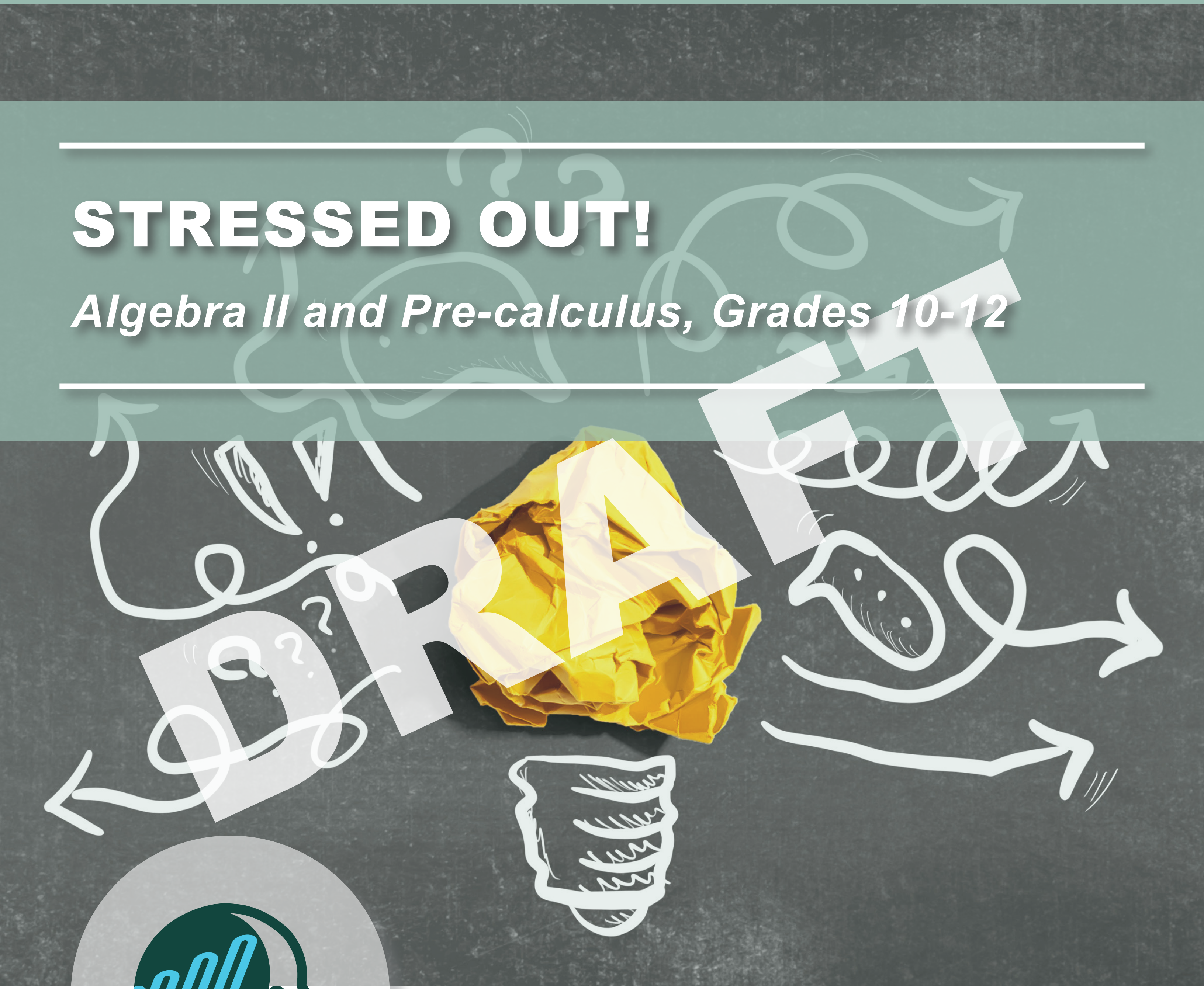

STRESSED OUT!

Algebra II and Pre-calculus, Grades 10-12

SCALE K-12

SCalable Asymmetric Lifecycle Engagement

PURDUE UNIVERSITY
INSPIRE Research Institute for Pre-College Engineering

INDIANA UNIVERSITY
SCHOOL OF EDUCATION
Bloomington

ROI
REGIONAL OPPORTUNITY INITIATIVES

Cover Information

Unit Title: Stressed Out!

Grade Level Range: Algebra II and Pre-calculus
Grades 10 - 12

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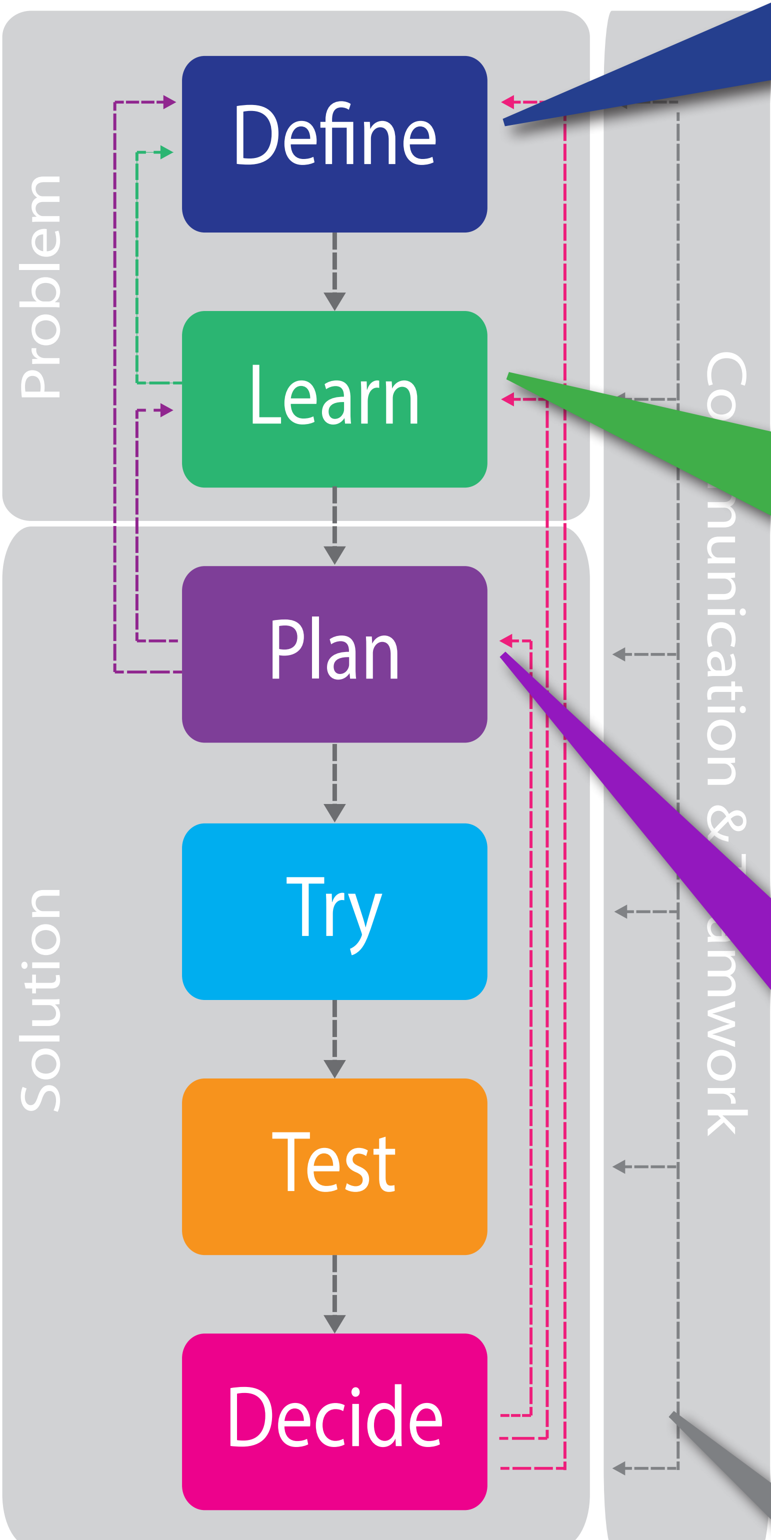
Overview: Engineering Design Process

Engineering Design Process
A way to improve



DEFINE THE PROBLEM

- Who is the **client**?
- What does the client need?
- Why does the client need it?
- Who is the **end user**?
- Why might the end user want it?
- What are the **criteria** (requirements)and **constraints** (limits) of the solution?

Problem Scoping:
WHO needs **WHAT** because **WHY**

LEARN ABOUT THE PROBLEM

- What kind of background knowledge is needed?
  - What science/math knowledge will be needed?
  - What materials will be needed?
- What has already been done to solve the problem?
- What products fill a similar need?
- How should we measure success and improvement?

PLAN A SOLUTION

- Continue to specify the criteria/ constraints
- Generate ideas of possible solutions
- Develop multiple solution paths
- Consider **constraints, criteria**, and **trade-offs** (criteria that compete with one another)
- Choose a solution to try
- Develop plans (blueprints, schematics, cost sheets, storyboards, notebook pages, etc.)

COMMUNICATION

- Communicate the solution clearly and make sure it is easily understandable
- Use **evidence** to support why the client should use your solution

Overview: Engineering Design Process

TRY A SOLUTION

- Put the plan into action
- Consider risks and how to optimize work
- Use criteria/constraints and consider trade-offs from the problem/plan to build a **prototype** (a testable representation of a solution), **model**, or **product**

TEST A SOLUTION

- Consider testable questions or hypotheses
- Develop experiments or rubrics to determine if the solution is meeting the stated criteria, constraints, and needs
- Collect and analyze data

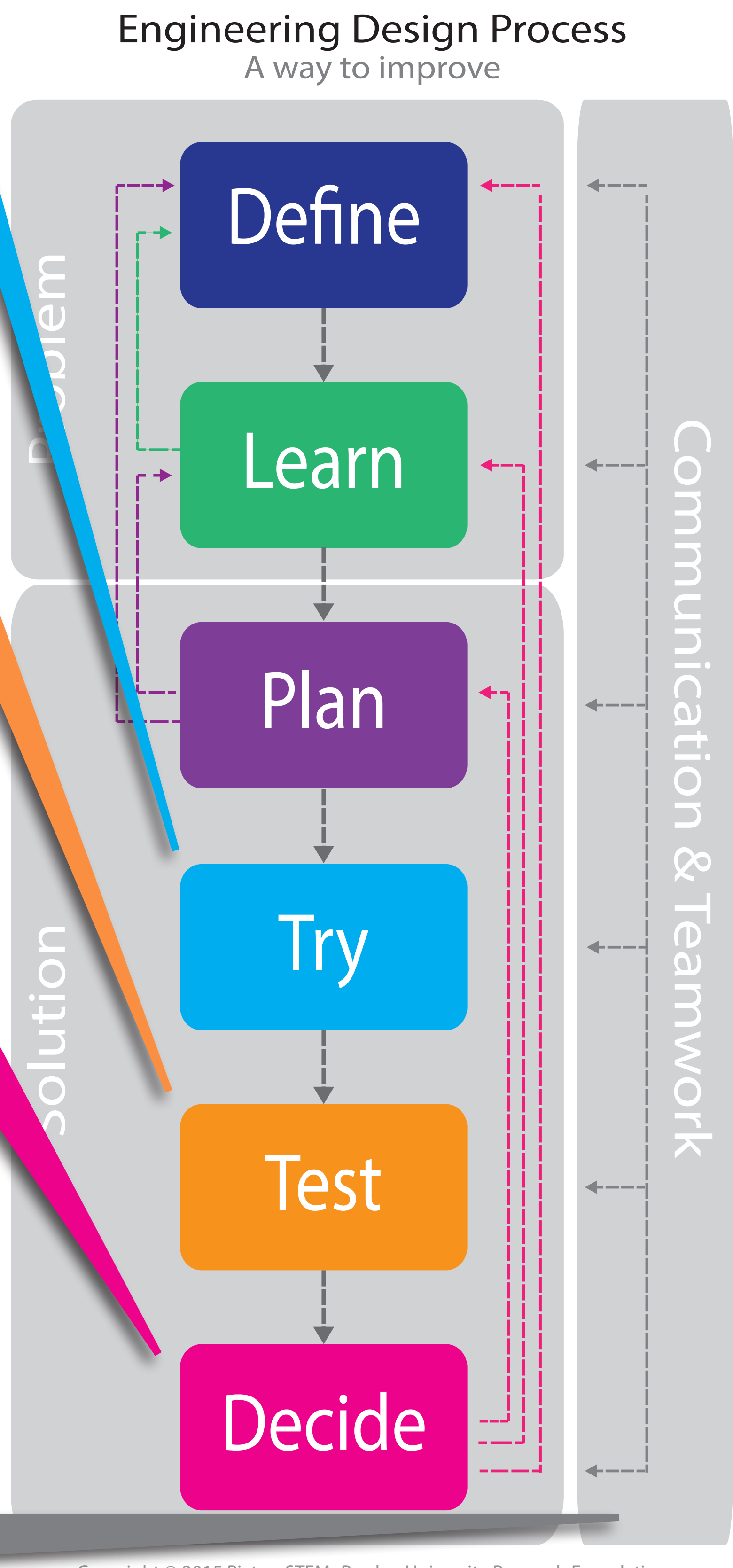
DECIDE IF THE SOLUTION IS GOOD ENOUGH

- Are users able to use the design to help with the problem?
- Does the design meet the criteria and constraints?
- How could the design be improved based on test results and feedback from the client/user?

Iterative nature of design: Always consider which step should be next!

TEAMWORK

- Discuss in teams how the solution meets the criteria and needs of the client
- Consider different viewpoints from each teammate



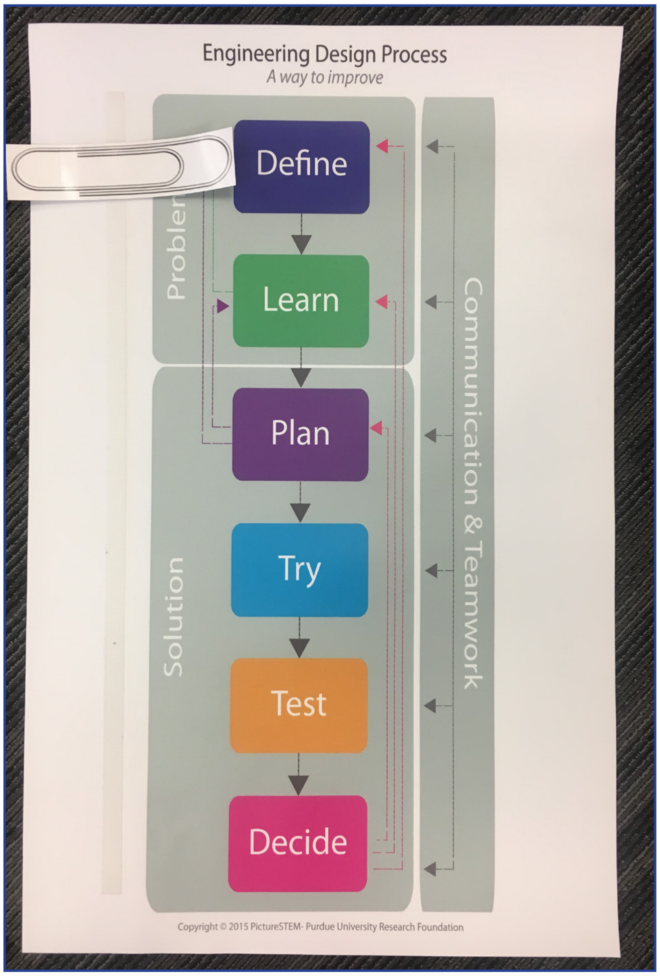
Overview: How to make EDP sliders

How to create the poster

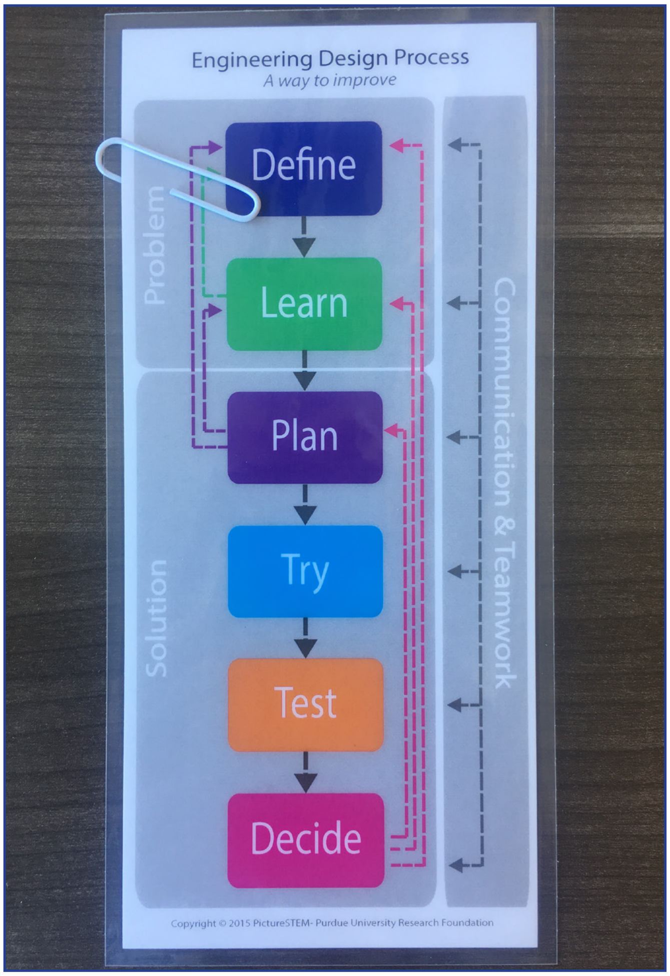
1. Download the high-quality PictureSTEM Slider Poster and the paper clip images from PictureSTEM.org.
2. Print the poster and the paper clip on poster-sized paper and cut to size. High-gloss or semi-gloss paper is the best choice.
3. Use self-sticking Velcro on the back of the paper clip and down the side of the poster so that the paper clip can be placed to point at all 6 sections of the slider.

How to create individual sliders

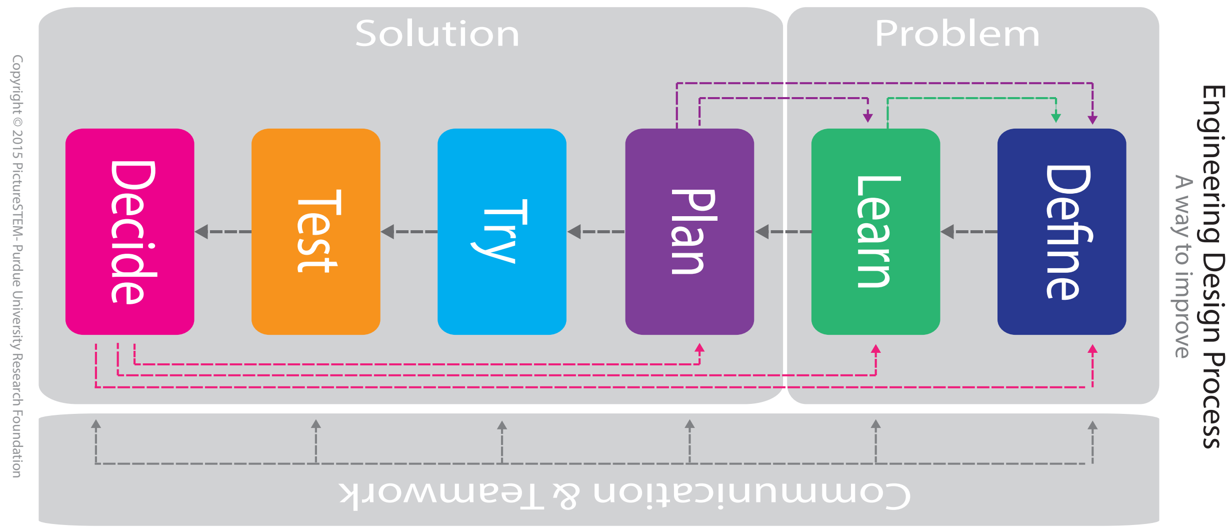
1. Print the sliders on the opposite page - enough for one slider per student in your class.
2. Cut the sliders apart.
3. Laminate the sliders individually.
4. Use a jumbo paper clip as the pointer for each slider.



Poster



Individual slider


Engineering Design Process
A way to improve
Problem
Solution
Define
Learn
Plan
Try
Test
Decide
Communication & Teamwork
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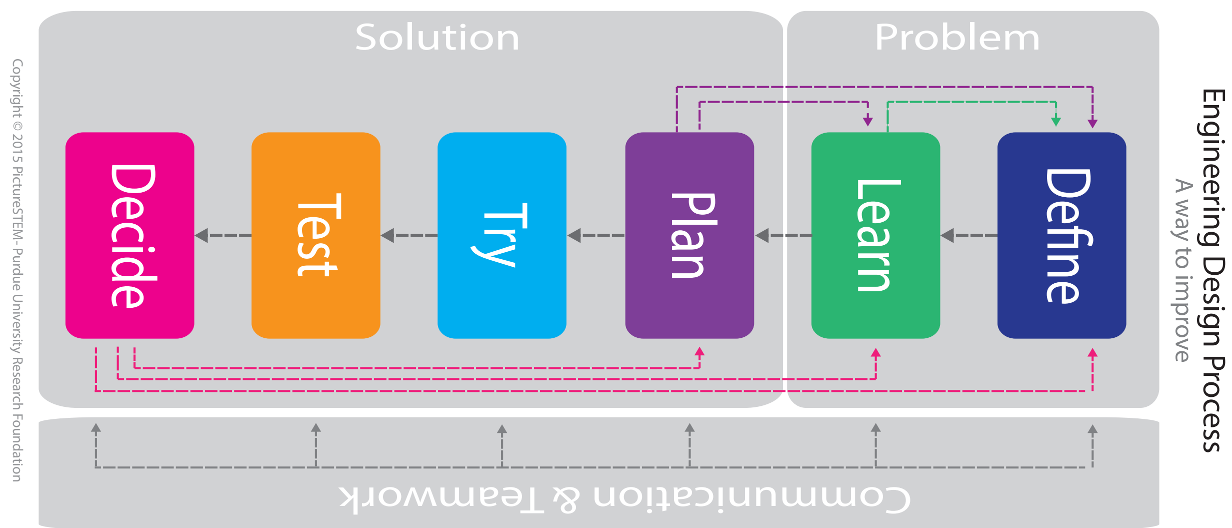
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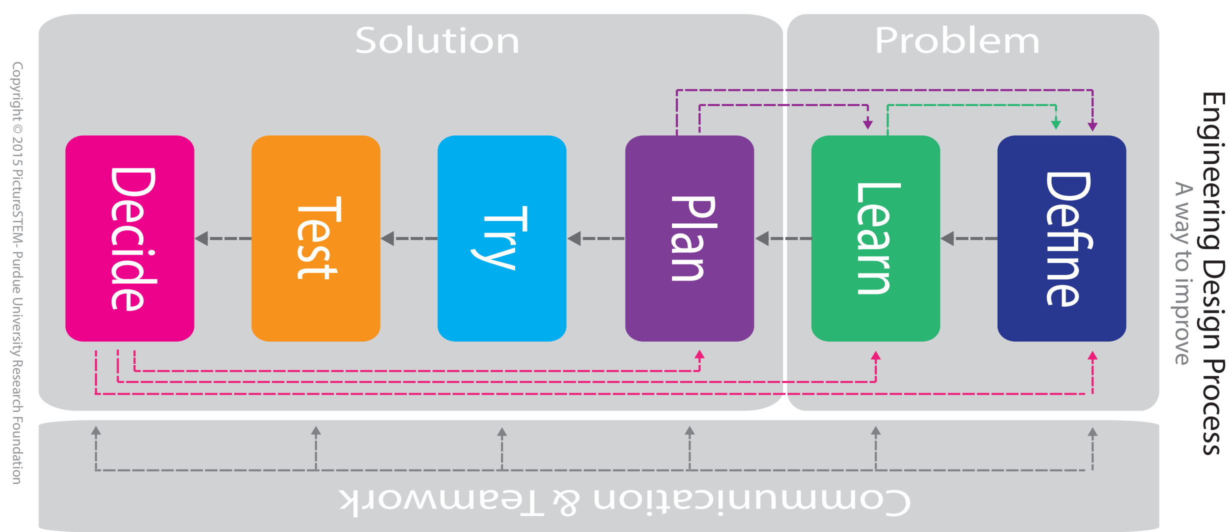
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Unit Overview

Grade Levels: Algebra II and Pre-Calculus
Grades 10 - 12

Approximate Time Needed to Complete Unit: Two - three weeks

Unit Summary

In this engineering design unit, students will design a method to allow students to monitor stress during self-scheduled activities. Students will learn about critical point, min/max behavior, intercepts and continuity in the context of heart rates. By using graphical knowledge, students will make decisions about their model and present their solutions to the client.

