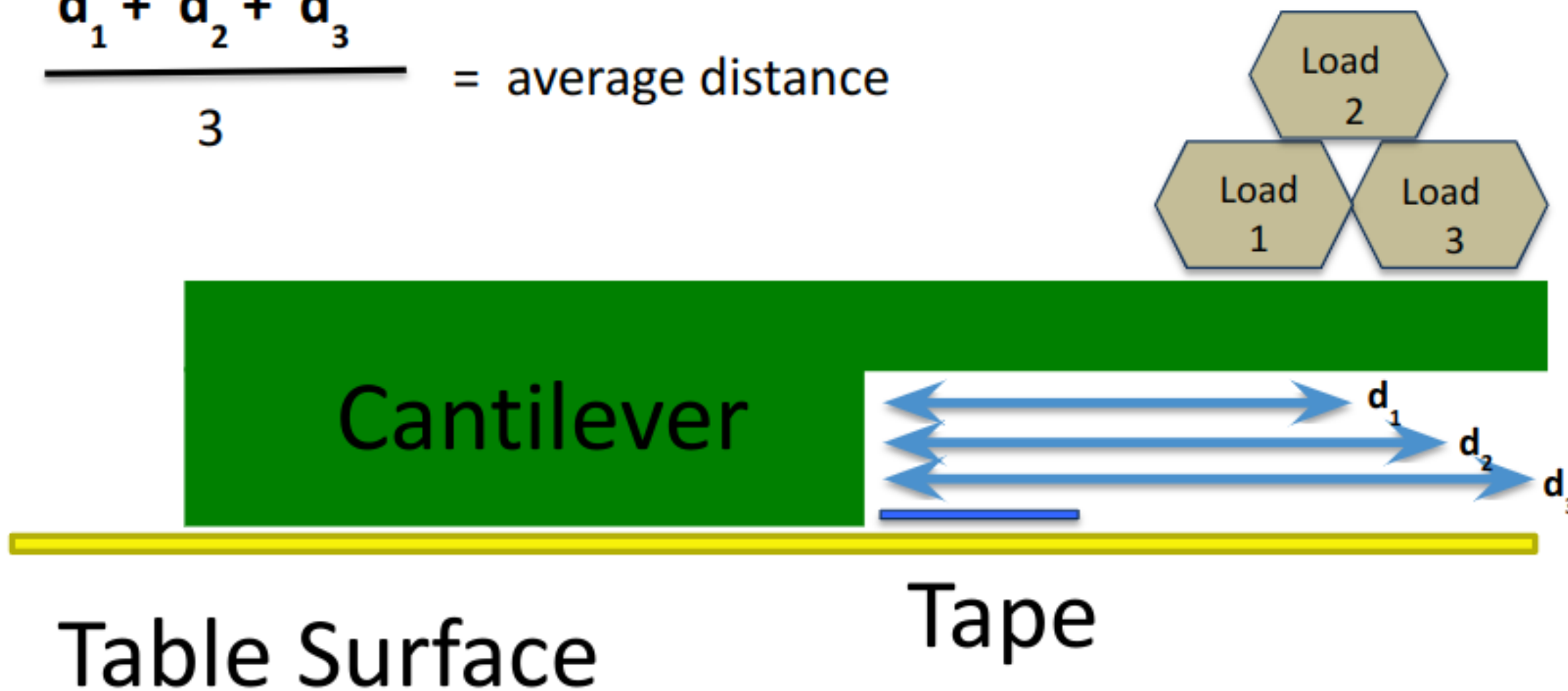
## ANALYSIS: PART 2

Record on the data sheet:

- Number of large popsicle sticks
- Number of small popsicle sticks
- Number of hex nuts used as counterweights
- Number of hex nuts counted as load
- Average cantilevered distance (cm)

# ANALYSIS: PART 2

$$\frac{d_1 + d_2 + d_3}{3} = \text{average distance}$$



Measure from back of tape to furthest edge each load, then average these numbers.