Subject Connections

Science Connections	Technology and Engineering Connections	Mathematics Connections
Health, data collection	Biomedical engineering, computer science, Microelectronics	Graphs, functions, factoring, continuity, extrema

Standards

2023 Indiana Academic Standards: Mathematics

Mathematics Process Standards

PS.1: Make sense of problems and persevere in solving them.
PS.2: Reason abstractly and quantitatively.
PS.3: Construct viable arguments and critique the reasoning of others.
PS.4: Model with mathematics.
PS.5: Use appropriate tools strategically.
PS.6: Attend to precision.

Algebra II

AII.FF.2: Graph each of the families of function with and without technology. Identify and describe key features, such as intercepts, domain and range, asymptotes, symmetry, and end behavior. Create inverse functions algebraically and/or graphically based on a given function. Model real-world situations with each function family.

AII.FF.3: Use graphical and algebraic structures and techniques to transform functions into equivalent forms to expose different information and identify key features. Connect the meaning of the key features to contextual situations.

AII.FF.4: Solve real-world problems with each function family, including situations in the context of science and economic phenomena.

Pre-Calculus

PC.F.1: For a function that models a relationship between two quantities, interpret key features of graphs and tables in terms of the quantities, and sketch graphs showing key features given a verbal description of the relationship. Key features include: intercepts; intervals where the function is increasing, decreasing, positive, or negative; relative maximums and minimums; symmetries; end behavior; and periodicity.

PC.F.2: Find linear models by using median fit and least squares regression methods, making use of technology. Decide which among several linear models gives a better fit. Interpret the slope and intercept in terms of the original context.

PC.QPR.6: Graph rational functions with and without technology. Identify and describe features such as intercepts, domain and range, and asymptotic end behavior.

2023 Indiana Academic Standards: High School Integrated STEM

HS.IDL.3: Evaluate the potential impact (short and/or long-term) of different technology solutions on society and the environment.

HS.AM.4: Demonstrate the use of computational, graphical, virtual, mathematical, and/or physical modeling to identify conflicting considerations before the entire system or solution is developed.

HS.IPS.1: Conduct or extend an investigation, analyze results, iterate, and revise to improve the design.

HS.DM.1: Use multiple systems of measurement (i.e., standard and metric) and data sets (e.g., plots, tables, graphs, charts) defined in course-level content standards to analyze real-world scenarios and the mathematical relationships represented by the data.

HS.DM.2: Construct visual representations or conduct statistical analyses defined in course-level content standards.

HS.DM.3: Use approximations and evaluate reasonableness of observations, results, and solutions throughout processes.

HS.CC.1: Communicate evidence, investigations, analyses, and the solution(s) of a problem in multiple media forms appropriate for the audience.

HS.CC.2: Implement roles and responsibilities to collaborate, contribute, and/or lead within and across various group settings (i.e., online, onsite and/or hybrid) and situations.

HS.CC.3: Evaluate competing solutions or arguments in a systematic way based on qualitative and/or quantitative evidence.

2023 Indiana Academic Standards: Science and Engineering Practices

SEP.1: Asking questions (for science) and defining problems (for engineering).

SEP.2: Developing and using models.

SEP.3: Planning and carrying out investigations.

SEP.4: Analyzing and interpreting data.

SEP.5: Using mathematics and computational thinking.

SEP.6: Constructing explanations (for science) and designing solutions (for engineering).

SEP.7: Engaging in argument from evidence.

SEP.8: Obtaining, evaluating, and communicating information.

Lesson Summaries

Lesson 1: Hot Off the Stress!

Students are introduced to the Engineering Challenge by their client which will serve as the context within which students can learn about stress. Students will learn about the Stress and Coping Cycle and how to self-regulate. Students will learn about the Engineering Design Process then take part in iterative class and group discussions to identify criteria, constraints, and knowledge gaps needed to successfully solve the client’s challenge.

Lesson 2: Stress than Zero

Students will learn about x- and y-intercepts and finding zeros of functions algebraically and graphically. Students will interpret graphs using this knowledge from health-based data.

Lesson 3: Extreme Stress!

Lesson 4: Stress Code

Lesson 5: Continuous Stress

Lesson 6: Stress Intervention

Lesson 7: Stress Test

Lesson 8: Coping with Stress

Unit Materials List

	Unit Materials	Lesson Used							
		1	2	3	4	5	6	7	8
Per classroom	Engineering Design Process instructions	✓	✓	✓	✓	✓	✓	✓	✓
	EDP Poster	✓	✓	✓	✓	✓	✓	✓	✓
Per team	Micro:bit kit with heart rate sensor: • heart rate (pulse) sensor (ex: pulsesensor.com) • 3 alligator clips • micro:bit • battery case • 2 AAA batteries • USB to micro-USB cable, • Ziptop plastic bag for storage				✓		✓	✓	
	Access to PowerPoint or equivalen								✓
Per student	EDP slider w/ jumbo paperclip	✓	✓	✓	✓	✓	✓	✓	✓
	Laptop or equivalent device	✓	✓	✓	✓	✓	✓	✓	✓
	Engineering notebook	✓	✓	✓	✓	✓	✓	✓	✓

Unit Planner

Lesson	Time Needed	Objectives Students will be able to …	Duplication Master
1. Hot off the Stress!	Two 45-minute lessons	• Identify the problem from a client • Identify background knowledge needed to develop a solution • Describe the Engineering Design Process • Explain the criteria and constraints	1.A Content Pre-Assessment 1.B Client Letter 1.C Stress Cycle Article 1.D Problem Scoping Prompts 1.E Problem Scoping Example 1.F Context Homework
2. Stress than Zero	Two 45-minute lessons	• Identify x- and y-intercepts • Find zeros of functions algebraically • Find zeros of functions graphically • Interpret graphs using health-based data	2.A Flowchart Factoring Types 2.B Flowchart Example 2.C Understanding Intercepts 2.D Factor to Graph 2.E Zero Homework 2.F Understanding Intercepts Key 2.G Factor to Graph Key 2.H Zero Homework Key
3. Extreme Stress!	Two 45-minute lessons	• Identify critical points • Identify relative/absolute maximum/minimum • Identify increasing/decreasing intervals • Analyze graphs using specific health-based data	3.A Relative Stress Data 3.B Client Memo 1 3.C Sensor Homework 3.D Sensor Homework Example
4. Stress Code	One 45-minute lesson	• Use a micro:bit to collect data representing student health • Identify how microelectronics are used in everyday life	4.A Micro:bit Assembly Guide 4.B Coding Instructions 4.C Conversion to Graph Instructions
5. Continuous Stress	One 45-minute lesson	• Identify discontinuities • Describe end behavior	5.A Health Monitoring Graphs 5.B End Behavior and Continuity Homework 5.C Client Memo 2 5.D Health Monitoring Example 5.E End Behavior and Continuity Key

Lesson	Time Needed	Objectives Students will be able to ...	Duplication Master
6. Stress Intervention	Two 45-minute lessons	• Consider criteria and constraints when planning solutions for stress intervention • Justify design decisions with math and science evidence	6.A Generating Ideas Prompts 6.B EBR Graphic Description 6.C Evidence-Based Reasoning 6.D EBR Example 6.E Build Your Testing Procedure 6.F Coding Support
7. Stress Test	One 45-minute lesson	• Test and evaluate solutions to the engineering design challenge • Redesign existing solutions using math evidence from testing	7.A Post-Test Evaluation 7.B Redesign 7.C Client Memo 3
8. Coping with Stress	Two 45-minute lessons	• Communicate science, technology, engineering, and mathematics ideas • Present their solutions to the problem • Use evidence-based reasoning to support their engineering decisions • Connect careers in microelectronics to the challenge	8.A Communication Requirements 8.B Client Memo 4 8.C Content Post-Assessment 8.D Content Post-Assessment Key

Unit Background

Introduction

This background defines important terms and concepts used within this unit.

Teamwork

This unit will have students working in teams. Effective teamwork is essential in this unit, just like in engineering. Students should be teamed strategically and may or may not be assigned jobs within their team. When forming student teams, consider academic, language, and social needs. In place of strategic teaming, a random teaming can be substituted.

Career Connections

Students will be introduced to new STEM content potentially for the first time. There are many career opportunities that align with the content in this unit. Please plan to highlight these as you see fit and encourage students to think about how these topics align with their personal and future interests.

Engineering Design Process

NOTE: If students are familiar with the engineering design process (EDP) before beginning the unit, the teacher can skip this (EDP) introduction.

The engineering design process (EDP) is an iterative, systematic process used to guide the development of solutions to engineering problems. There is no single engineering design process, just like there is no one scientific method. However, the various engineering design processes have similar components. The engineering design process (EDP) involves understanding the problem, learning background information necessary to solve the problem, planning, trying, testing the solution, making changes based on the tests, and communicating their ideas. Students will use an engineering design process slider throughout the unit to help them understand where they are in the design process. For more information about the steps of the engineering design process presented in this unit, see the front matter section at the front of the unit.

Some common misconceptions about engineering

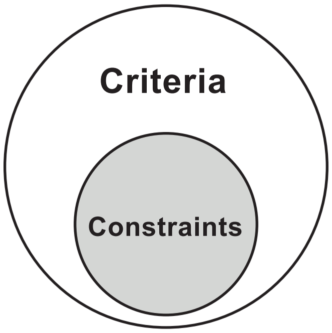
- Engineers do not have to learn anything new when they are working on a project. **In reality**: Engineers need to continually learn throughout their lives.
- Engineers come up with solutions that are just “good enough” and do not take risks. **In reality**: Engineers strive to create the best solution possible through optimization. It is normal to experience failure when solving engineering problems.
- Engineers work alone to solve a design problem. **In reality**: Engineers collaborate with people in different disciplines and fields to best solve a problem. Engineering problems often require a wide range of content knowledge.

Some common misconceptions about the EDP

- The engineering design process is linear, and you never need to go back to previous phases. **In reality**: The EDP is a cyclical process that requires many iterations.
- Once the project is done, it is considered complete and not revisited. **In reality**: The engineering design process is never really “done” and it is revisited so engineers can improve projects and make changes.

Criteria and Constraints

One difficulty that students might experience is distinguishing between criteria and constraints. Criteria are the things required for a successful design, or the goals of the designed solutions. They help engineers decide whether the solution has solved the problem. Another way of thinking about criteria are that they are anything that the client and the engineers will use to judge the quality of a solution. Constraints are a specific type of criteria; they are those criteria that limit design possibilities, or the ways that problem can be solved. If constraints are not met, the design solution is by default not a viable solution to the problem. The relationship between criteria and constraints is represented in the figure. It may be helpful to post the definitions with the figure somewhere in the classroom for future reference.



Problem Scoping

Define the problem and learn about the problem combine to make Problem Scoping. In this stage, students will be first introduced to the engineering problem through a client letter and then be given a chance to ask questions to the client to receive more information about the problem. The problem statements given in the client memos purposefully do not provide all the information necessary to solve the problem. Students are tasked with generating questions about the problem to try to fill in this missing information. Based on all information from the client, students will then define the problem in terms of: what the problem is and why it is important, who are the client and end users, what are the criteria and constraints, and what other information they may need to learn about in order to solve the problem. This process of generating ideas and questions for the client is an important skill on its own both in engineering and in other fields, but it also helps to ensure that the students fully understand the problem and their task in the engineering design challenge.

Solution Generation

The Solution Generation section of the engineering design process includes plan the solution, try out the plan of the solution, test the solution, and decide whether the solution is good enough. When engineers are generating solutions, they will use iteration to continually improve their solution, reflect back on the problem definition and what they have learned about the problem, and consider criteria, constraints, and trade-offs. Trade-offs involve having to make compromises about which criteria to emphasize because they compete with one another in terms of making the solution effective. For example, cost could be a trade-off for durability.

Engineering Notebook

Throughout the unit students will be recording information in an engineering notebook, and they will need the notebook at the start of the unit. The engineering notebook is set of documents which includes writing prompts, black space to take notes or upload pictures of work, and copies of the duplication masters that are listed in each lesson. The engineering notebook can be offered electronically or on paper and can be adapted to your classroom needs. Students' engineering notebooks will support their communication of ideas and should be used consistently throughout the unit.

Unit Background

Microelectronics

Microelectronics (ME) can be defined as the design, manufacture, and use of microchips and integrated circuits. Students will use microelectronics in this unit as a tool to learn algebra/pre-calculus material.

What are microelectronics? The microchips are the key that makes microelectronics work. The microchips are made from small pieces of a semiconductor material, which is usually silicon. Semiconductors are special because they can allow electrons to move through them or not, depending on how they are used. Engineers take advantage of silicon's semiconductor property to design circuits that control how electrons move through a microchip. There are four main types of microchips: memory chips that store information, logic chips that process information, application-specific integrated chips that perform repetitive tasks, and system-on-a-chip chips that combine multiple circuits into a single chip.

When you use the micro:bit in this unit, you can see its microchips on the back. One is the processor, or the brains, of the micro:bit; the processor reads and completes the tasks in the code. The other is the USB cable chip, which lets the micro:bit communicate with the computer. See descriptions here: https://microbit.org/get-started/features/overview/. This link shows an image of the inside of a chip similar to the processor in the micro:bit: https://en.wikipedia.org/wiki/ARM_Cortex-M#/media/File:STM32F100C4T6B-HD.jpg

How are microelectronics made? This is a highly technical process, but broadly, it works like this: Sand is refined into pure silicon that is grown into crystals and then cut into thin circular wafers. Fabrication companies design the circuits for a microchip's purpose and etch that circuitry onto the silicon. They then cut each circuit out of the wafer and package it into a case that protects it and lets it function with other electronic components, like speakers, sensors, motors, and more. The circuits on a chip can contain thousands to billions of tiny components (primarily transistors but other components, too). Because the circuits are so small, they must be manufactured in a clean room. A piece of dust is big when compared to the size of a transistor on a chip! For reference, a low-end iPhone in 2023 has a microchip that is a system-on-a-chip with 15 billion transistors on it and is roughly one square centimeter in size.

Once the microchips are designed and manufactured, they are sent to other sites where they are integrated into devices like the micro:bit, your phone, your school bus, your dishwasher, and your toys.

Why are microelectronics important? Microelectronics are everywhere. They help make electronic devices cheaper, faster, and more energy efficient. Without them, many things we take for granted would stop working. Many high tech, high paying, and in-demand jobs require knowledge of microelectronics.

You do not need to be familiar with ME content to teach this unit however having some basic knowledge may help you feel more prepared to talk about ME-related topics with your students.
https://www.pbs.org/video/integrated-circuits-moores-law-crash-course-computer-sci-r2spce/
https://whyy.pbslearningmedia.org/resource/what-is-a-semiconductor/what-is-a-semiconductor/
https://whyy.pbslearningmedia.org/resource/how-computers-compute/how-computers-compute/
https://roadtripnation.com/roadtrip/microelectronics-documentary

Vocabulary

Students will be introduced to many new microelectronic and engineering vocabulary terms throughout the unit. It may be helpful to create a vocabulary section in their notebook with term definition and memory clue. Additionally, the class could maintain a word wall.

Term	Definition
problem scoping	defining the problem and learning about the problem
criteria	features of the solution that the client wants
constraints	a specific type of criteria; the criteria that limit design possibilities or ways that the problem can be solved
evidence-based reasoning	supporting a solution or recommendation with scientific analysis and/or data
design matrix	a tool used to compare, assess, and prioritize a set of options based on weighted criteria
client	the person or company who requests your help to solve a problem
end user	anyone who will use the solution you provide to the client's problem
microelectronics	the design, manufacture, and use of microchips and microcircuits
microchip	computer chip or integrated circuit that is used for processing and storing information in electronic devices

LESSON ONE:

Lesson Objectives
Students will be able to:
- Identify the problem from a client.
- Identify background knowledge needed to develop a solution.
- Describe the Engineering Design Process (EDP).
- Explain the criteria and constraints.

Materials
Per classroom
- EDP Poster

Per student
- EDP slider and jumbo paperclip
- Laptop/Chromebook/Tablet
- Engineering notebook

Time Required
Two 45-minute lessons

Standards Addressed
IAS Science and Engineering Practices
- SEP.1, SEP.8

IAS Integrated STEM
- HS.IDL.3

Key Terms
- client
- engineering design process
- criteria
- constraints
- microelectronics
- stress

Lesson Summary

Students are introduced to the Engineering Challenge by their client which will serve as the context within which students can learn about stress. Students will learn about the Stress and Coping Cycle and how to self-regulate. Students will learn about the Engineering Design Process then take part in iterative class and group discussions to identify criteria, constraints, and knowledge gaps needed to successfully solve the client's challenge.

Background

Teacher Background

Teamwork: Students will be grouped according to the type of stress they are interested in studying. Students will work in these groups, or "teams" throughout the unit. Effective teamwork is essential in this unit as well as in engineering in general; however, this unit does not provide specific support to develop those skills. If your students do not have experience with teamwork, it is highly recommended that you do some targeted team-building activities prior to beginning this unit. The teams will each specialize in a specific context related to their interests. This is explained further in the client letter.

Problem Scoping: In this lesson, students will be in the Problem Scoping section of the engineering design process, specifically on the "Define" step.

Engineering Notebook: Throughout the unit students will be recording information in an engineering notebook. You may want to have your students write in their notebooks in two different colors – one for thoughts and prompts that are individual and one for thoughts and prompts that they discuss in their teams. This well help you assess the students' ideas as well as help them recognize their own contributions and ideas. You also may want to have students complete a Notebook Cover and start a Table of Contents page. You may choose to have students tape/glue copies of the notebook prompts and/or the duplication masters into their notebooks or they can copy down a projected version of the prompts.

Stress and Coping: Coping with stress is a life skill that many of us could do a better job with. The first step in becoming better is examining what makes us stressed out, and what some of our reactions to that stress are. By paring this conversation with how graphs can help us explain data and test out solutions, we hope to engage students in the context introduced in the client letter.

Vocabulary:

Before the Activity

- Assemble the Engineering Design Process Sliders and post the EDP Poster in the classroom (see the front matter for how to assemble them). Make sure you and your students can refer to the EDP sliders and/or poster throughout the unit.
- Determine student teams of three or four. These teams should be their teams throughout the rest of the unit.
- Print and make copies of the following duplication masters in the labeled amounts:
    - (1 per student) 1.A Content Pre-Assessment, 1.B Client Letter, 1.C Stress Cycle Article, 1.F Context Homework
    - *Optional:* Print out a copy of the 1.D Problem Scoping Prompts for each student if you want them to tape/paste them into their notebooks instead of copy down the prompts

Classroom Instruction

Introduction

1. **Complete the content pre-assessment activity.** The students will participate in a formal pre-assessment activity to figure out their prior knowledge regarding the topics of factoring, microelectronics, zeros, and extrema. Distribute the 1.A Content Pre-Assessment and have students answer the questions individually without access to references or resources. Make sure to tell students that this is just to assess their prior knowledge, so it is okay to not know the answers.

2. **Review prior knowledge.** Lead a discussion with the class in which students are able to share their prior knowledge on the topics of engineering, factoring polynomials, absolute and relative extrema, data analysis, electronics, and mental health monitoring (stress to be more specific to this context). Prompts may include the following: What do engineers do? What kinds of industries do engineers work in? What are the differences between absolute and relative extrema? How are electronics

Assessments

Pre-Activity Assessment

Assess students' prior knowledge by listening to their responses to section 1 of 1.D Problem Scoping Prompts.

Activity Embedded Assessment

Students will respond to prompts based on the client letter and the article in their engineering notebooks

Post-Activity Assessment

After examining an article in class, students will examine a different article on their own as homework

Duplication Masters

- 1.A Content Pre-Assessment
- 1.B Problem Scoping Prompts
- 1.C Client Letter
- 1.D Stress Cycle Article
- 1.E Context Homework

Educator Resources

- 1.F Problem Scoping Example
- 1.G Context Homework Key

used in health care? How does stress affect daily life?

3. **Introduce the unit. Say:** *Stress is on the rise, and many people don't realize how many of their day-to-day activities stress them out. If they are aware of the stress, many don't have great coping skills to give them relief from the physical symptoms of stress. This is a problem that has doctors, school counselors, and engineers as just a few of the professions trying to solve it. Today, we will be looking at this problem using a combination of engineering and math, with you bringing in your personal experiences and interests into solving this problem.*

4. **Introduce microelectronics**. **Ask**: *What do you know about microelectronics? How do you think writing is important if you design, work with, or use microelectronics?* Tell students they will get a chance to work with microelectronics in this unit.

5. **Introduce the Engineering Notebooks. Say:** *Engineers use notebooks to document their design process and keep notes. We will also be using Engineering Notebooks throughout our engineering challenge. Each day, you'll use the notebooks to take notes and record what you are learning. In addition, there are questions that you'll be asked to answer individually and in teams. Each day, turn in your engineering notebooks before you leave class.*

Activity

6. **Start problem scoping.** Introduce Section 1 of the 1.B Problem Scoping Prompts. Either pass out copies or project the prompts so students can address them in their notebooks. Direct students to respond to these prompts individually. Make sure to let them know that it is okay if they do not know very much about engineers or engineering - just have them answer these questions to the best of their ability.

7. **Discuss engineers and engineering.** Allow students to share their answers from 1.D Section 1. Define engineers and engineering and allow students to take some notes in their notebooks. As a class create a list of the different types of engineering and have students brainstorm careers that may fall under each type. **Say:** *Different types of engineers, produce different types of things. Some produce physical products and prototypes. Others produce processes or code files to solve problems and serve as the deliverable of their projects.* Explain that the problem they will be solving falls under the category of

computer or biomedical engineering and draws on elements of graphical analysis, and electronics to understand the context and generate a solution.

8. **Introduce the Engineering Design Process. Say:** *Engineers use an engineering design process along with mathematics, science, and creativity to understand a problem and come up with a solution.* Pass out the sliders and outline each step of the engineering design process. The amount of time this will take will vary dependent on your students' familiarity with engineering. There is a detailed description of the EDP Slider in the front matter of the unit. **Ask:** *Based on what we have discussed so far, where do you think we are in the engineering design process?* (Define).

9. **Introduce the problem.** Ask students about their relationship with stress. Give students time to share any experiences they feel comfortable talking about. Have students read the 1.C Client Letter, and have a class (or shoulder partner) discussion so students can begin to identify the problem from the client and the required information, which engineers call criteria and constraints. Encourage students to take notes throughout the problem scoping phase in their engineering notebooks.

10. **Identify required information.** Have students work together to brainstorm a list of "required information" in order to help the client with their request. Encourage them to highlight/underline the things on the list they already know. They should be able to revisit their list throughout the unit to make sure they are learning what they need to and can add additional questions they have for the client.

11. **Students explore the Stress and Coping Cycle.** Have students Read the 1.D Stress Cycle Article individually. After reading, talk to them about their experience with stress. Possible prompts include: *Where do you think you fall in this model? What are negative coping skills?* An optional enrichment activity could be to bring in the school guidance counselor to share more stories, information, and/or statistics to really bring out the real-world relevance to students.

12. **Complete problem scoping section 2.** This section asks students to ask questions to the client. The teacher may want to enlist the school counselor to answer some of the questions about stress, and the teacher may answer other questions about

the project as they come up. Start the answer with “After talking with the client...” or “The client said...”

13. **Form student teams.** After students have finished the prompts, explain that students will be working in small teams to solve a problem brought to them by the client. The client identified four areas that they are interested in exploring. Divide students into teams of 3 or 4 trying to prioritize grouping students by interest area (video games, sports, TV, school/work performance).

14. **Complete problem scoping section 3.** This is where the students will formally define the problem.

15. **Introduce HW assignment.** Distribute copies of 1.E Context Homework to students. The students will either self-select or the teacher will assign them into groups based on topic. This curriculum is designed with 4 main topics with 2 sub topics each for a total of 8 groups, but this can change based on class needs.
    - Video games: Fighting vs. Puzzle/Strategy
    - Sports: Participating vs. Watching
    - TV: Reality vs Game Show
    - Performance: Unit Test vs. Work Tasks

    NOTE: The gaming assignment measures heart rate variability, which measures the change in heart rate over a period of time. All of the other groups will have heart rate data. This was done to increase variability and limit the sharing of answers between groups.

Closure

16. **Revisit the problem.** Have students restate the problem in their own words, and provide one piece of evidence from the 1.D Stress Cycle Article about why the problem is important.

17. **Discuss the engineering design process. Ask:** *Which phase of the engineering design process did we focus on related to our challenge today? Why is this important?* Ex: Students need to understand the root of the problem from the perspective of the client and other stakeholders before attempting a solution.

Name____ Date_______________ Period ___________

1.A Content Pre-Assessment

1. How do you solve a polynomial for zeroes if there are four terms?

2. What are the x-intercepts for $f(x) = x^3 - 2x^2$? Show your work.

3. What is the difference between relative and absolute extrema?

4. Describe what can happen to stress levels when using different kinds of coping skills.

5. What is a micro:bit?

Name____ Date_______________ Period __________

1.A Content Pre-Assessment

6. Describe one kind of a critical point in a continuous function?

7. Factor this function to its simplest form: $f(x) = x^3 + 15x^2 + 75x + 125$

8. What does the term, “microelectronics” mean?

9. How are microelectronics used in the field of algebra or pre-calculus?

10. What jobs would you be interested in that use microelectronics? Provide one example of how microelectronics is used in that job.

1.B Problem Scoping Prompts

Section 1

Directions: Please answer the following questions.

1. What do engineers do?

2. How do engineers solve problems?

Section 2

Directions: Please answer this question after hearing about the engineering challenge.

3. What questions do you want to ask to the client?

Section 3

Directions: Please answer these questions after you have been able to ask questions about the challenge.

First, on your own, complete each prompt. Then write your revised answer (if different) to the prompt, based on the discussion with your team. You may use a different color writing utensil to distinguish your answer and how it changed after talking with teammates.

4. The client is:

1.B Problem Scoping Prompts

5. The client's problem is:

6. The problem is important to solve because:

7. The end users are:

8. An effective solution for the client will meet the following criteria:

9. The constraints (or the limits) of the solution are:

10. Think about the problem of coping with stress. In terms of monitoring heart rate, what are 2 things you need to learn in order to develop a stress intervention method? Make sure to consider all important aspects of the problem. Be specific.

1.C Client Letter

Dear Engineers,

High school students are experiencing unprecedented levels of negative stress. Stress is a normal response to danger and can be useful; enhancing focus and providing energy to escape harm or simply perform better under pressure. In reality, this can sometimes manifest in negative ways, building up in unnecessary situations. Screens, social media, the pressures of school and work can all trigger this cycle of stress and the long-term outcome is dependent on positive or negative coping strategies.

A lack of healthy coping strategies can increase the intensity and duration of the physical and mental reactions to stress. The problem is that many people, adults and teens alike, do not pay attention to what their coping strategies are and the effect that they have on their relationship with stress. We recently created a series of helpful information on the link between stress and health, the first of which can be found in the paper at the end of this letter. Because there are many factors that impact stress, we need to understand what stress looks like in multiple contexts. We are interested in stress related to sports, video games, TV, and performance (ex: test anxiety).

To improve student self-regulated coping strategies, we are partnering with school counselors across the state to find out more about the stress of high school students in schools like yours. The method we would like you to use to monitor stress is heart rate. We have a microelectronics-based sensor you can use to take heart rate measurements. Your design will need to incorporate this sensor and will be used by high school students to intervene during instances of high negative stress.

I want to enlist your help to develop a method for interrupting harmful cycles of stress in high school students. Please use the engineering design process, mathematics and science knowledge, and your ingenuity to make an evidence-based recommendation for us. Include this evidence in your final design report and be sure you consider reliability, ethics, and use mathematical reasoning. I look forward to seeing your final designs and implementing your recommendation.

Sincerely,

Art Beet

Art Beet
Consulting Engineer – Mental Health Outreach
Revitalizing Lives in Educational Facilities (RELIEF)

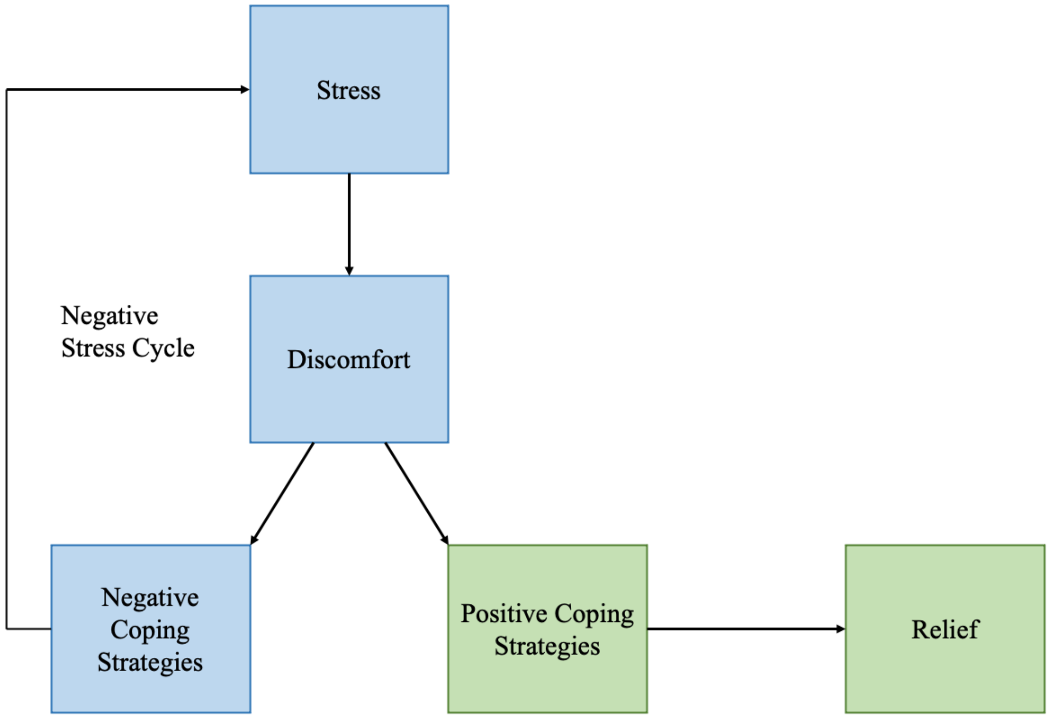
PS. If you are curious about other companies like ours, https://www.activeminds.org/ is another good example!

1.C Stress Cycle Article

What happens when you are stressed?

Studies have long shown a strong correlation between heightened stress levels and a decline in other wellness factors. This means that monitoring students' stress levels is vital for overall wellness at school and at home. Some ways to monitor stress include physiological signals like EKG (Electrocardiogram with cardio meaning heart) and EEG (Electroencephalogram with encephalo referring to the brain). Both of these methods involve charting (the gram part of the words) the electronic signals that both of these organs give out. An even more physical indicator of stress is an elevated pulse rate, as this can be detected and measured simply by looking closely or using your fingers to find your pulse.

The symptoms of stress are different for everyone, but some of the most common physical symptoms are muscle tightness/fatigue, digestion issues, sleep issues, and even increased likelihood of sickness. You also have to think about the social symptoms, which can be things like focus issues, temper flares, disengagement with friends and family, and loss of interest in hobbies. Some studies show that 45% of students report being stressed almost every day in high school.



Adapted from:
https://parentandteen.com/teen-stress-management-plan/

1.C Stress Cycle Article

What can we do about it?

The figure on the previous page depicts the cycle we can get stuck in if we do not implement positive coping mechanisms. Negative coping strategies will only continue the cycle which eventually has negative effects on our mental and physical health. We know the scientific ways of measuring stress, and you may be able to identify your own unique symptoms of stress, but what could we do about it?

Some techniques to deal with stress are:

- Deep Breathing and Meditation: Practice deep breathing exercises or meditation to calm your mind and reduce stress. These techniques can help you become more mindful and present in the moment.
- Creative Outlets: Explore creative activities such as drawing, painting, writing, playing a musical instrument, or crafting. These activities can provide a sense of accomplishment and act as a form of self-expression.
- Social Connections: Spend time with friends and family who are supportive and understanding Talking to someone you trust about your feelings can help reduce stress.

Like the symptoms and triggers of stress, the coping mechanisms that are most effective are different for everyone. Doing more research on different types and listening to your body is one of the best things that you can do for yourself in the pursuit of overall wellness

Name____ Date_______________ Period __________

1.E.1 Context Homework

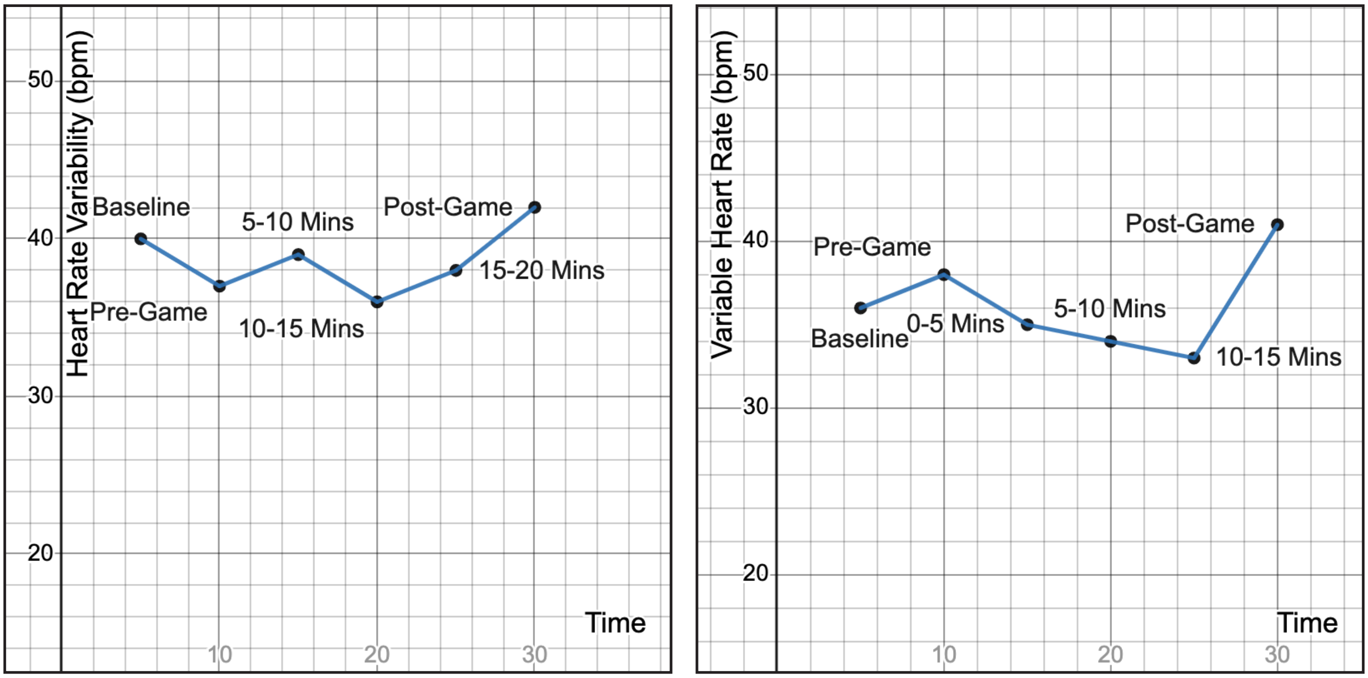
Video Game Stress

If you play video games, you are likely to have experienced a heart-racing moment. What might not be so obvious is the impact that stress like this can have overtime. Limiting Screen Time, breathing techniques, and other things can help mitigate the effects. Take a look at these two graphs. One shows a player's heart rate while playing the action/fighting game Mortal Kombat. The other shows a player's heart rate while playing the puzzle game Tetris. Use the graphs to answer the questions below.

Effects of Video games on Heart Rate

Graph A

Graph B



1. Which game is represented in Graph A and in Graph B? Why do you think this?
   - Graph A: ________________________________
   - Graph B: ________________________________
2. Compare and contrast the change in heart rate in the two graphs.
3. What components of the graphs do you see?
4. What can you tell about the data from looking at the graphs?

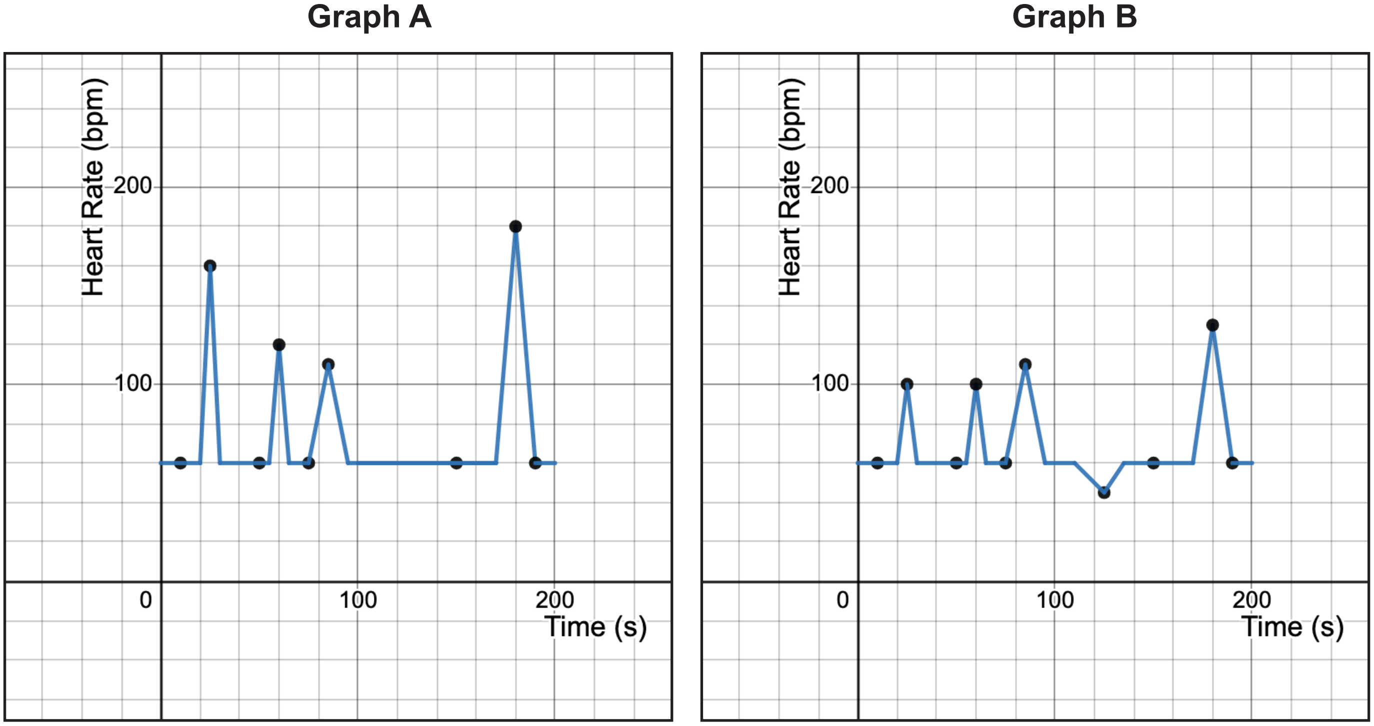
Name____ Date_______________ Period __________

1.E.2 Context Homework

TV Stress

Watching television is a way for many people to relax and unwind after their school or work day. Certain shows however, are designed to be exciting and even gut-wrenching as a way of attracting more viewers. Take a look at these two graphs. One shows the heart rate for an individual watching a game show, and the other is the heart rate while watching a reality TV show. Use the graphs to answer the questions below.

Effects of TV on Heart Rate Variability



1. Which game is represented in Graph A and in Graph B? Why do you think this?
   - Graph A: ________________________________
   - Graph B: ________________________________
2. Compare and contrast the change in heart rate in the two graphs.
3. What components of the graphs do you see?
4. What can you tell about the data from looking at the graphs?

Name____ Date_______________ Period ___________

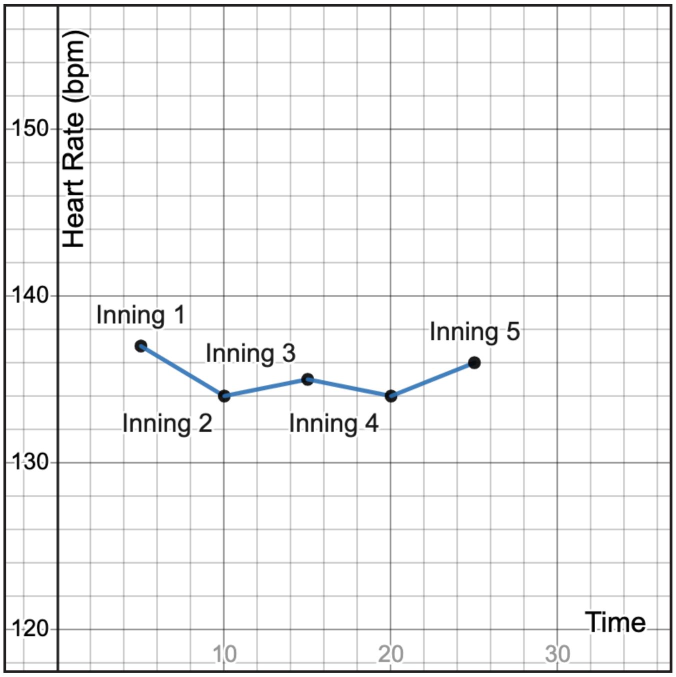
1.E.3 Context Homework

Sports Stress

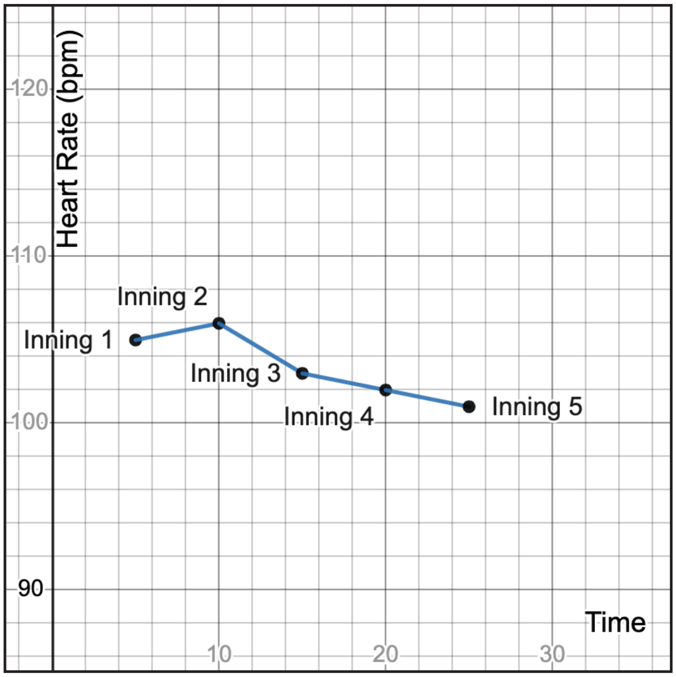
Athletes often channel their stress into adrenaline that helps them during the game, but stress while playing sports is still something to monitor. Sports fans also can be very passionate about the game, but monitoring their stress levels is important as well since many of us know someone (or are that someone) who can get a little too intense about the game. Take a look at the two graphs. One shows the heart rate of someone playing baseball, and the other is of someone watching baseball. Use the graphs to answer the questions below.

Effects of Sports on Heart Rate Variability

Graph A



Graph B



1. Which game is represented in Graph A and in Graph B? Why do you think this?
   - Graph A: ________________________________
   - Graph B: ________________________________
2. Compare and contrast the change in heart rate in the two graphs.
3. What components of the graphs do you see?
4. What can you tell about the data from looking at the graphs?

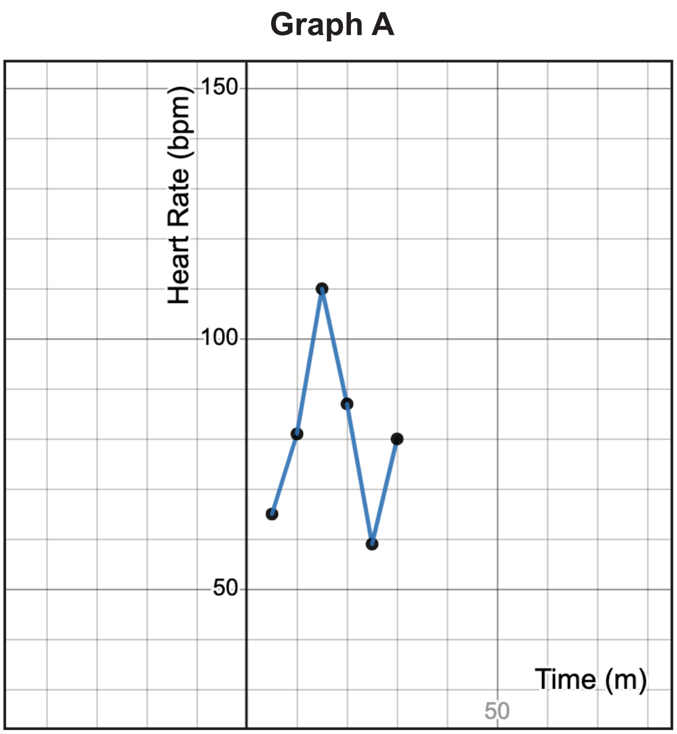
Name______________________________________ Date______________ Period __________

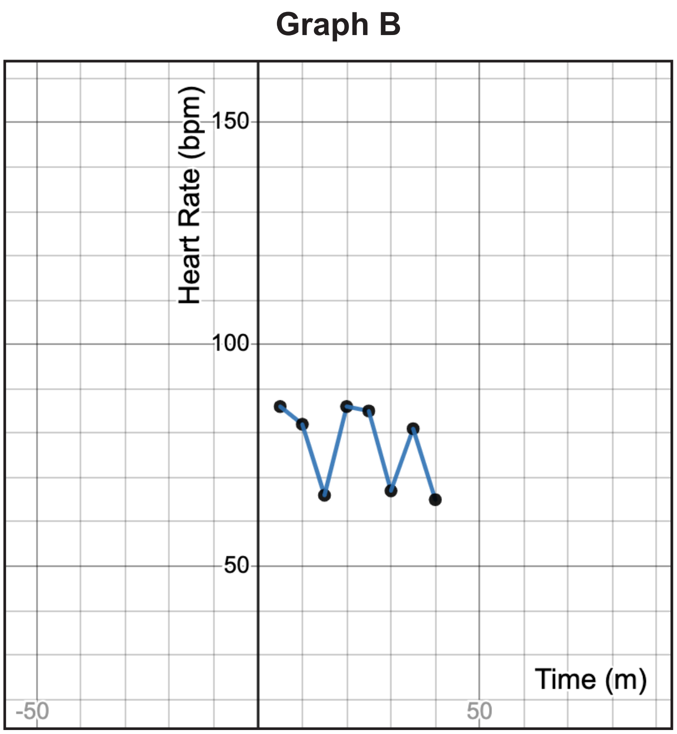
1.E.4 Context Homework

Testing Stress

Testing Stress is something that most of us have felt and likely will feel again. Take a look at the two graphs. One shows an individual taking a test, and the other is of an individual working a shift at their job. Use the graphs to answer the questions below.

Effects of School and Work on Heart Rate Variability





1. Which game is represented in Graph A and in Graph B? Why do you think this?
   - Graph A: ________________________________
   - Graph B: ________________________________
2. Compare and contrast the change in heart rate in the two graphs.
3. What components of the graphs do you see?
4. What can you tell about the data from looking at the graphs?

1.F Problem Scoping Example

Section 1

Directions: Please answer the following questions.

1. What do engineers do?

   Answers will vary but here is one example: Design products or processes to solve problems.

2. How do engineers solve problems?

   Answers will vary but here is one example: They use science and math knowledge, creativity, and the EDP.

Section 2

Directions: Please answer this question after hearing about the engineering challenge.

3. What questions do you want to ask to the client?

Section 3

Directions: Please answer these questions after you have been able to ask questions about the challenge.

First, on your own, complete each prompt. Then write your revised answer (if different) to the prompt, based on the discussion with your team. You may use a different color writing utensil to distinguish your answer and how it changed after talking with teammates.

4. The client is:

   Ex: Art Beet from Relief

1.F Problem Scoping Example

5. The client's problem is:

   Answers will vary but here is one example: High school students are too stressed.

6. The problem is important to solve because:

   Ex: Too much negative stress overtime can be bad for teen health.

7. The end users are:

   Ex: High school students and counselors.

8. An effective solution for the client will meet the following criteria:

   Ex: Interrupt instances of high negative stress.

9. The constraints (or the limits) of the solution are:

   Ex: Use a specific heart rate sensor, incorporate a math concept.