This is the *average cantilevered distance*.



# DISCUSSION

What were the major steps we progressed through, starting with us introducing the design challenge and ending with our celebratory applause? Jot your thoughts in a numbered or bulleted list.







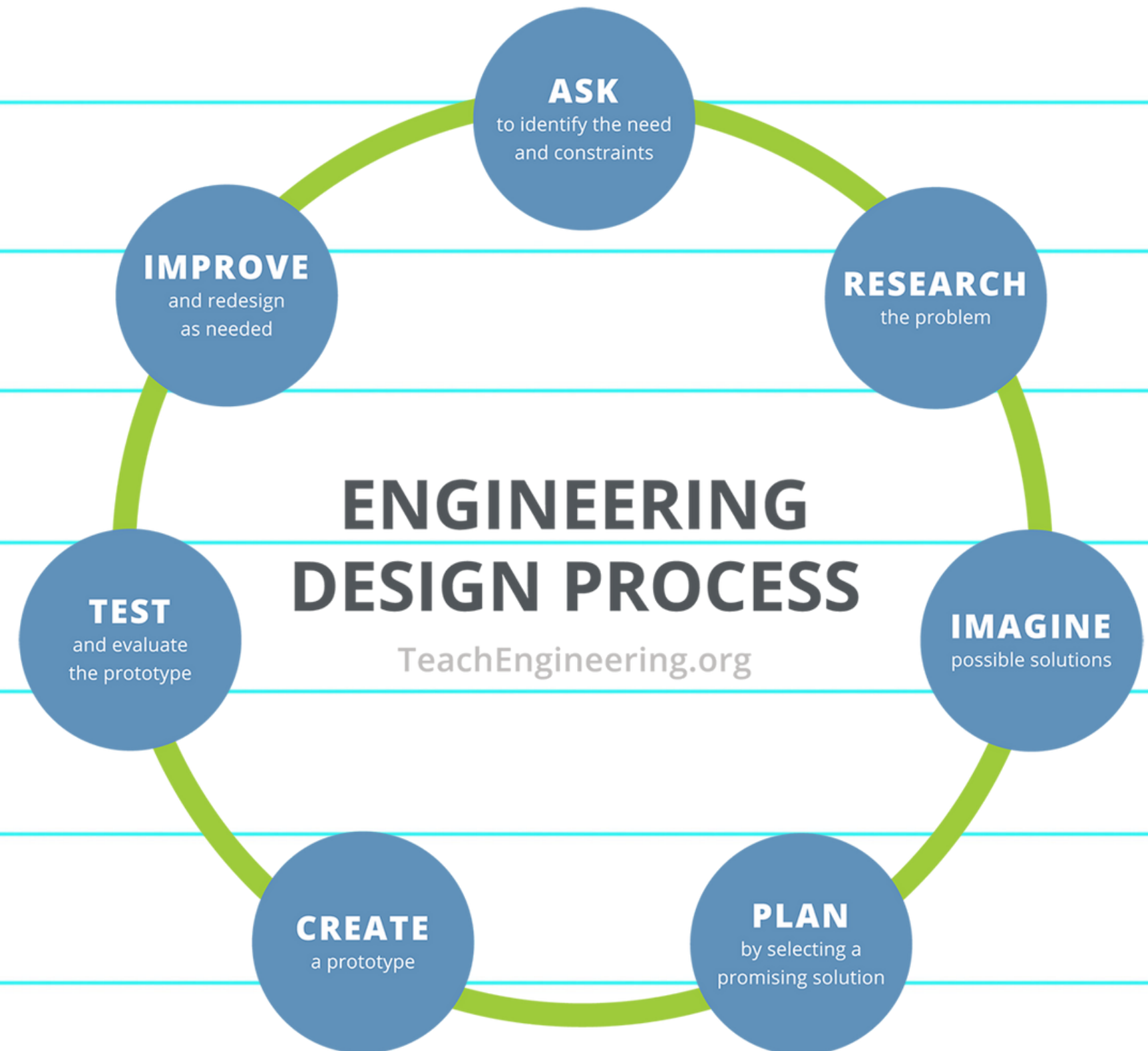
# WHAT IS THE ENGINEERING DESIGN PROCESS?