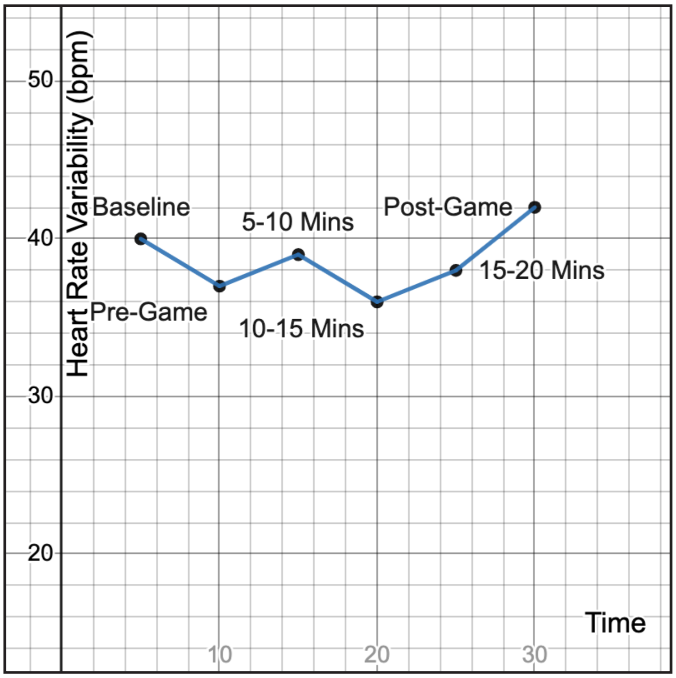
10. Think about the problem of coping with stress. In terms of monitoring heart rate, what are 2 things you need to learn in order to develop a stress intervention method? Make sure to consider all important aspects of the problem. Be specific.

    Ex: (1) Learn what math concepts will work for monitoring stress.
    (2) What heart rates are considered an indicator of negative stress.

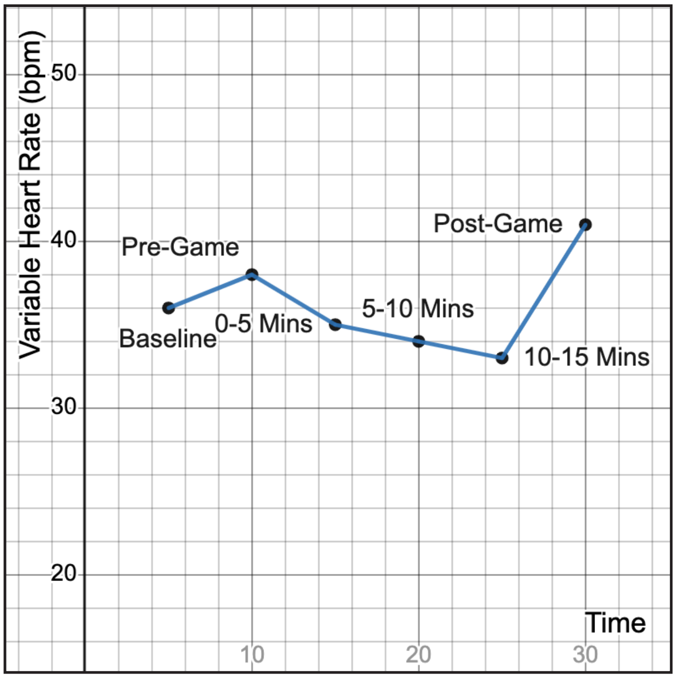
1.G Context Homework Key

1.E.1 Video Game Graphs

Graph A = Mortal Kombat

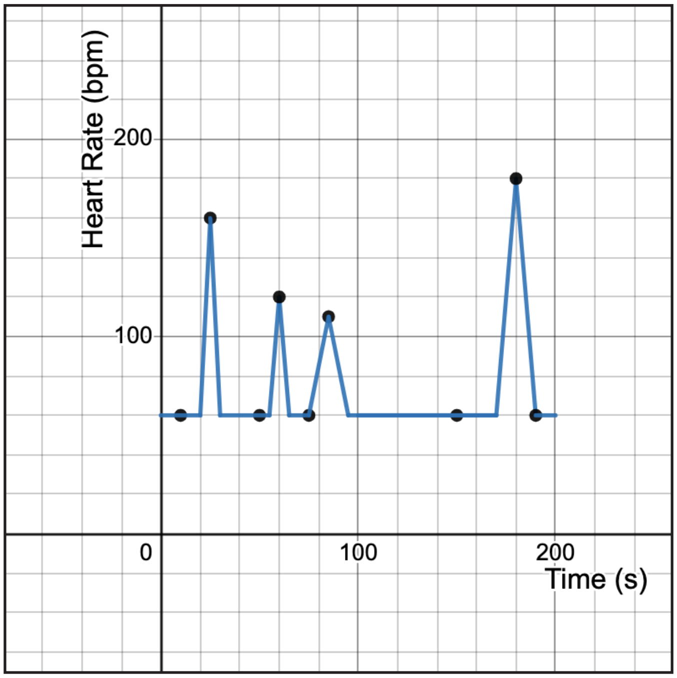


Graph B = Tetris

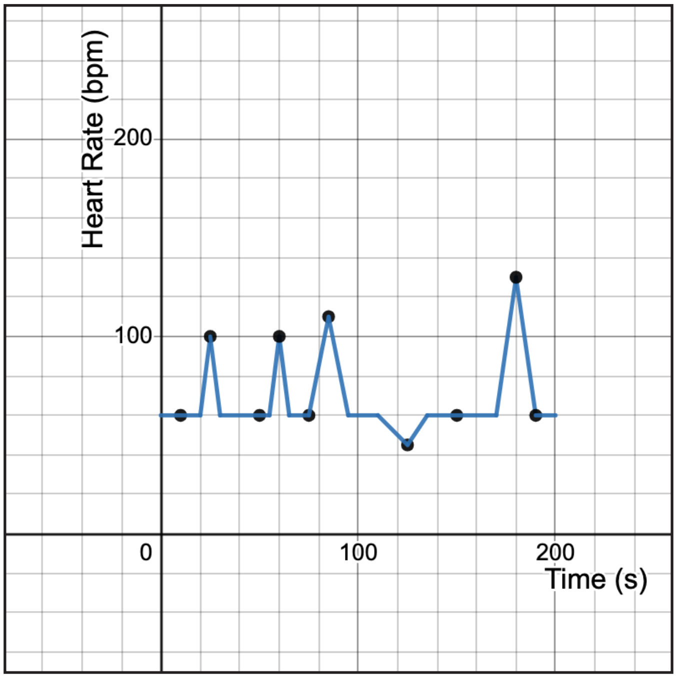


1.E.2 TV Show Graphs

Graph A = Game show



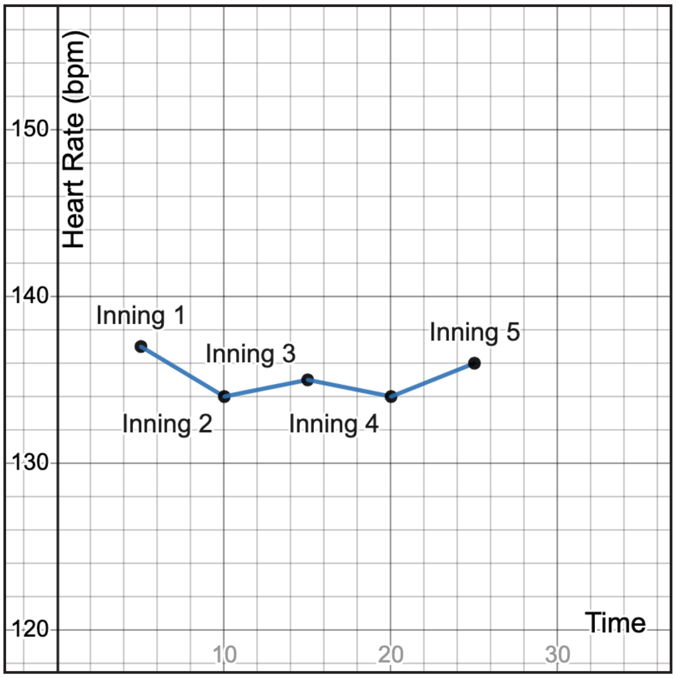
Graph B = Drama show



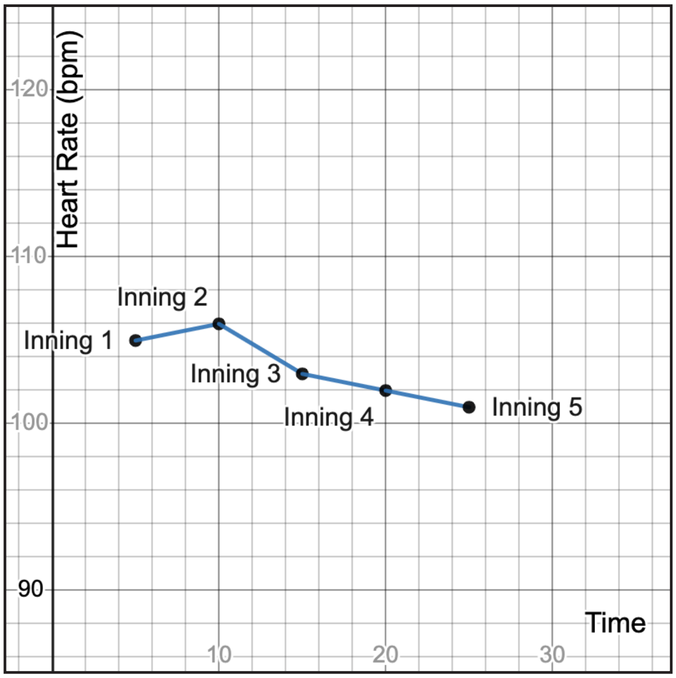
1.G Context Homework Key

1.E.3 Sports Stress Graphs

Graph A = Playing Baseball

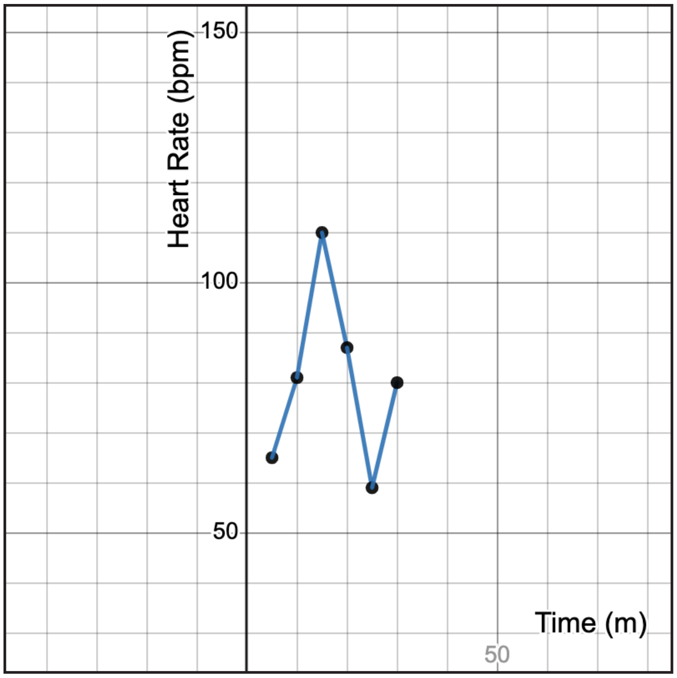


Graph B = Watching Baseball

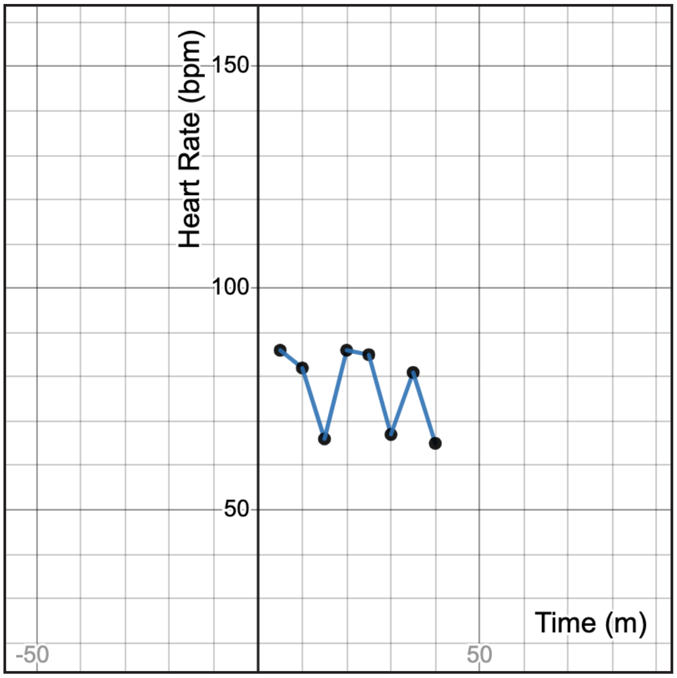


1.E.4 Testing Stress Graphs

Graph A = Taking a test



Graph B = Working a shift



LESSON TWO:

Lesson Objectives
Students will be able to:
- Identify x- and y-intercepts
- Find zeros of functions algebraically
- Find zeros of functions graphically
- Interpret graphs using health-based data

Materials
Per classroom
- EDP Poster

Per Team
- None

Per student
- EDP slider and paperclip
- Laptop or equivalent device
- Engineering notebook

Time Required
Two 45-minute lessons

Standards Addressed
IAS Mathematics
- PS.1, PS.2, PS.3, PS.4, PS.5, PS.6
- AII.FF.2, AII.FF.3, AII.FF.4
- PC.F.1, PC.F.2

IAS Science and Engineering Practices
- HS.DM.1

Key Terms
- x-intercepts (solutions, zeros, roots)
- y-intercepts

Lesson Summary

Students will learn about x- and y-intercepts and finding zeros of functions algebraically and graphically. Students will interpret graphs using this knowledge from health-based data.

Background

Teacher Background

The purpose of this lesson is to review factoring polynomials and get students comfortable using Desmos through learning about intercepts/zeros. This lesson assumes that students have some prior instruction on factoring. They will be asked to create a flowchart mapping out the process of factoring different polynomials. This activity is meant to serve as a review of factoring but if students are not comfortable, you may need to spend more time discussing grouping and difference of squares before beginning this lesson. After a review of factoring, students will need to use a device like a Chromebook or iPad with access to Desmos to complete activities on algebraically and graphically finding zeros. Because a lot of the “learn” lessons utilize Demos in some capacity, students should create an account to be used throughout this engineering design unit. Instructors can use the Desmos activities linked in this curriculum to monitor student work and check for understanding mid-activity. There are also opportunities for students to collaborate with classmates within the Desmos activities.

Before the Activity

- Use the list of 2.A Flowchart Factoring Types to create a classroom example similar to the 2.B Flowchart Example that best fits your previous classroom instruction on factoring.
- Make copies of the duplication masters:
  - 2.C Understanding Intercepts (1 per student)
  - 2.D Factor to Graph (1 per student)
  - 2.E Zero Homework (1 per student)

Classroom Instruction

Introduction

1. **Discuss 1.F Homework assignment.** Group students by topic so they can discuss the articles they read before class. Ask them to identify and talk about elements of the graphs that surprised them or did not surprise them. Have students share their observations with the class.

2. **Tie in the engineering problem. Ask:** *What is our engineering design problem?* Students may need to revisit the original client letter to remind themselves of the engineering design challenge.

3. **Identify where they are in the engineering design process (Learn). Say:** *So far, we have defined the problem with help from our client.* Point out the "Define" block on the engineering design process and have students look at their Engineering Design Process sliders. **Say:** *Before we can start designing solutions, we need more information*. **Ask:** *What step of the engineering design process are we in now?* Students should identify that they are in the "Learn" phase.

4. **Identify what students need to learn about. Say:** *In the previous lesson, you brainstormed what we need to learn about.* **Ask:** *What were some of those concepts that we need to learn?* Remind students to refer to their notes from the previous lesson. **Say:** *To learn the math concepts we need to know to solve the client's problem, we first need to review factoring.*

Activity

5. **Introduce factoring flowchart activity. Say:** T*o review factoring, each group will work together to make a flowchart. Your goal is to create a flowchart that an Algebra I student could use to factor any polynomial up to 4 terms.* Hand out copies of 2.A Flowchart Factoring Types to each student. **Say:** *You can use this list as a starting point for the flowchart your team will make in your engineering notebooks.* After they are done have students display their flowcharts (do a gallery walk, have students post on post-it notes, etc) to see the different flowcharts, then walk through the 2.B Flowchart Example as a class to make sure students understand how it works. NOTE: If students need help, provide them with a starting point using the 2.B Flowchart Example.

6. **Understanding intercepts using Desmos.** Have students walk through the 2.C Understanding Intercepts activity individually. They will need to be able to access Desmos.com on their device to complete the intercept exploration. After students have completed the activity encourage them to take notes on what they have learned in their engineering notebook.

7. **Connect algebraic factoring to graphs.** Have students walk through the 2.D Factor to Graph activity individually. They will

Assessments

Pre-Activity Assessment

Listen to group discussion of the articles that students read for homework to assess their comfort with graphical interpretation of real-world data. Check for student completion of the associated reading comprehension questions.

Activity Embedded Assessment

When reviewing factoring, use student factoring flowcharts to assess their understanding of the factoring process from previous learning experiences. Listen to student reflections after completing the 2.D Factor to Graph activity and use the 2.G Factor to Graph Key to formally assess their work.

Post-Activity Assessment

Use the class discussion on the importance of intercepts to evaluate the review of factoring and zeros. Grade the 2.E Zero Homework for assessment on an individual-student basis of finding intercepts algebraically and graphically using the 2.H Zero Homework Key.

Duplication Masters

- 2.A Flowchart Factoring Types
- 2.C Understanding Intercepts
- 2.D Factor to Graph
- 2.E Zero Homework

Educator Resources

- 2.B Flowchart Example
- 2.F Understanding Intercepts Key
- 2.G Factor to Graph Key
- 2.H Zero Homework Key

need to solve the algebraic equations BEFORE graphic results in Desmos. After they are done, lead a class discussion to help students reflect on any difficulties they had factoring the functions.

8. **Discuss importance of zeros (x-intercepts, solutions) & y-intercepts.** Have a discussion with students about why they will need to understand these concepts for the unit. **Say:** *To be prepared to solve the engineering challenge and to be able to understand the next math concepts, we will all need to be comfortable finding intercepts (or finding zeros).* Additionally, you can review the concepts in this lesson using Khan Academy here: https://www.khanacademy.org/math/algebra/x2f8bb11595b61c86:linear-equations-graphs/x2f8bb11595b61c86:x-intercepts-and-y-intercepts/a/intercepts-of-lines-review-x-intercepts-and-y-intercepts.

Closure

9. **Connect the activity to the engineering design challenge. Ask:** *What did we learn today that will help us provide a solution to the client? Why is factoring and finding intercepts important? How can we use graphical knowledge to understand health related data?* Students should understand that being able to identify features of graphs like zeros can help them interpret and describe what the graph represents. **Say:** *We will continue the Learn phase of the EDP during our next class.*

10. **Assign the homework.** Introduce the 2.E Zero Homework assignment to help students review intercepts explaining that the problems they are going to solve are all about health and stress related data.

2.A Flowchart Factoring Types

1. Check for a GCF

2. 2 Terms

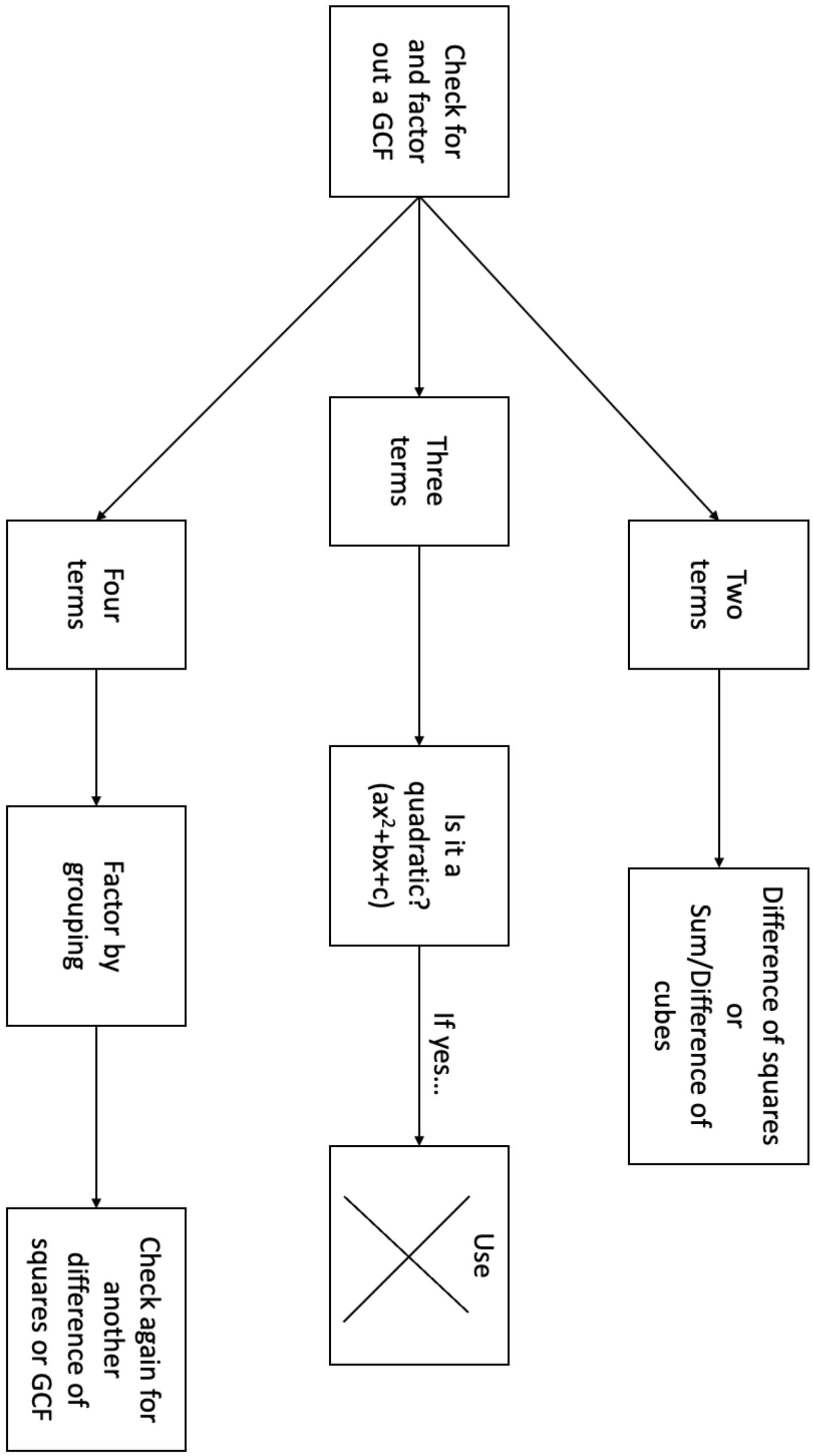
3. 3 Terms

4. 4 Terms

5. Check for another difference of squares or a GCF

6. Check again for a DOS or GCF!!!

2.B Flowchart Example



Name______________________________________ Date______________ Period __________

2.C Understanding Intercepts

Begin by going to *Desmos.com* on your device. Then follow the steps below to answer questions using Demos graphs.

1. Type in this function: $f(x) = x^3 - 4x$

   The function you just entered has three x-intercepts. List all of the intercepts below in the appropriate category.

   a. x-intercept(s):

   b. y-intercept(s):

2. Type in this function: $f(x) = x^3 - 2x^2$

   The function you just entered has two x-intercepts.

   a. Identify which intercepts they are:

   b. Explain how you know:

3. Explore the parent function, $f(x) = x^3$. Does this graph have an intercept?

4. Remember we will need to use math knowledge in our design challenge and be able to explain our decisions using math reasoning to our client. If you only have a few sentences to communicate what we are learning to our client, WRITE what you would say to explain intercepts and parent functions to someone who has never taken a math class before.

Name____ Date_______________ Period __________

2.D Factor to Graph

In the first part of this activity, you will need to factor each of the following functions.

1. $f(x) = x^2 - 4$

2. $f(x) = x^2 + 11x + 28$

3. $f(x) = x^3 - x^2 - x + 1$

4. $f(x) = 5x^3 + 15x^2 + 75x + 225$

5. $f(x) = x^4 - 2x^3 + 7x - 14$

6. $f(x) = x^3 + 6x^2 - 3x - 18$

7. $f(x) = x^3 + x^2 - 12x$

8. $f(x) = x^4 - 25x^2 + 144$

Name______________________________________ Date______________ Period ___________

2.D Factor to Graph

In the second part of this activity, graph the original function in Desmos. Then graph your factored version to see if you factored the equation correctly. Circle whether the factored graph was the same or different from the original equation. If the two graphs are different, you will need to fix the factoring mistake. If you circle different, try factoring again and write the correct factored equation in the space below. Once you have a correctly factored equation, identify and write the x-intercepts.

1. SAME or DIFFERENT — Correct Answer ______________________ Zeros ______________________

2. SAME or DIFFERENT — Correct Answer ______________________ Zeros ______________________

3. SAME or DIFFERENT — Correct Answer ______________________ Zeros ______________________

4. SAME or DIFFERENT — Correct Answer ______________________ Zeros ______________________

5. SAME or DIFFERENT — Correct Answer ______________________ Zeros ______________________

6. SAME or DIFFERENT — Correct Answer ______________________ Zeros ______________________

7. SAME or DIFFERENT — Correct Answer ______________________ Zeros ______________________

8. SAME or DIFFERENT — Correct Answer ______________________ Zeros ______________________

Name______________________ Date______________ Period ________

2.E Zero Homework

Read these instructions carefully so you can follow the steps for the following equations:

1. Factor each equation then write the zeros in the space provided
2. Circle the zeros on each graph and write them in the space provided below each graph
3. Use the zeros you found by factoring and visually looking at the graph to match the graphs (A-F) to their corresponding equation (1-6).

1. $f(x) = x^2 - 4$

Zeros: _____________; Graph: ___

2. $f(x) = x^3 - 4x^2 - 21x$

Zeros: _____________; Graph: ___

3. $f(x) = x^3 + x^2 - 3x - 3$

Zeros: _____________; Graph: ___

4. $f(x) = x^3 + 15x^2 + 75x + 125$

Zeros: _____________; Graph: ___

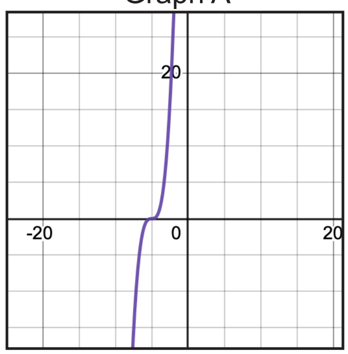
5. $f(x) = x^4 + 2x^3 - 48x^2$

Zeros: _____________; Graph: ___

6. $f(x) = x^4 - 40x^2 + 144$

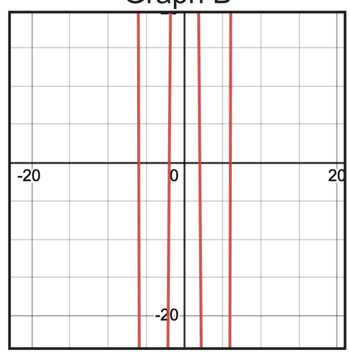
Zeros: _____________; Graph: ___

Graph A



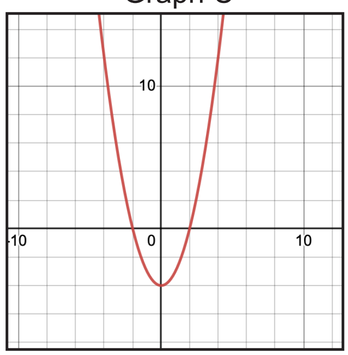
Zeros: __________

Graph B



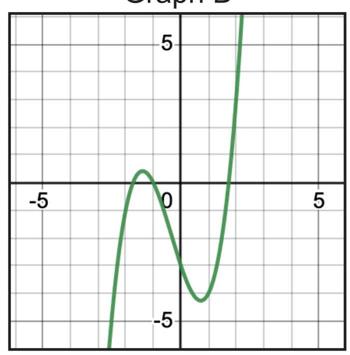
Zeros: __________

Graph C



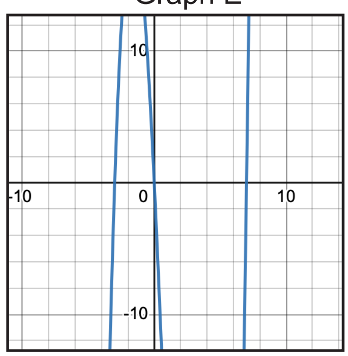
Zeros: __________

Graph D



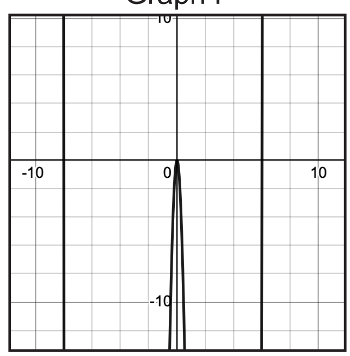
Zeros: __________

Graph E



Zeros: __________

Graph F



Zeros: __________

2.F Understanding Intercepts Key

Begin by going to *Desmos.com* on your device. Then follow the steps below to answer questions using Demos graphs.

1. Type in this function: $f(x) = x^3 - 4x$

   The function you just entered has three x-intercepts. List all of the intercepts below in the appropriate category.

   a. x-intercept(s): [-2, 0, 2]

   b. y-intercept(s): [0]

2. Type in this function: $f(x) = x^3 - 2x^2$

   The function you just entered has two x-intercepts.

   a. Identify which intercepts they are: [x-intercepts: 0, 2; y-intercept: 0]

   b. Explain how you know: [Looking at the Desmos graph or factoring the function]

3. Explore the parent function, $f(x) = x^3$. Does this graph have an intercept?

   [Yes. The intercept is at x=0, y=0]

4. Remember we will need to use math knowledge in our design challenge and be able to explain our decisions using math reasoning to our client. If you only have a few sentences to communicate what we are learning to our client, WRITE what you would say to explain intercepts and parent functions to someone who has never taken a math class before.

   Answers will vary.

2.G Factor to Graph Key

In the first part of this activity, you will need to factor each of the following functions.

1. $f(x) = x^2 - 4$

   ANSWER: $f(x) = (x - 2)(x + 2)$

2. $f(x) = x^2 + 11x + 28$

   ANSWER: $f(x) = (x + 7)(x + 4)$

3. $f(x) = x^3 - x^2 - x + 1$

   ANSWER: $f(x) = (x - 1)(x + 1)(x - 1)$

4. $f(x) = 5x^3 + 15x^2 + 75x + 225$

   ANSWER: $f(x) = (x + 3)(x^2 + 15)$

5. $f(x) = x^4 - 2x^3 + 7x - 14$

   ANSWER: $f(x) = (x^3 + 7)(x - 2)$

6. $f(x) = x^3 + 6x^2 - 3x - 18$

   ANSWER: $f(x) = (x^2 - 3)(x + 6)$

7. $f(x) = x^3 + x^2 - 12x$

   ANSWER: $f(x) = (x - 3)(x + 4)(x)$

8. $f(x) = x^4 - 25x^2 + 144$

   ANSWER: $f(x) = (x - 3)(x + 3)(x - 4)(x + 4)$

2.H Zero Homework Key

Read these instructions carefully so you can follow the steps for the following equations:

1. Factor each equation then write the zeros in the space provided
2. Circle the zeros on each graph and write them in the space provided below each graph
3. Use the zeros you found by factoring and visually looking at the graph to match the graphs (A-F) to their corresponding equation (1-6).

1. $f(x) = x^2 - 4$

ANSWER: $f(x) = (x - 2)(x + 2)$

Zeros: -2, 2 ; Graph: C

2. $f(x) = x^3 - 4x^2 - 21x$

ANSWER: $f(x) = (x - 7)(x)(x + 3)$

Zeros: -3, 0, 7 ; Graph: E

3. $f(x) = x^3 + x^2 - 3x - 3$

ANSWER: $f(x) = (x^2 - 3)(x + 1)$

Zeros: -sqrt(3), -1, sqrt(3) ; Graph: D

4. $f(x) = x^3 + 15x^2 + 75x + 125$

ANSWER: $f(x) = (x + 5)^3$

Zeros: -5, -5, -5 ; Graph: A

5. $f(x) = x^4 + 2x^3 - 48x^2$

ANSWER: $f(x) = (x + 8)(x^2)(x - 6)$

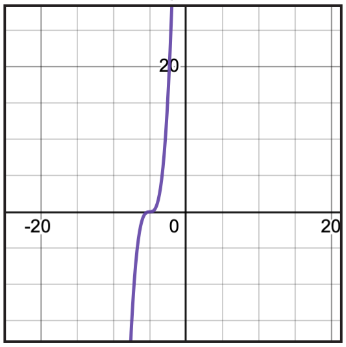
Zeros: -8, 0, 0, 6 ; Graph: F

6. $f(x) = x^4 - 40x^2 + 144$

ANSWER: $f(x) = (x + 2)(x - 6)(x - 2)(x + 6)$

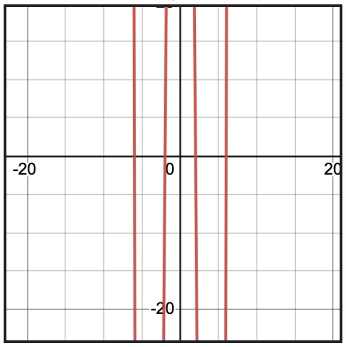
Zeros: -6, -2, 2, 6 ; Graph: B

Graph A



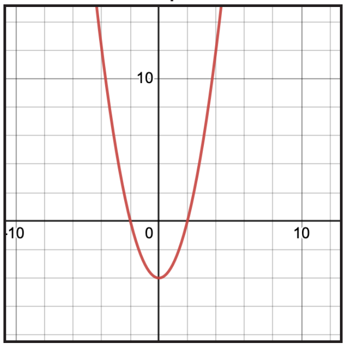
Zeros: -5, -5, -5

Graph B



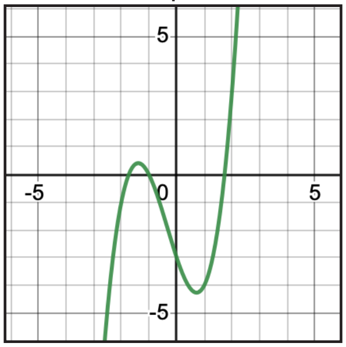
Zeros: -6, -2, 2, 6

Graph C



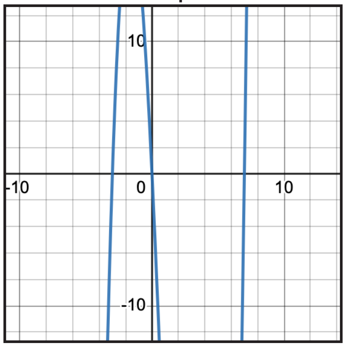
Zeros: -2, 2

Graph D



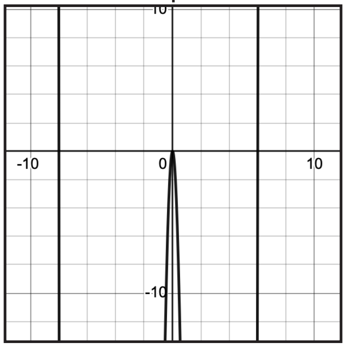
Zeros: -sqrt(3), -1, sqrt(3)

Graph E



Zeros: -3, 0, 7

Graph F



Zeros: -8, 0, 0, 6

LESSON THREE:

Lesson Objectives
Students will be able to:
- Identify critical points
- Identify relative/absolute maximum/minimum
- Identify increasing/decreasing intervals
- Analyze graphs using specific health-based data

Materials
Per classroom
- EDP Poster

Per team
- None

Per student
- EDP slider and paperclip
- Laptop or equivalent device
- Engineering notebook

Time Required
Two 45-minute lessons

Standards Addressed
IAS Mathematics
- PS.1, PS.2, PS.3, PS.4, PS.5, PS.6
- AII.FF.2, AII.FF.3, AII.FF.4
- PC.F.1

IAS Integrated STEM
- HS.DM.1

Key Terms
- critical points
- relative/absolute
- maximum/minimum
- increasing/decreasing
- stress

Lesson Summary

Students will learn about critical points, relative/absolute extrema, and increasing/decreasing behavior. Students will compare data between short-term stress and long-term stress. Specific to their interest, students will analyze graphs with the new concepts and critically think about what happened. Increasing and decreasing intervals of a graph will be demonstrated using Desmos.

Background

Teacher Background

To be able to complete the activity in this lesson students will need to have access to Desmos, specifically through the Desmos classroom setup. The teacher will need to go to the Desmos link for each activity and create a classroom so students can join and work through each activity about extrema and increasing/decreasing behavior. Using the classroom function, the teacher can monitor student understanding and progress through the slides, games, and assessments. Additionally by setting up activities through a specific classroom, teachers can have students work together like during the polygraph activity in this lesson.

Before the Activity

- Make copies of the duplication masters:
  - 3.A Relative Stress Data (1 per student)
  - 3.B Client Memo 1 (1 per student)
  - 3.C Sensor Homework (1 per student)

Classroom Instruction

Introduction

1. **Discuss 2.E Zero Homework.** Give students time to ask any questions they had about the homework assignment.

2. **Tie in the engineering problem. Ask:** *What is our engineering design problem?*

3. **Identify where they are in the engineering design process (Learn). Say:** *So far, we have defined the problem and started to learn about the math concepts we will need to use to help the client.* Point out the “Learn” block on the engineering design process and have students look at their Engineering Design Process sliders. **Say:** *Before we can start designing solutions,*

we need more information. **Ask:** *What step of the engineering design process are we in?* Students should identify that they are still in the "Learn" phase.

4. **Identify what students need to learn about. Ask:** *What did we learn about in the previous lesson?* Remind students to refer to their notes from the previous lesson. Students should identify that they learned about algebraically and graphically finding intercepts. **Ask:** *What are the remaining math concepts we need to know to solve the client's problem?* Wait for student responses. **Say:** *Today we will be learning about critical points, extrema, and increasing/decreasing behavior using health-related graphs.*

Activity

5. **Introduce critical points definition.** Introduce or review critical points while students take notes in their engineering notebooks. Feel free to use any lecture material or teaching tools you are comfortable with when defining critical points. Have a brief class discussion about what they've learned and answer any questions.
6. **Discuss the difference between relative and absolute extrema.** Have students individually complete the Desmos activity on extrema. https://teacher.desmos.com/activitybuilder/custom/64ff6a0b566fb55d5cda6b74 After they have finished, discuss what they learned as a class and answer any questions.
7. **Compare data between short-term stress and long-term stress.** Pass out 3.A Relative Stress Data to each student. Have them work individually, to identify relative and absolute extrema associated with all of the stress-related data, taking notes in their engineering notebooks or directly on the graphs.
8. **Introduce increasing and decreasing behavior.** Provide the Desmos link to students so they can work through the activity on increasing and decreasing behavior. https://teacher.desmos.com/activitybuilder/custom/6500bf75a517f85b317fbc9f After they have finished discuss what the learned as a class and answer any questions.
9. **Make observations about specific interest graphs.** Revisit 3.A Relative Stress Data instructing students to focus only on their design teams' interest area (sports, video games, etc.). As they work in their groups, encourage students to

Assessments

Pre-Activity Assessment

Review student homework to make sure they understand intercepts and factoring.

Activity Embedded Assessment

Monitor discussions about 3.A Relative Stress Data to check for understanding of relative and absolute extrema in the context of stress.

Post-Activity Assessment

Review student work from Desmos activities to check for student understanding of math concepts (i.e., critical points, extrema, etc.) and comfort with math vocabulary.

Duplication Masters

- 3.A Relative Stress Data
- 3.B Client Memo 1
- 3.C Sensor Homework

Educator Resources

- 3.D Sensor Homework Example

make observations about extrema, intercepts, and increasing/decreasing behavior associated with their specific dataset.

10. **Desmos polygraph game.** Provide students with the link to the polygraph game. https://teacher.desmos.com/activitybuilder/custom/6500c0477f10e72b0bedb64b **Say:** *This game works similar to Guess Who so you will be paired with a classmate and each of you will be given a secret graph. Whoever is going first will ask a yes/no question about the graphs to attempt to eliminate the incorrect options. Use questions about absolute and relative maximum or minimum, critical points, increasing and decreasing behavior, and any previous math concepts you have learned about graphs. You will alternate eliminating graphs to try to guess your classmate's secret graph.* After students begin the activity, answer any questions they have. Additionally, you can make a list of example questions for the class that they could start with in case your students get stuck.

11. **Reflect on polygraph activity.** Ask students what they found challenging about the game encouraging them to think about what math concepts came easy to them and what was hard to ask/answer about their graphs. Have students reflect about their math knowledge in their engineering notebooks.

Closure

12. **Read 3.B Client Memo 1.** Give students time to read and take notes on client memo 1 in their engineering notebooks. As a class, discuss what students think they will need to learn about next.

13. **Connect the activity to the engineering design challenge. Ask:** *What did we learn today that will help us better design a solution to our engineering challenge? How can knowledge of relative and absolute extrema and critical points be helpful when monitoring human stress and overall health?*

14. **Assign homework about sensors in healthcare.** Students should read the 3.C Sensor Homework article and answer the reading comprehension questions. The article is from a blog post by a company that sells sensors used in healthcare. Encourage students to pay more attention to the sensor function rather than who makes and sells them, because there are many of these types of companies.

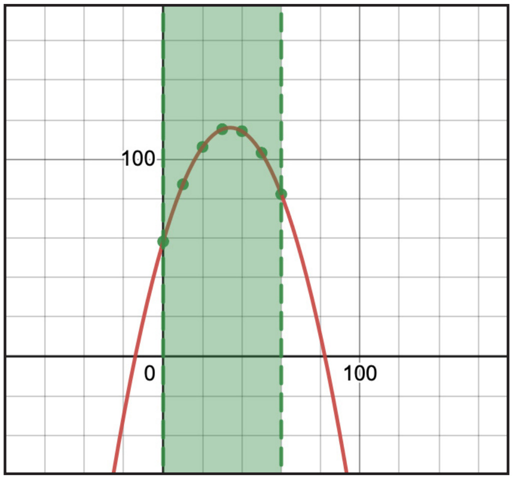
3.A Relative Stress Data

Instructions: For the following situations, find the absolute max and min as well as the relative max and min (in the shaded domains. Additionally, discuss what you think would happen to the heart rate of those measured in the hour after the hockey game or exam ended.

Heart Rate Variability for Spectators at a Hockey Game

- Data were recorded for the last hour of the game (green points)
- The function which best fit the data is represented with solid red line
- The green shaded domain represents the last hour of the game

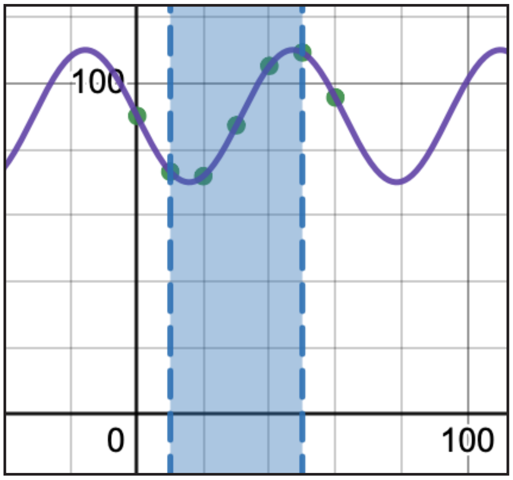
x (time in minutes)	f(x) (heart rate in BPM)
0	58.2
10	87.2
20	106.2
30	115.2
40	114.2
50	103.2
60	82.2



Heart Rate Variability for College Students Taking an Exam

- Data were recorded during the 40 minute exam as well as 10 minutes before and after (green points)
- The function which best fit the data is represented with purple solid line
- The blue shaded domain represents the 40 minute exam

x (time in minutes)	f(x) (heart rate in BPM)
0	90
10	73.2
20	71.8
30	87.2
40	105.1
50	109.2
60	95.6



Data simulated based on the following studies: https://files.eric.ed.gov/fulltext/EJ876527.pdf ; https://onlinecjc.ca/article/S0828-282X(17)30903-0/fulltext

3.B Client Memo 1

Dear Engineers,

Thank you for agreeing to work with us on the engineering design challenge. Previously you began learning about or reviewing some of the math concept you will likely need to know to develop a successful stress intervention method for teens. Hopefully you will be able to apply your knowledge of math concepts like zeros, extrema, and continuity to make evidence-based design decisions using graphical analysis.

To understand how to use devices to monitor stress, you will need to learn more about microelectronics. I hope the next lesson and activity will help you better understand the challenge at hand. The information provide on sensors may be of use to you.

Sincerely,

Art Beet

Art Beet
Consulting Engineer – Mental Health Outreach
Revitalizing Lives in Educational Facilities (RELIEF)

Name____ Date_______________ Period __________

3.C Sensor Homework

Instructions: Read the article about sensors in healthcare and answer the questions below. The full-text blog post can be found here: https://sps.honeywell.com/us/en/support/blog/siot/complete-guide-to-medical-sensors-benefits-and-applications

Reading Comprehension Questions:

1. Choose a type of sensor mentioned in the article. What sensor did you choose?

2. In what application(s) is that sensor used in? (What does it sense? Where is it located on the patient/in the hospital setting?)

3. What is an example of the device that this sensor would be used in? What is the function of that device?

Ilie, A. (2021, June 14). Sensing better health: Complete guide to medical sensors – benefits and applications. *Honeywell International Inc.* https://sps.honeywell.com/us/en/support/blog/siot/complete-guide-to-medical-sensors-benefits-and-applications

Name____ Date_______________ Period __________

3.D Sensor Homework Example

Instructions: Read the article about sensors in healthcare and answer the questions below. The full-text blog post can be found here: https://sps.honeywell.com/us/en/support/blog/siot/complete-guide-to-medical-sensors-benefits-and-applications

Reading Comprehension Questions:

1. Choose a type of sensor mentioned in the article. What sensor did you choose?

   EXAMPLE: Oxygen sensor

2. In what application(s) is that sensor used in? (What does it sense? Where is it located on the patient/in the hospital setting?)

   EXAMPLE: Oxygen sensors typically help regulate the composition of the air delivered to patients in a hospital setting. They can measure and adjust to make sure the air has a certain amount of oxygen.

3. What is an example of the device that this sensor would be used in? What is the function of that device?

   EXAMPLE: Oxygen sensors are used in ventilators, anesthesia delivery machines, and oxygen concentrators

Ilie, A. (2021, June 14). Sensing better health: Complete guide to medical sensors – benefits and applications. *Honeywell International Inc.* https://sps.honeywell.com/us/en/support/blog/siot/complete-guide-to-medical-sensors-benefits-and-applications

LESSON FOUR:

Lesson Objectives
Students will be able to:
- Use a micro:bit to collect data representing student health
- Identify how microelectronics are used in everyday life

Per classroom
- EDP Poster

Per group
- Micro:bit
- Heart rate sensor
- (3) Alligator clip wires
- Micro-USB cord

Per student
- EDP slider and paperclip
- Laptop or equivalent device
- Engineering notebook

Time Required
One 45-minute lesson

Standards Addressed
IAS Mathematics
- PS.5, PS.7

IAS Science and Engineering Practices
- SEP.2, SEP.4

IAS Integrated STEM
- HS.CC.2, HS.DM.2

Key Terms
- microelectronics
- coding
- analysis
- data collection

Lesson Summary
This lesson explores microelectronics and introduces the micro:bit. Students will collect heart-rate readings in different scenarios of their interest – sports (running in place), video games (apps on phone, console connected to TV), watching intense/dramatic TV show. The class will compare the stress between the different data.

Background
Teacher Background
Micro:bits are a type of micro-controller, so called because they have most of the controls of a computer, but in a much smaller "micro" package. These devices have chips that are responsible for all of the features, such as lights and sound outputs, and input reception from the on-board buttons or a computer via the micro-usb cable. These devices are made even more powerful when used with sensors that give the micro:bit the ability to sense all types of things from temperature, moisture, or in this case heart rate. Students will learn about the constraints of the equipment, the pros and cons of using the sensor. In this lesson, students will work together in small groups to get the heart rate monitors, micro:bit, and provided code to function as designed.

Before the Activity
- Make sure YouTube Video can play, and put a Micro:bit kit out for every group of students
- Make sure the groups are able to download the code. You will be letting each student measure their heart rate to practice getting different readings and seeing approximate ranges for an average sitting heart rate.