*EDP Overview*



# ENGINEERING DESIGN PROCESS

The engineering design process (EDP) is a series of steps followed to create/ find a solution to a problem. The EDP is iterative in nature, requiring the engineer to go back and make adjustments to their solutions to best solve the problem. There are seven steps to the EDP, beginning with "ask" and ending with "improve." The EDP requires the engineer to keep asking why (why do we do it that way), until all options have been exhausted.



# WHY IS EDP IMPORTANT TO INCLUDE IN OUR INSTRUCTIONAL STRATEGIES?



## *Research on EDP*

*EDP teaches us how to recognize a real world problem or need and come up with multiple solutions. (Songer, N. 2023).*

*EDP promotes resilience as students learn from their failures and continue to revise their products. (teachengineering.org, n.d)*

*EDP gives students the opportunity to apply real life STEM skills to their learning. (Gabel, 2021)*

*EDP promotes creativity and divergent thinking. (Howard et al., 2008)*



# ENGINEERING DESIGN: NOT JUST FOR STEM

*EDP Across the Curriculum*



LANGUAGE

ARTS



SOCIAL

STUDIES



ARTS



SPECIAL

EDUCATION



“

“THE IDEAL ENGINEER IS A COMPOSITE ... HE IS NOT A SCIENTIST, HE IS NOT A MATHEMATICIAN, HE IS NOT A SOCIOLOGIST OR A WRITER; BUT HE MAY USE THE KNOWLEDGE AND TECHNIQUES OF ANY OR ALL OF THESE DISCIPLINES IN SOLVING ENGINEERING PROBLEMS.”

*Nathan W. Dougherty, American civil engineer*

# INTERDISCIPLINARY EDP

# Engineering-Social Studies

# Raise the Flag Challenge

Students design a device to raise and lower a flag, connecting to social studies themes of culture and geography.

How might art be involved here? Language arts?





# BREAKOUT GROUPS

*Objective: Work with other teachers in your discipline to begin to consider how EDP can connect to your discipline.*





# SOCIAL STUDIES



01 Pilot Pen /Assembly Line Activity

<https://www.canva.com/design/DAFvgVRYTlw/FBhTpg02LM9V9MVGJ0nXqQ/edit>

02 Discussion on how this activity could use the Engineering Design Process to enhance learning in social studies in a World War 2 Unit

03 Taking that initial activity and brainstorming other activities that make the social studies unit more interdisciplinary

04 Discuss the steps of EDP and how it makes an impact on social studies curriculum

# LANGUAGE ARTS

## Breakout Session

As a group, discuss how EDP can be incorporated into Language Arts. Use the questions on the right as starting points or come up with your own.

- 1 What similarities do you see between EDP and the Writing Process?
- 2 How can this be used to explain the Writing Process to students more familiar in STEM?
- 3 What other types of writing can be incorporated into EDP? (step-by-step direction writing, informational writing, etc.)
- 4 How can EDP be used to make a story come to life?

# ARTS

Using the supplied engineering supplies, think about something you can make that would be used in your program. (prop or costume for a play, a sculpture, an impromptu musical instrument, etc.)

Then, as a group, discuss how EDP can be incorporated into the Arts. Use the questions on the right as starting points or come up with your own.

- 1 What aspects of engineering do you see in your area of the arts?
- 2 How could the EDP correlate or be used within your branch of the arts?
- 3 How can the EDP help your students understand your area of the arts?