Classroom Instruction
Introduction
1. **Connect to Challenge. Say:** *Today we are going to get our feet wet with the technology we are going to use to measure our stress. Today we are going to be measuring our resting heart rates.*
2. **Identify Current Phase of Engineering Design Process. Say:** *We are in the Learn phase, taking a break from the math learning to learn about the technology.*
3. **Talk about microelectronics relevance.** Ask if students have heard anything about the new microelectronics industry work that is coming to Indiana. Talk about where microelectronics are

most commonly found in the devices that we use every day.

4. **Play video.** This is an older video from a German manufacturing company, but it is a quick snapshot of the most common use cases of microelectronics, and could be used to visualize the type of industry the United States hopes to build in Indiana. https://www.youtube.com/watch?v=XzzLw4Vvr2o

Activity

5. **Discuss homework with class.** Have students share with their shoulder partner how they answered each question, or share with the class. Ask students to share out with their shoulder partner or group. Have 3+ students share out to the class their sensor choice, use cases, and applications.
6. **Introduce microelectronics.** Have students write a definition of microelectronics in their own words, along with one example.
   a. Sample Response: Microelectronics is really, really tiny electrical systems that allow our cell phones and other tech to be so much slimmer and smaller than they used to be.
   b. A Definition from Technopedia: Microelectronics is a subdivision of the field of electronics that deals with very small and microscopic elements to manufacture electronic components. Microelectronics has been rapidly evolving as the most in-demand field of electronics because of the ever-increasing demand for inexpensive and lightweight equipment.
7. **Build measuring devices. Say:** *Now we are going to build the devices we will use to measure pulse. Once we get a base reading of everyone's resting heart rate, we will do some testing on the effect of different stressors.* See Duplication Masters 4.A
   a. Have students sitting in their teams from the homework assignment, these will be their teams for the rest of the project
8. **Work in teams to collect data. Say:** *Alright everyone finished? Well, those who are can start collecting data, you will each take a full minute holding the pulse sensor and recording the data to get your average.* See Duplication Masters 4.B
   a. Have Each student time themselves holding the pulse sensor while the code runs for 60 seconds
   b. Click the 'Export' Button in the top right corner of the screen

Assessments

Activity Embedded Assessment

Students will be executing code in this lesson, a functioning code and graph is evidence of lesson comprehension.

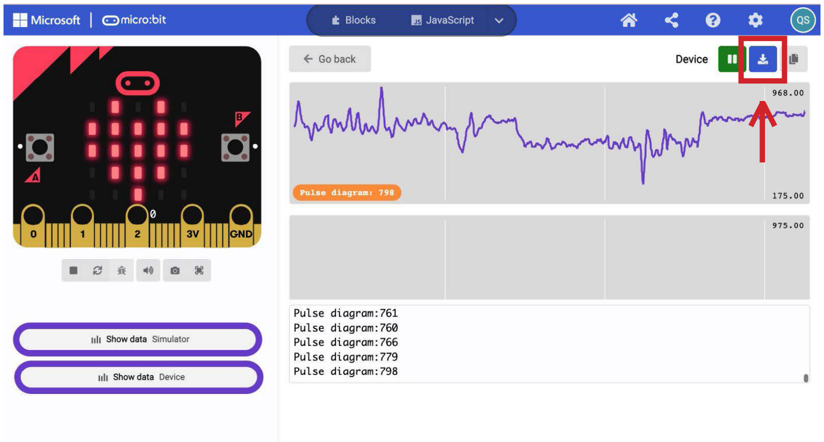
Duplication Masters

- 4.A Micro:bit Assembly Guide
- 4.B Coding Instructions
- 4.C Conversion to Graph Instructions

Educator Resources

- https://microbit.org/

c. Students will need to copy and paste the data readout into a Google Sheet, and take an average. See Duplication Master 4.C



Closure

9. **Connect the activity to the EDP: Say:** *We are learning about the equipment that you will use to solve the problem. This will help you plan your solution.*
10. **Assign homework.** Make sure students are able to access either a digital or printed version of their heart rate from this activity. Have students compare resting heart rate values with each other, and make a list of things that may cause stress in their lives by raising their heart rate. For homework, students should be analyzing their heart rate graphs an circling sections which can be represented by math concepts they are familiar with. For example, they can find the absolute maximum and minimums as well as the number of intercepts.

4.A Micro:bit Assembly Guide

Figure 1. A micro:bit and USB to micro-USB Cable

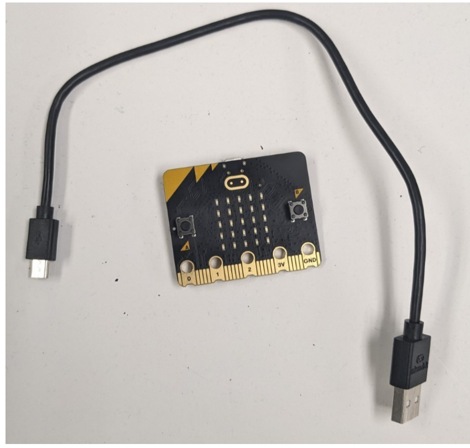
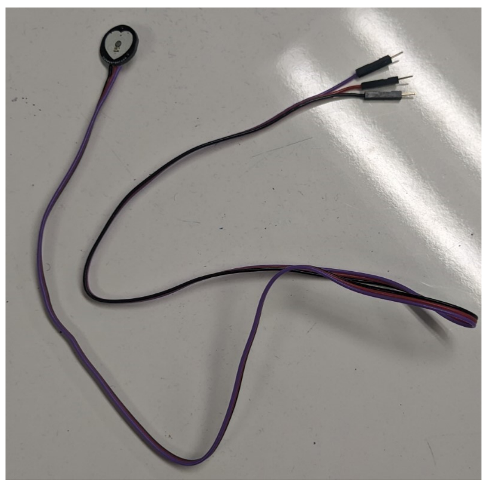
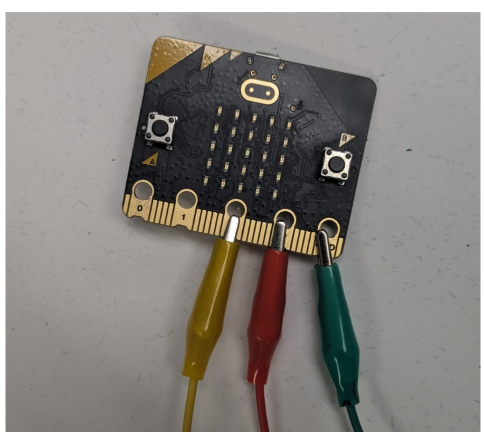


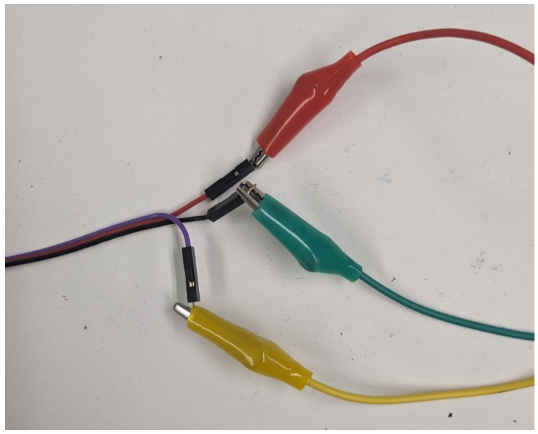
Figure 2. Pulse Sensor



Step 1. Connect Alligator Clips to Microbit in the Configuration below

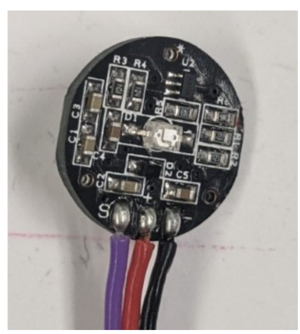


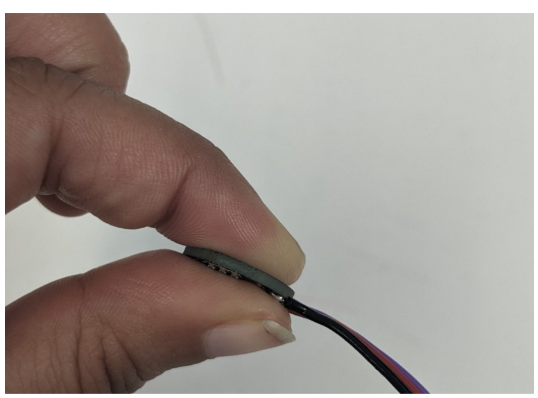
Step 2. Connect the other End of the Alligator Clips to the Heart Rate monitor.
The black lead on the sensor is the ground, the red lead is the power, and the purple lead is the data. These need to be connected to the Ground, the 3V connection, and the ‘2’ port on the Microbit.



Step 3. Connect the micro-usb cable to the port on the top of the Micro:bit, and connect the USB end to the computer

The Heart Rate Sensor is seen below. Pinching the sensor between two fingers is one way to get a reading, but playing it on the wrist or other pulse point is also an option.

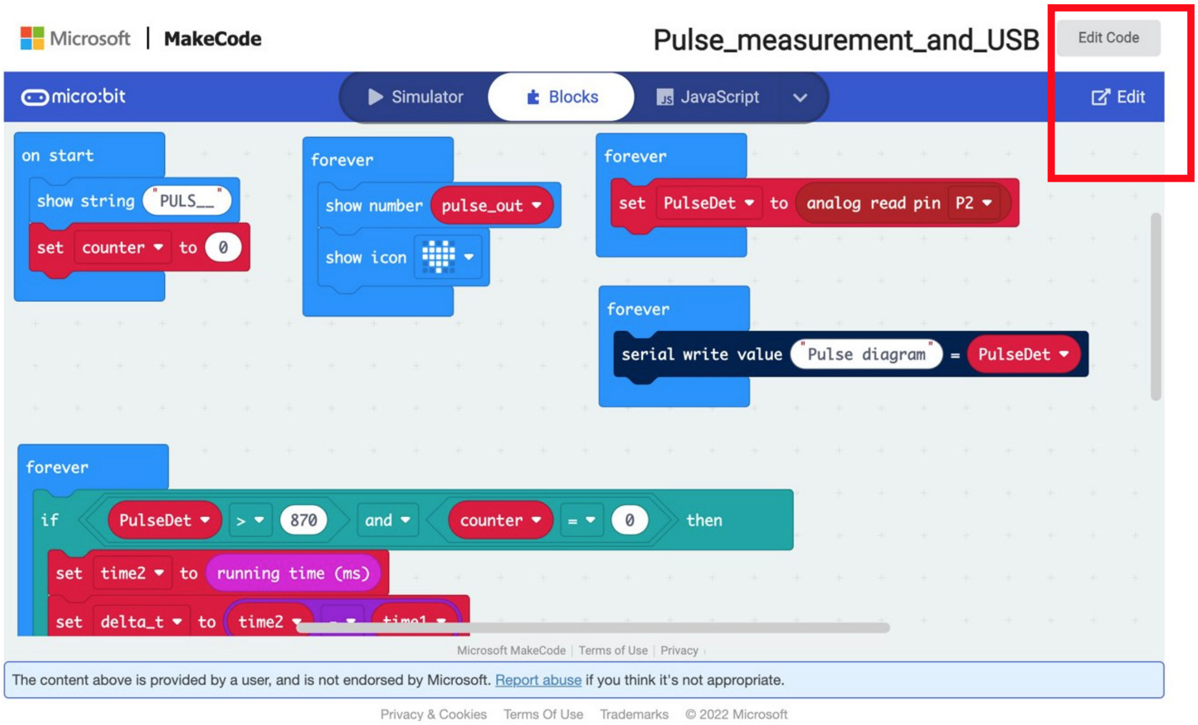




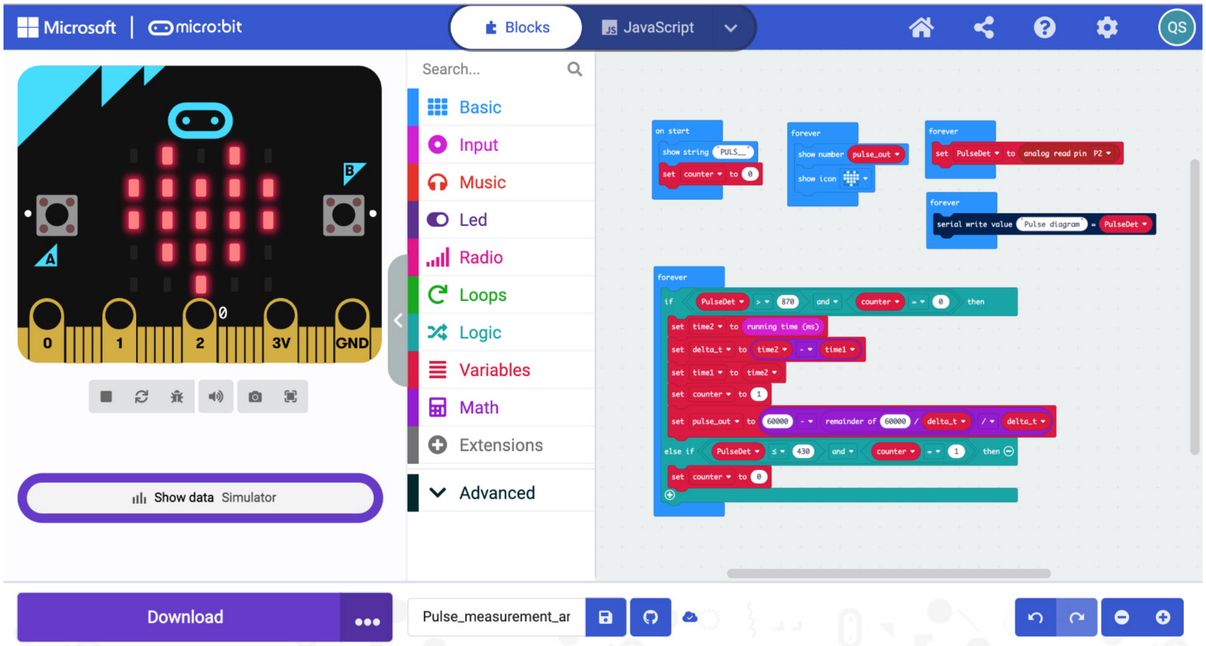
4.B Coding Instructions

Use Link: https://makecode.microbit.org/_iid8zbRi7Uq2

Click the 'Edit' Button

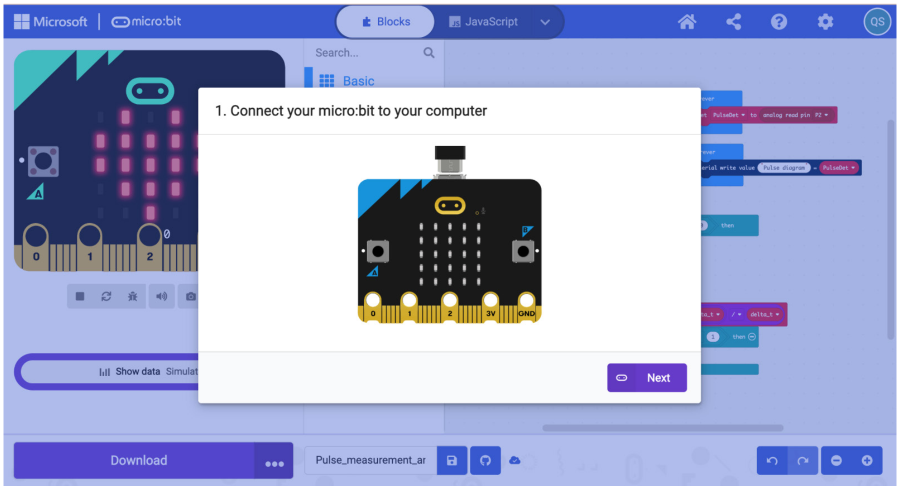


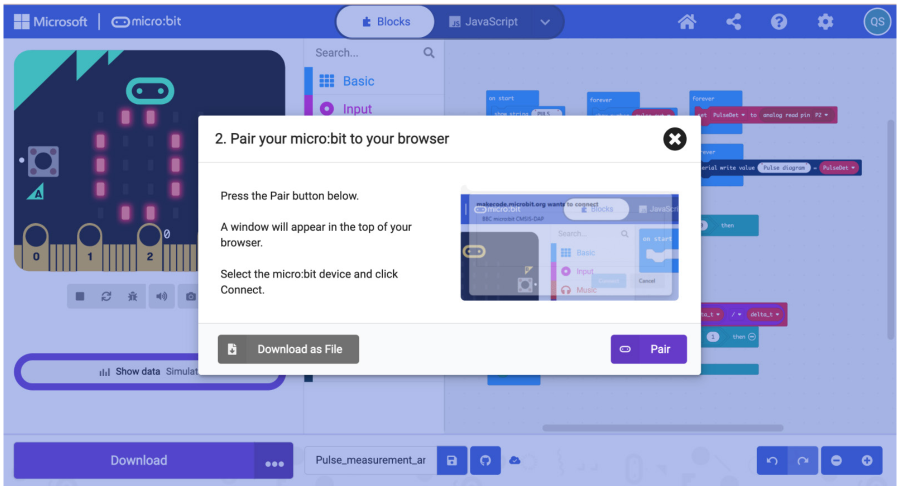
Screen Should Look Like This, Click the Three Dots Next to the Download Button

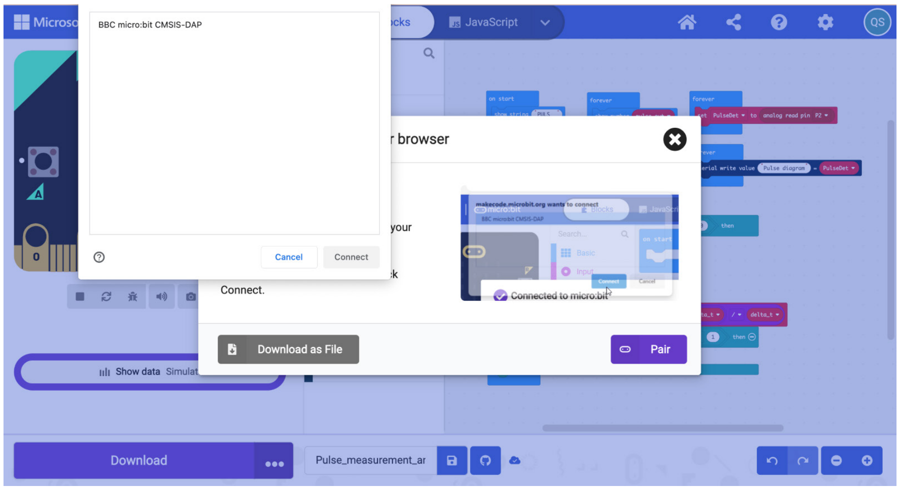


4.B Coding Instructions

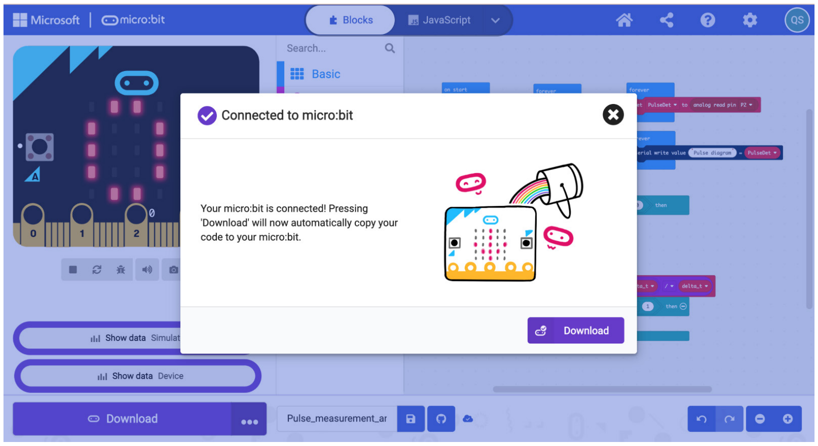
Follow the Instructions on the Screen



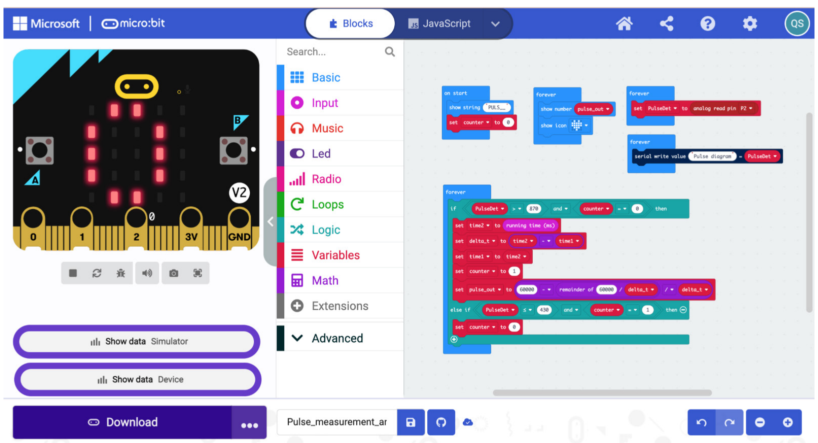




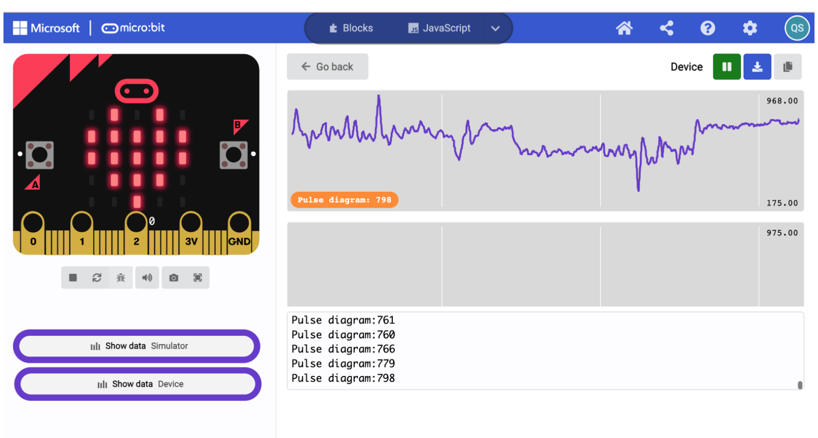
4.B Coding Instructions



Now you should have a Show Data – Device Button

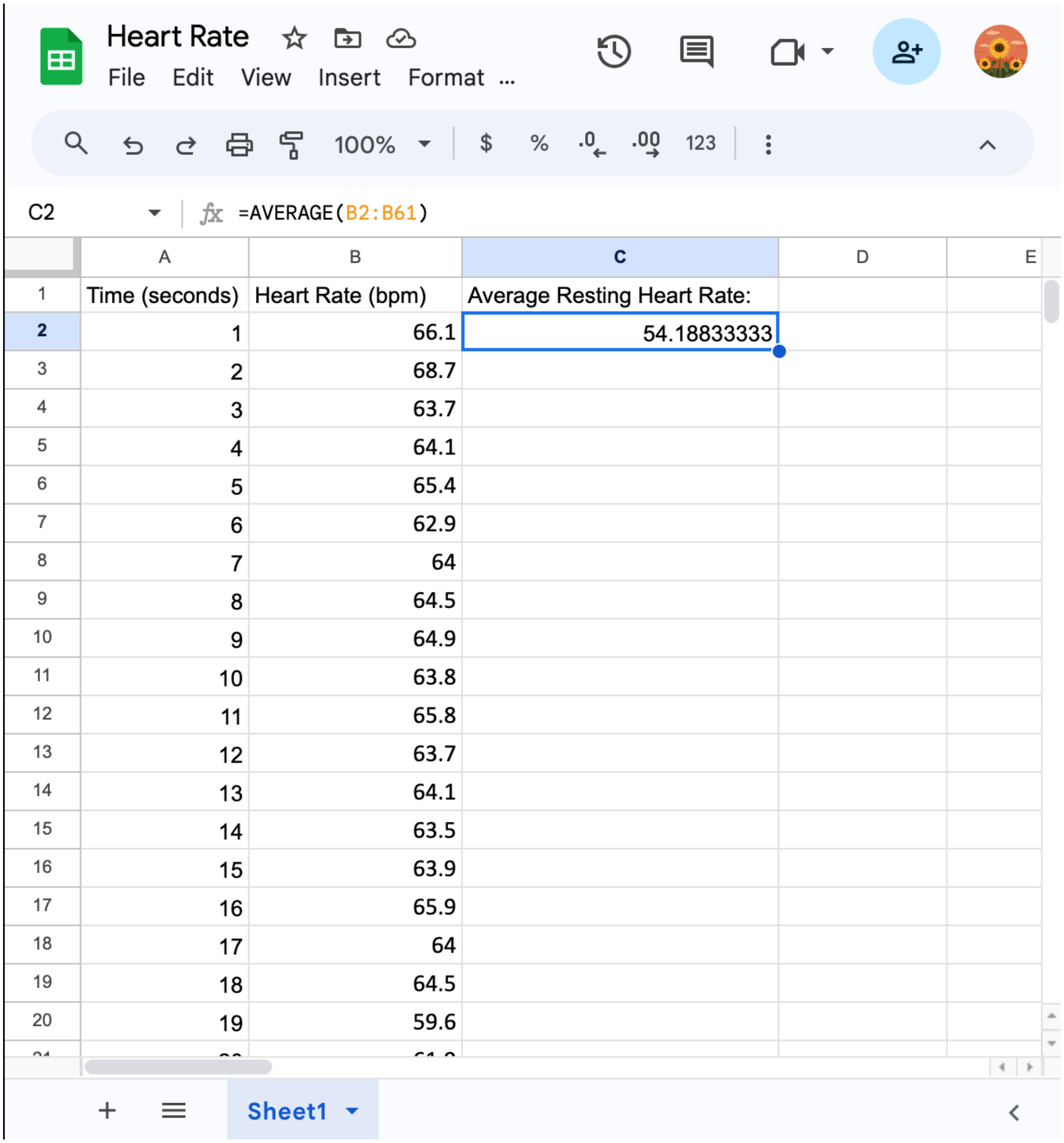


Clicking that button will display a graph as shown below



Troubleshooting: If the code ever behaves differently than you think it should or the microbit stops responding, hitting the download button will reconfigure the code and start the program over. This is a way to restart data collection as well