# SPECIAL EDUCATION

THEN, DESIGN CHALLENGE:

*Students will design a bridge with toothpicks and marshmallows. Discuss how you would adapt this*

*activity for these following students:*

- *A student who struggles with comprehension and memory*
- *A student with Autism with deficits in social skills*
- *A student with ADHD who struggles with planning/executive function*
- *A student with limited verbal skills*

FIRST, PRESENTER

WILL PRESENT:

STRATEGIES FOR STEM AND

EDP IN SPECIAL

EDUCATION

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# SPECIAL EDUCATION

After planning for the activity, talk through these discussion questions and share your thoughts with the group.

- 01 How can we adapt this for each of the students listed individually?
- 02 What teaching strategies can we use to break this process down into simpler steps?
- 03 How can we facilitate positive peer interactions for all students, particularly the ones with disabilities?
- 04 How can we incorporate Universal Design for Learning into this process?

# PLANNING SESSION

*Objective: Develop an  
Engineering Design  
Challenge you could use in  
your classroom this year.*





# SOCIAL STUDIES PLANNING SESSION RESOURCES

01 Pilot Pen /Assembly line Activity  
<https://www.canva.com/design/DAFvgVRYTlw/FBhTpg02LM9V9MVGJ0nXqQ/edit>

02 Engineering Design Process  
<https://www.teachengineering.org/populartopics/designprocess>

03 Discuss the steps of EDP and how it impacts the social studies curriculum.

<https://media.doe.in.gov/standards/indiana-academic-standards-grade-7-social-studies.pdf>

# LANGUAGE ARTS

## Planning Session Resources

01 Writing Process -  
[https://owl.purdue.edu/owl/general\\_writing/the\\_writing\\_process/index.html](https://owl.purdue.edu/owl/general_writing/the_writing_process/index.html)

02 Novel Engineering -  
<https://www.novelengineering.org/>

03 Next Generation Science Standards Practices  
incorporating explanations of findings,  
engaging in arguments from findings, and  
communicating information  
<https://nap.nationalacademies.org/read/13165/chapter/7#67>



# SPECIAL EDUCATION

## Planning Session

## Resources

- 01 Universal Design for Learning-  
<https://www.stairwaytostem.org/universal-design-for-learning-udl-supporting-all-stem-college-learners/>
- 02 STEM and Special Education -  
<https://doi.org/10.1177/004005991304500401>
- 03 Inclusive Teaching Practices-  
<https://www.naeyc.org/resources/pubs/yc/summer2022/using-engineering-design>

# REFERENCES

*Engineering design process*. TeachEngineering.org. (n.d.).

<https://www.teachengineering.org/populartopics/designprocess#:~:text=The%20engineering%20design%20process%20emphasizes,to%20challenges%20in%20any%20subject!>

Gabel, E. (2021, October 28). How to teach the engineering design process to inspire future engineers. Revolutionized.

<https://revolutionized.com/engineering-design-process/>

Howard, T. J., Culley, S. J., & Dekoninck, E. (2008). Describing the creative design process by the integration of engineering design and cognitive psychology literature. *Design Studies*, 29(2), 160–180. <https://doi.org/10.1016/j.destud.2008.01.001>

Notre Dame Center for STEM Education. (2022). CREST: Collaboration to refine and enhance STEM teaching [Google Slides]. Retrieved from:

[https://docs.google.com/presentation/d/1rEXNV2r3nUfBTOMnRUzAmDqEUAKJuROVfecnyCN2Mog/edit#slide=id.gb5769cd4a1\\_0\\_12](https://docs.google.com/presentation/d/1rEXNV2r3nUfBTOMnRUzAmDqEUAKJuROVfecnyCN2Mog/edit#slide=id.gb5769cd4a1_0_12)

Songer, N. (2023), "Why is engineering design important for all learners?", Open Access Government April 2023, pp.300-301. Available at <https://www.openaccessgovernment.org/article/engineering-design-important-leaners-stem/155374/>.

(Accessed: 30 Aug 2023)





THANK YOU!

*Need follow-up support after this workshop?*

*Contact us here:*