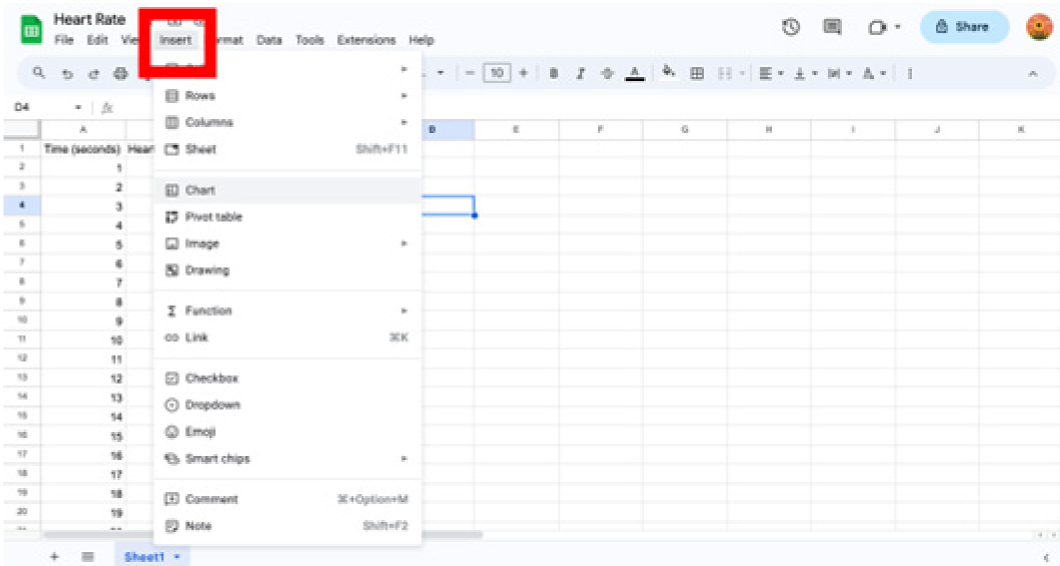
How to Turn Your Sensor Data into A Graph



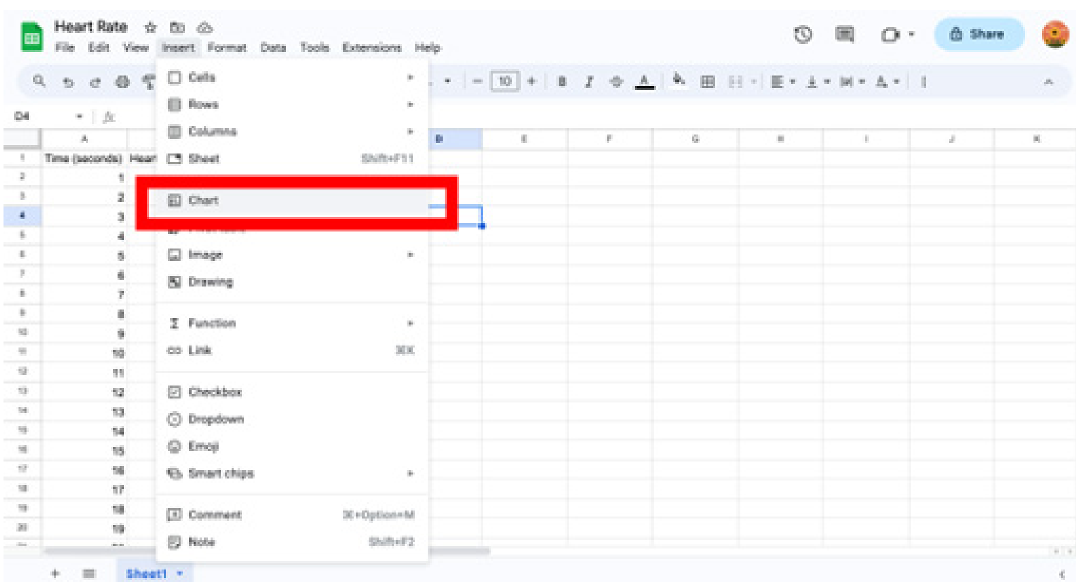
	A	B	C	D	E
1	Time (seconds)	Heart Rate (bpm)	Average Resting Heart Rate:		
2	1	66.1	54.18833333		
3	2	68.7			
4	3	63.7			
5	4	64.1			
6	5	65.4			
7	6	62.9			
8	7	64			
9	8	64.5			
10	9	64.9			
11	10	63.8			
12	11	65.8			
13	12	63.7			
14	13	64.1			
15	14	63.5			
16	15	63.9			
17	16	65.9			
18	17	64			
19	18	64.5			
20	19	59.6			

After Copy/Pasting 60 seconds worth of data into a Google Sheet, Click the ‘Insert’ Tab

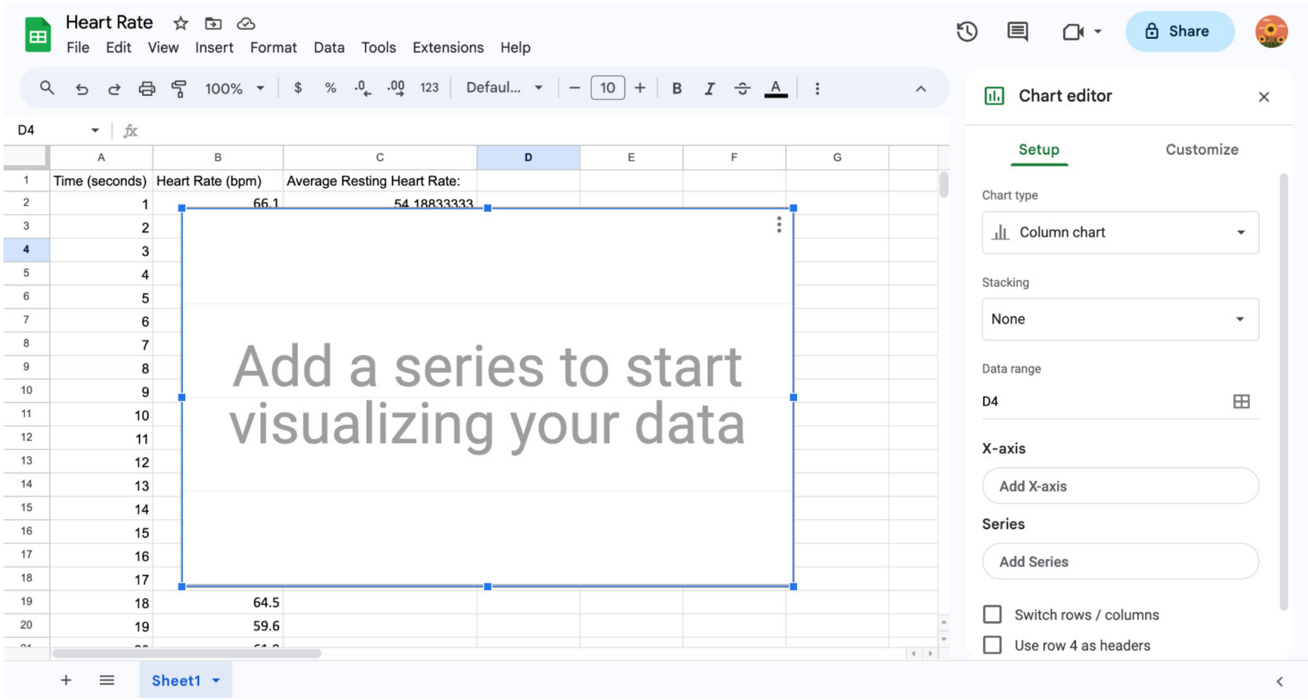
4.C Conversion to Graph Instructions



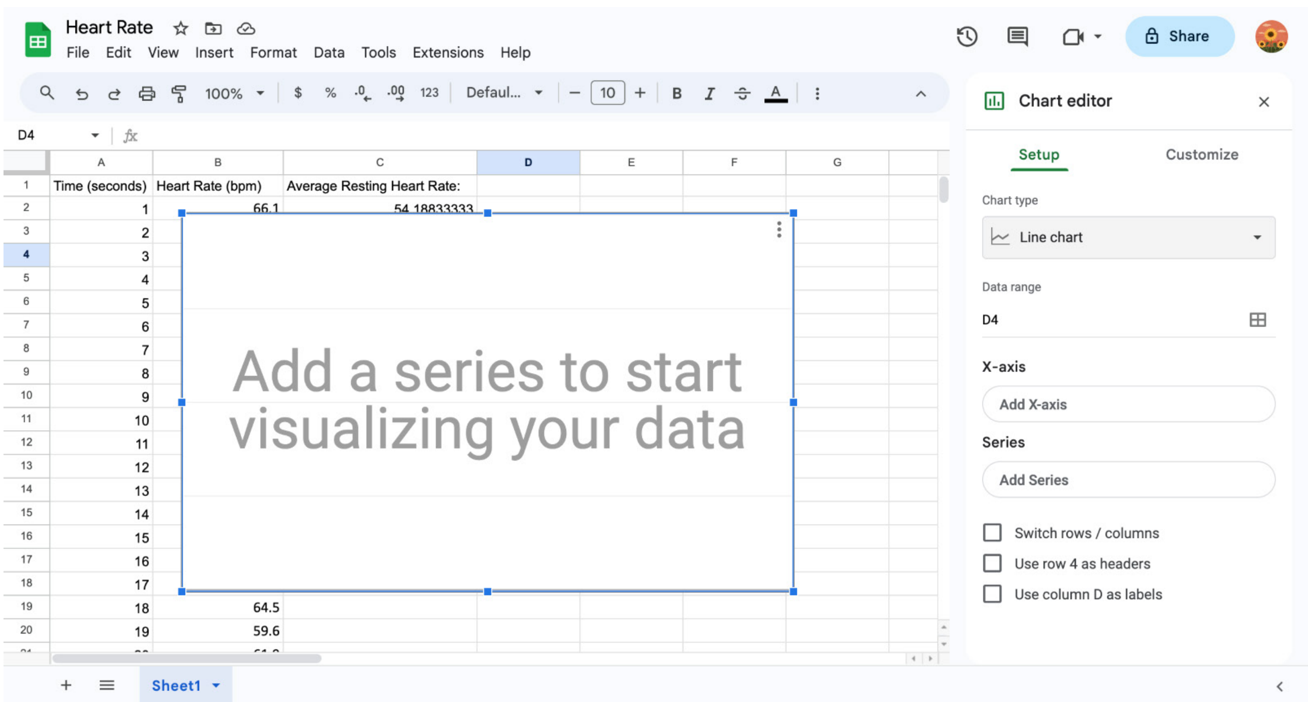
Click On the ‘Chart’ Option



4.C Conversion to Graph Instructions

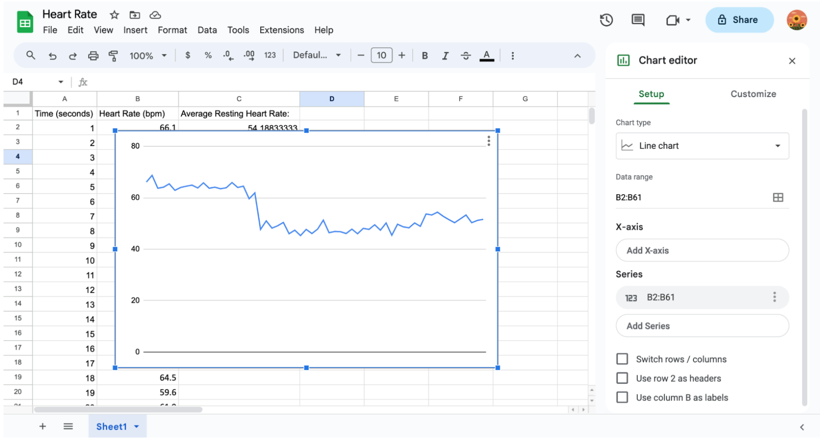


Change the Chart Type to a Line Chart

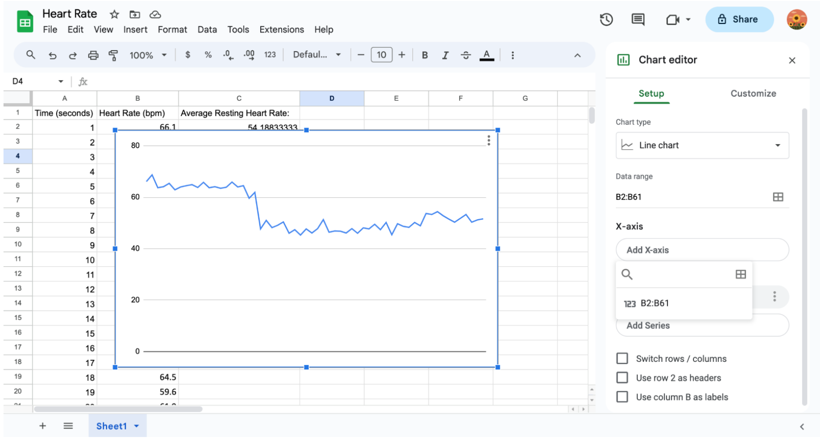


Set the Data Range from B2:B61

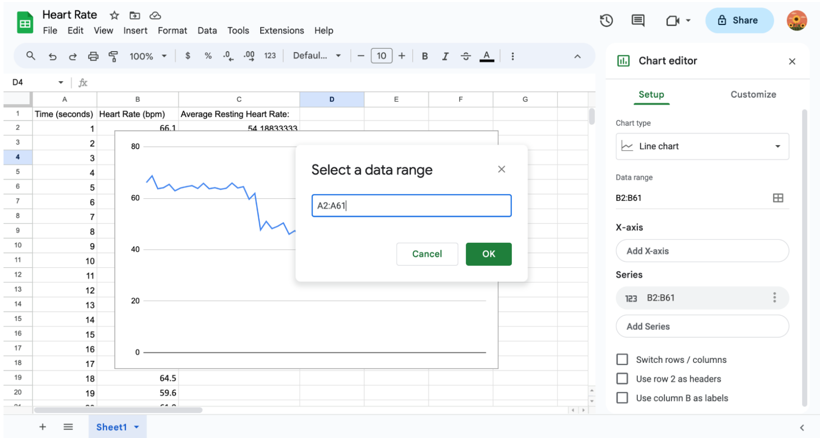
4.C Conversion to Graph Instructions



Click the ‘Add X-axis’ Button, then Click the 4 Box Button



Set the X-Axis to A2:A61



This provides a visualization of the graph data

LESSON FIVE:

Lesson Objectives
Students will be able to:
- Identify discontinuities
- Describe end behavior

Materials
Per classroom
- EDP Poster

Per student
- EDP slider and paperclip
- Laptop or equivalent device
- Engineering notebook

Time Required
One 45-minute class

Standards Addressed
IAS Mathematics
- PS.1, PS.2, PS.3, PS.4
- AII.FF.3 AII.FF.4
- PC.F.1

IAS Science and Engineering Practices
- SEP.4, SEP.5

IAS Integrated STEM
- HS.DM.1

Key Terms
- asymptote
- discontinuity
- end behavior

Lesson Summary

In this lesson, students will explore continuity and end behavior in the context of health. Students will learn about continuity then analyze different types of discontinuity using heart rate data. To explore end behavior, students will be shown examples from heart rate and stress (resting heartrate levels out with asymptote, stress over life with infinity end behavior).

Background

Teacher Background

As in Lesson 3, students will need access to Desmos. They will start apply the information they have been learning about math concepts like intercepts, extrema, and continuity to health-related data. This lesson is the last learn lesson before students move on the plan their designs.

Before the Activity

- Make copies of the duplication masters:
    - 5.A Health Monitoring Graphs (1 per student)
    - 5.B End Behavior and Continuity Homework (1 per student)
    - 5.C Client Memo 2 (1 per student)

Classroom Instruction

Introduction

1. **Reflect on resting heartrate data.** Group students so they get to talk to classmates who are not in their design team. **Say:** *Share your data from the last lesson with the group you are sitting in now. Discuss the differences and similarities between your data specifically comparing critical points and increasing/decreasing behavior like you did for homework.* Encourage students to take notes on their discussion in their engineering notebooks.
2. **Tie to the engineering problem. Ask:** *How did the activity we did in the last lesson help us better understand the design challenge? What do we still need to do in order to solve our client's problem?*
3. **Revisit the engineering design process (Learn). Ask:** *Which phase of the engineering design process will we be in today?* Student will continue learning about math concepts they need to understand before moving on to begin planning in the next lesson.

Activity

4. **Introduce vocabulary using examples of graphs.** Have students work through this Demos activity to learn about end behavior, even/odd functions, asymptotes, and discontinuity. https://teacher.desmos.com/activitybuilder/custom/6500c162ebec19d88bac5a4a
5. **Use examples of graphs to identify end behavior and discontinuity as a class.** Distribute 5.A Health Monitoring Graphs to each student. In their small groups, have students answer the questions about each graph regarding end behavior, asymptotes, and continuity.
6. **Within groups discuss concerns with various health issues (heart rate, temp., stress, etc.).** After students are done working through the questions encourage them to talk about how asymptotes, end behavior, and continuity can be indicators when monitoring health issues. **Ask:** *When would an asymptote be a sign of healthy body temperature? When would issues of continuity in heart rate data be concerning?* Allow students to use only their 5.A Health Monitoring Graphs to think about the application of the math concepts they are learning.
7. **Share ideas with class why some of these features may be alarming to see in a health chart.** Give students some time to research heart rate and other health related monitoring indicators. Ask them to look for ways to use the math concepts they have been learning (extrema, end behavior, discontinuity) to evaluate whether a person is healthy.
8. **Assignment the homework.** Pass out 5.B End Behavior and Continuity Homework to give students a chance to practice graphically and algebraically identifying end behavior.

Closure

9. **Read 5.C Client Memo 2.** Give students time to read and take notes on the client memo in their engineering notebooks. **Ask:** *How has the new information changed our problem definition? What additional criteria and constraints do we need to consider when we start planning?*
10. **Reflect on the learn lessons.** Have students reflect on the learn lessons in their notebooks. **Ask:** *What are the math, science, and technology concepts you have learned so far that will best help you solve the client's problem?* **Say:** *Take some time to free-write in your engineering notebook about what you have learned and how it can help you when making design decisions in our next lesson.*

Assessments

Pre-Activity Assessment

Listen to discussion of student analysis of the heart rate data they collected in the previous lesson. Gauge students' comfort using math concepts and vocabulary to describe their data.

Activity Embedded Assessment

Pay attention to student discussion on when asymptotes and discontinuity show up in health related data.

Post-Activity Assessment

The 5.B End Behavior and Continuity homework will serve as the last assessment strictly on math concepts.

Duplication Masters

- 5.A Health Monitoring Graphs
- 5.B End Behavior and Continuity Homework
- 5.C Client Memo 2

Educator Resources

- 5.D Health Monitoring Example
- 5.E End Behavior and Continuity Key

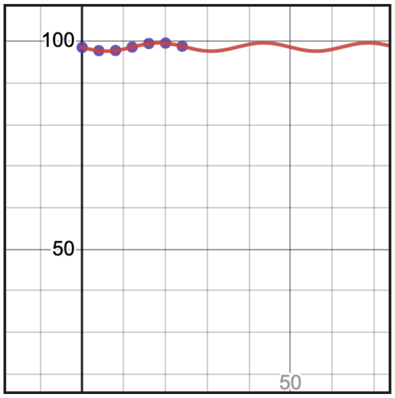
11. **Revisit problem scoping and solution generation. Ask:** *Has your definition of the client's problem changed since you filled out the problem scoping prompts?* Give students a chance to think and free-write about how everything they have learned so far will help them solve the engineering challenge. Have students draft a few ideas they have about how they might want to plan and test their future designs.

Name____ Date_______________ Period __________

5.A Health Monitoring Graphs

Instructions: Analyze these the following data and associated functions about body temperature. Answer the questions about continuity and end behavior then reflect on your own heart rate data.

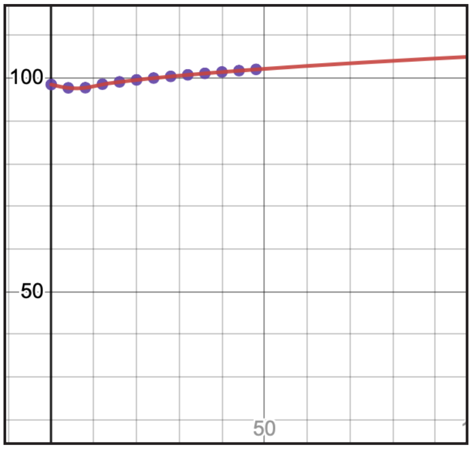
Graph A: Average body temperature of a healthy person in degrees F (y) vs. Time in hours (x)



- Data collected every 4 hours over one day or 24 hours (purple)
- The curve fit to the data (red) represents hypothesized future average body temperature

1. Describe the end behavior and continuity for the function in Graph A.
2. What does this tell us about healthy human body temperature?

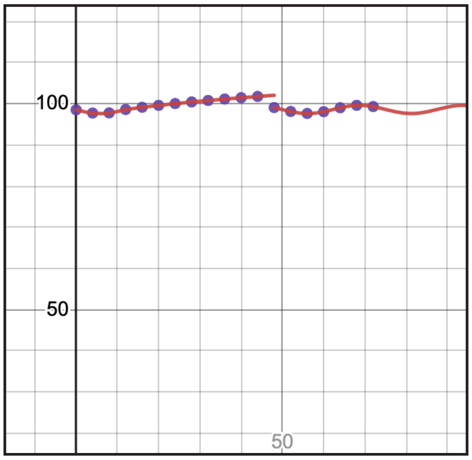
Graph B: Average body temperature of a person getting sick in degrees F (y) vs. Time in hours (x)



- Data collected every 4 hours over two days or 48 hours (purple)
- The person shows signs of a fever at the end of the first day
- The curve fit to the data (red) represents future body temperature if the fever is not controlled

3. How is the end behavior different between Graphs A and B?
4. How can you determine the health of a person based on the end behavior of their body temperature data?

Graph C: Average body tempature of a person who gets sick then takes medicine in degrees F (y) vs. Time in hours (x)



- Data collected every 4 hours over three days (purple)
- The person shows signs of a fever at the end of the first day and takes medicine at the end of the second day.

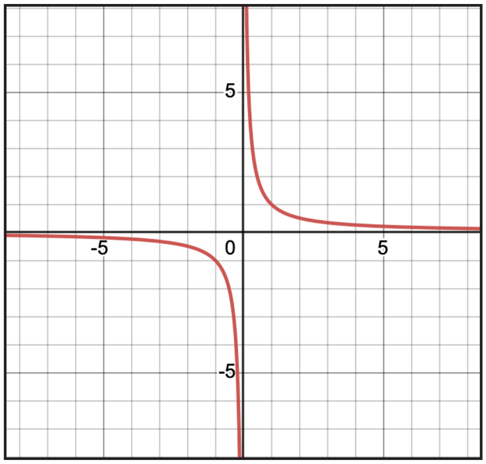
5. How does the medicine impact the end behavior in Graph C?
6. Is this graph continuous? How do you know?
7. In this case, what does the continuity and end behavior tell you about the health of the person?

Data adapted from: Coiffard, B., Diallo, A. B., Mezouar, S., Leone, M., & Mege, J. (2021). A tangled threesome: Circadian rhythm, body temperature variations, and the immune system. Biology, 10(1), 65. https://doi.org/10.3390/biology10010065

Name______________________________________ Date______________ Period __________

5.B End Behavior and Continuity HW

Part 1 Directions: Identify the following attributes (as shown in the example) for the functions below. You will need to use information from the function itself as well as the associated graphs.



Example: f(x) = 1 / x

A. Circle one: Even Odd Neither

B. Describe end behavior of f(x) as GOES UP, GOES DOWN, or APPROACHES (INSERT VALUE)

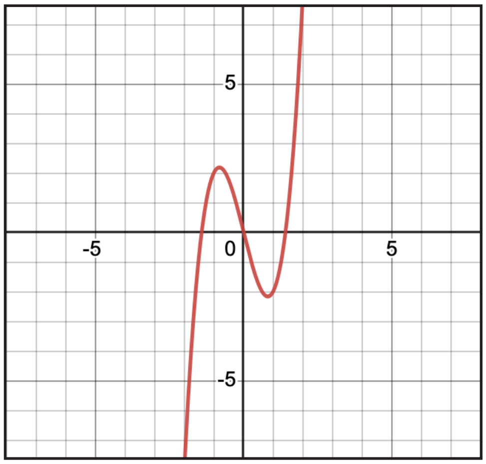
Left side: Approaches 0 Right side: Approaches 0

C. Circle one: Continuous Discontinuous

If the function has a discontinuity, list the intervals where the function is continuous:

(- ∞ < x < 0), (0 < x < ∞)

Problem 1)



$f(x) = 2x^3 - 4x$

A. Circle one: Even Odd Neither

B. Describe end behavior of f(x) as GOES UP, GOES DOWN, or APPROACHES (INSERT VALUE)

Left side: ____________________ Right side: ____________________

C. Circle one: Continuous Discontinuous

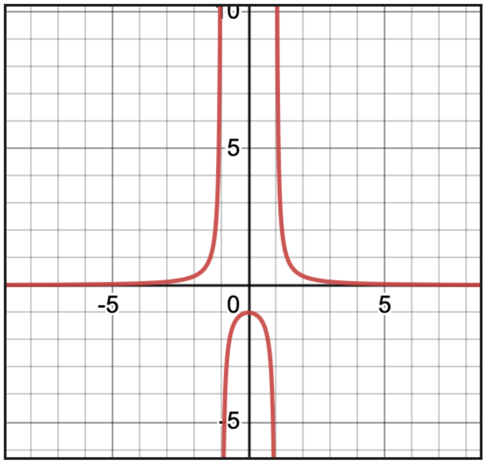
If the function has a discontinuity, list the intervals where the function is continuous:

____

Name____________________________________ Date______________ Period __________

5.B End Behavior and Continuity HW

Problem 2)



$f(x) = 1 / (x^2 - 1)$

A. Circle one: Even Odd Neither

B. Describe end behavior of f(x) as GOES UP, GOES DOWN, or APPROACHES (INSERT VALUE)

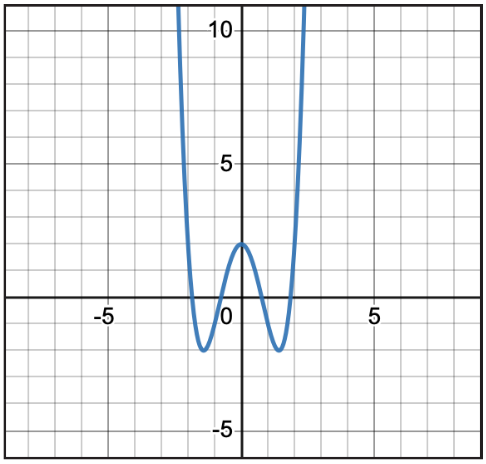
Left side: ____________________ Right side: ____________________

C. Circle one: Continuous Discontinuous

If the function has a discontinuity, list the intervals where the function is continuous:

____

Problem 3)



$f(x) = x^4 - 4x^2 + 2$

A. Circle one: Even Odd Neither

B. Describe end behavior of f(x) as GOES UP, GOES DOWN, or APPROACHES (INSERT VALUE)

Left side: ____________________ Right side: ____________________

C. Circle one: Continuous Discontinuous

If the function has a discontinuity, list the intervals where the function is continuous:

____

Bonus problem: Come up with a function which is neither even or odd.

____

Name____ Date_______________ Period __________

5.B End Behavior and Continuity HW

Part 2 Directions: Using all of the information you have learned so far about graphical elements of functions, match the function to it's graph. Think about end behavior, continuity, intercepts, increasing and decreasing behavior, and extrema. HINT: It may help to factor the functions first.

Functions

1. $f(x) = 1 / x^2$
Matching graph: ___

2. $f(x) = 3x^4 + 6x^3 - 24x^2$
Matching graph: ___

3. $f(x) = x^3 - 12x^2 + 48x - 64$
Matching graph: ___

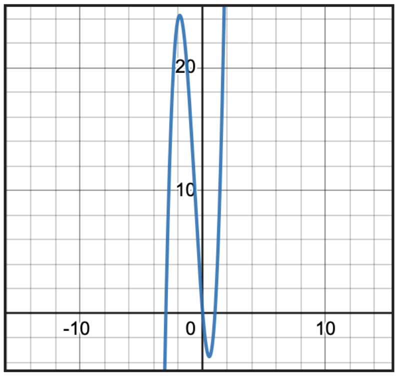
4. $f(x) = 2x^3 - 72x$
Matching graph: ___

5. $f(x) = x^2 + 2x - 35$
Matching graph: ___

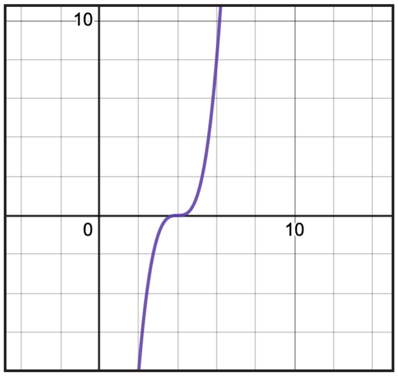
6. $f(x) = 4x^3 + 8x^2 - 12x$
Matching graph: ___

Graphs

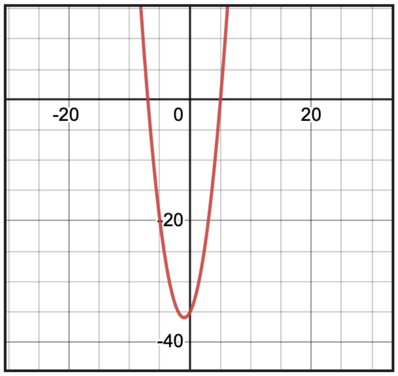
A)



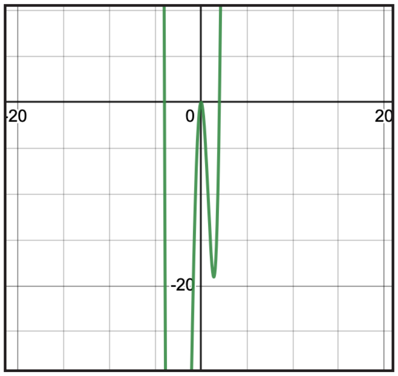
B)



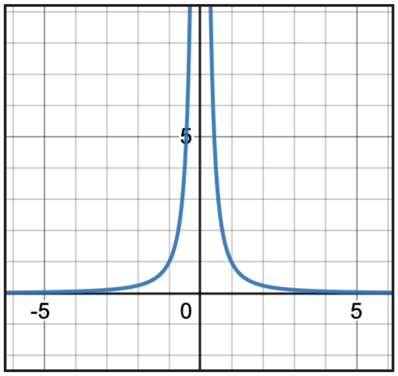
C)



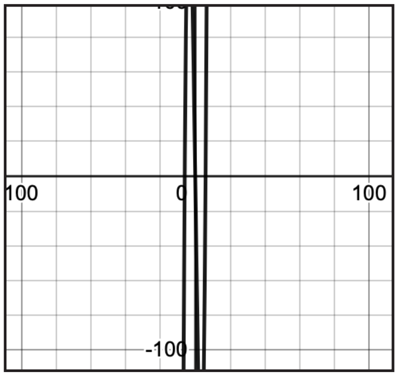
D)



E)



F)



5.C Client Memo 2

Dear Engineers,

Thank you for your work so far in learning about graphs, sensors, and stress. As part of your stress intervention method, you will need to create and communicate a procedure describing how you will test your intervention method. A procedure is a series of steps that engineers, scientists, practitioners or many other folks use to conduct an experiment. You will to use your math knowledge and stress knowledge to design a procedure to conduct an experiment to test a stress management technique. With your group, design a procedure themed around your topic. Keep the context of your group's interest area in mind throughout this process.

Your stress intervention design needs to utilize the micro:bit, heart rate sensor, and be able to perform some function to interrupt a negative stress cycle. We have two main requirements we would like you to follow in your designs. First, you will need to rely on math knowledge (like intercepts, extrema, and continuity) to determine the point at which your micro:bit will enact the stress intervention signal. Second, you will need to decide on a type of signal from a list of options we have provided. When adhering to both of these requirements please justify your decisions along the way and provide evidence for your final prototype choices.

Sincerely,

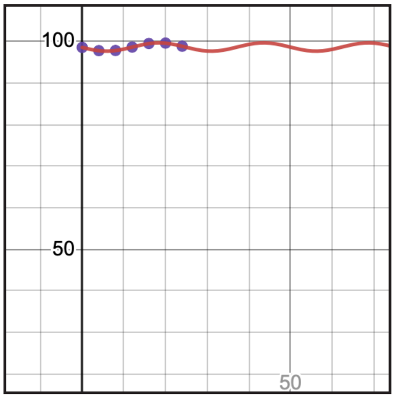
Art Beet

Art Beet
Consulting Engineer – Mental Health Outreach
Revitalizing Lives in Educational Facilities (RELIEF)

5.D Health Monitoring Example

Instructions: Analyze these the following data and associated functions about body temperature. Answer the questions about continuity and end behavior then reflect on your own heart rate data.

Graph A: Average body temperature of a healthy person in degrees F (y) vs. Time in hours (x)



- Data collected every 4 hours over one day or 24 hours (purple)
- The curve fit to the data (red) represents hypothesized future average body temperature

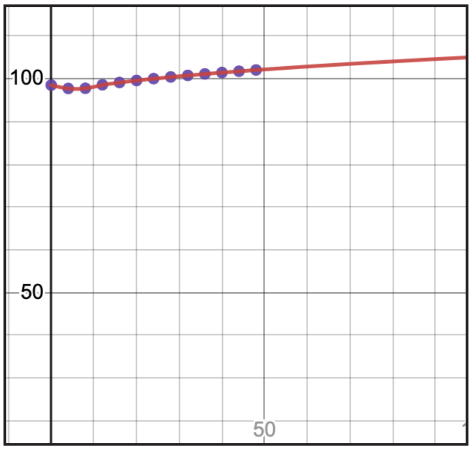
1. Describe the end behavior and continuity for the function in Graph A.

ANSWER: beginning at x=0 the function is continuous and has oscillating end behavior around 98.6 degrees F

2. What does this tell us about healthy human body temperature?

ANSWER: a healthy human body temperature oscillates throughout the day around 98.6 degrees F

Graph B: Average body temperature of a person getting sick in degrees F (y) vs. Time in hours (x)



- Data collected every 4 hours over two days or 48 hours (purple)
- The person shows signs of a fever at the end of the first day
- The curve fit to the data (red) represents future body temperature if the fever is not controlled

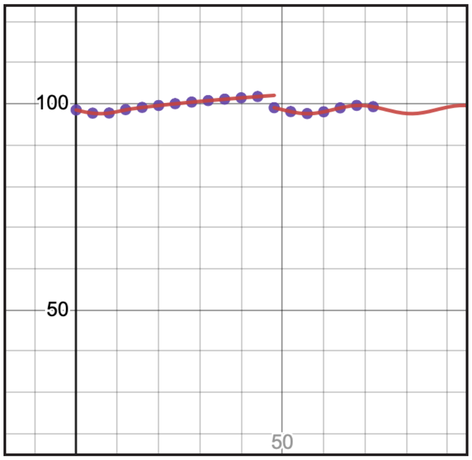
3. How is the end behavior different between Graphs A and B?

ANSWER: Graph A oscillates around 98.6 degrees F while Graph B steadily increases for an infinite amount of time

4. How can you determine the health of a person based on the end behavior of their body temperature data?

ANSWER: If the data does not fit with an oscillating function and instead the function increases (or decreases) the person is sick

Graph C: Average body tempature of a person who gets sick then takes medicine in degrees F (y) vs. Time in hours (x)



- Data collected every 4 hours over three days (purple)
- The person shows signs of a fever at the end of the first day and takes medicine at the end of the second day.

5. How does the medicine impact the end behavior in Graph C?

ANSWER: The end behavior is no longer increasing. It oscillates.

6. Is this graph continuous? How do you know?

ANSWER: It is not continuous. There is a break in the graph at the end of day 2.

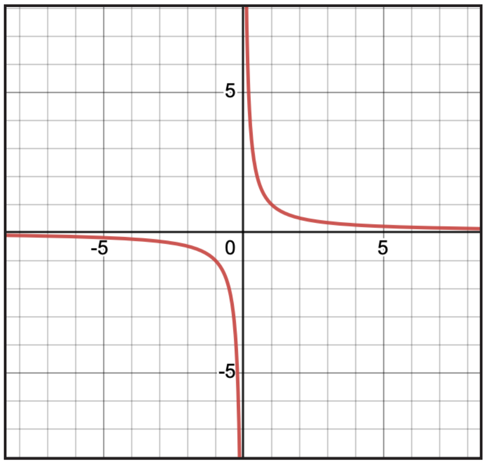
7. In this case, what does the continuity and end behavior tell you about the health of the person?

ANSWER: When measuring body temperature, increasing end behavior is an indication someone is sick while a discontinuity was representative of a fever breaking and going back to a healthy temp.

Data adapted from: Coiffard, B., Diallo, A. B., Mezouar, S., Leone, M., & Mege, J. (2021). A tangled threesome: Circadian rhythm, body temperature variations, and the immune system. Biology, 10(1), 65. https://doi.org/10.3390/biology10010065

5.E End Behavior and Continuity Key

Part 1 Directions: Identify the following attributes (as shown in the example) for the functions below. You will need to use information from the function itself as well as the associated graphs.



Example: f(x) = 1 / x

A. Circle one: Even Odd Neither

B. Describe end behavior of f(x) as GOES UP, GOES DOWN, or APPROACHES (<u>INSERT VALUE</u>)

Left side: Approaches 0 Right side: Approaches 0

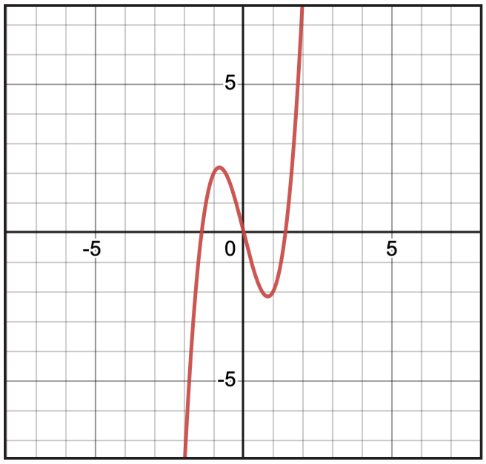
C. Circle one: Continuous Discontinuous

If the function has a discontinuity, list the intervals where the function is continuous:

(- ∞ < x < 0), (0 < x < ∞)

Problem 1)

$f(x) = 2x^3 - 4x$



A. Circle one: Even Odd Neither

B. Describe end behavior of f(x) as GOES UP, GOES DOWN, or APPROACHES (<u>INSERT VALUE</u>)

Left side: Goes down Right side: Goes up

C. Circle one: Continuous Discontinuous

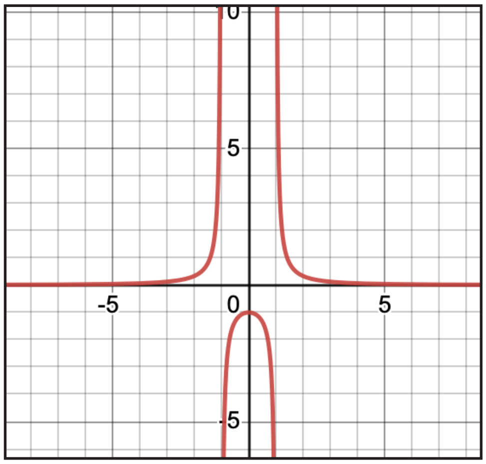
If the function has a discontinuity, list the intervals where the function is continuous:

N/A, function is continuous

Name____________________ Date______________ Period ___________

5.E End Behavior and Continuity Key

Problem 2)



$f(x) = 1 / (x^2 - 1)$

A. Circle one: Even Odd Neither

B. Describe end behavior of f(x) as GOES UP, GOES DOWN, or APPROACHES (INSERT VALUE)

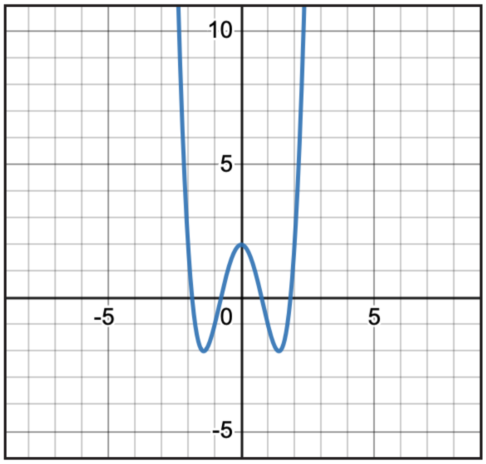
Left side: Approaches 0 Right side: Approaches 0

C. Circle one: Continuous Discontinuous

If the function has a discontinuity, list the intervals where the function is continuous:

$(-\infty < x < -1)$, $(-1 < x < 1)$, $(1 < x < \infty)$

Problem 3)



$f(x) = x^4 - 4x^2 + 2$

A. Circle one: Even Odd Neither

B. Describe end behavior of f(x) as GOES UP, GOES DOWN, or APPROACHES (INSERT VALUE)

Left side: Goes up Right side: Goes up

C. Circle one: Continuous Discontinuous

If the function has a discontinuity, list the intervals where the function is continuous:

N/A, function is continuous

Bonus problem: Come up with a function which is neither even or odd.

Example: $f(x) = x^3 - 2x^2 - 1$

Name____ Date_______________ Period ___________

5.E End Behavior and Continuity Key

Part 2 Directions: Using all of the information you have learned so far about graphical elements of functions, match the function to it's graph. Think about end behavior, continuity, intercepts, increasing and decreasing behavior, and extrema. HINT: It may help to factor the functions first.

Functions

1. $f(x) = 1 / x^2$
Matching graph: E

2. $f(x) = 3x^4 + 6x^3 - 24x^2$
Matching graph: D

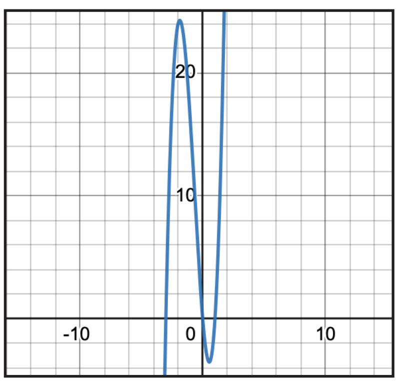
3. $f(x) = x^3 - 12x^2 + 48x - 64$
Matching graph: B

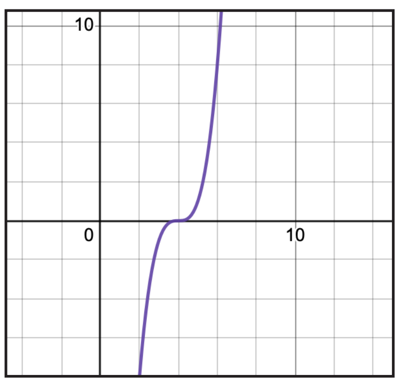
4. $f(x) = 2x^3 - 72x$
Matching graph: F

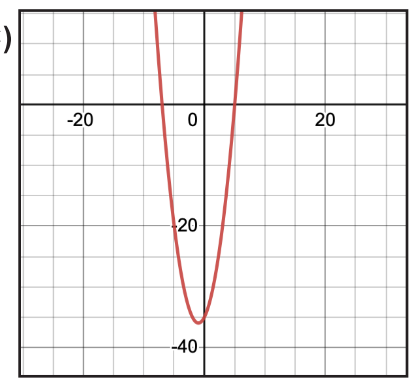
5. $f(x) = x^2 + 2x - 35$
Matching graph: C

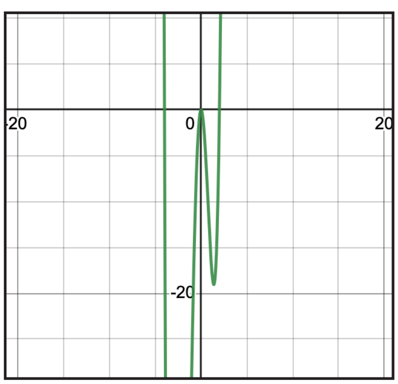
6. $f(x) = 4x^3 + 8x^2 - 12x$
Matching graph: A

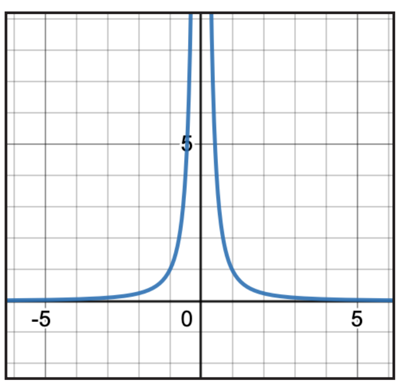
Graphs

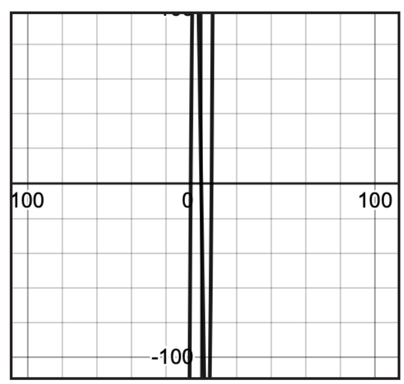
A)


B)


C)


D)


E)


F)


LESSON SIX:

Lesson Objectives
Students will be able to:
- Consider criteria and constraints when planning solutions for stress intervention
- Justify design decisions with math and science evidence

Materials
Per classroom
- EDP Poster

Per group
- Micro:bit
- Heart rate sensor
- (3) Alligator clip wires
- Micro-USB cord

Per student
- EDP slider and paperclip
- Laptop or equivalent device
- Engineering notebook

Time Required
Two 45-minute classes

Standards Addressed
IAS Science and Engineering Practices
- SEP.2, SEP.6, SEP.7,

IAS Integrated STEM
- HS.CC.2, HS.AM.4

Key Terms
- evidence-based reasoning

Lesson Summary
In this lesson, students will plan their stress intervention method using math knowledge incorporating criteria/constraints from the client. Using evidence-based reasoning, students will plan their method and code micro:bits to be tested in the following lesson.

Background
Teacher Background
Students will need an understanding of both the math concepts and the general function of the micro:bit and heart sensor to plan their solution. One of their deliverables will be a procedure-style list of steps to give instructions to a test subject that was not on the team. The procedure should be clear and detailed enough so that multiple people can execute the plan and the same steps be followed. When developing their solution, students will need to use evidence-based reasoning.

Evidence-based reasoning (EBR) refers to the engineering practice of providing rational for design ideas and decisions. It is somewhat similar to scientific argumentation in the sense that it involves using evidence and explanations to support a statement, but it is ultimately different. In EBR, the statement being supported is an engineering design idea or decision, whereas in scientific argumentation it is a claim or conclusion about a natural phenomenon. EBR is used in the context or generating solutions for engineering problems; scientific argumentation is used to answer scientific questions about nature. Science and mathematical principles are important justification for scientific argumentation and EBR. However, EBR often also includes justifications related to context, criteria, and constraints of the engineering problem (e.g., cost, user needs, technical feasibility). In this lesson, students will use EBR to think deeply about their proposed decisions and to justify them with information about the engineering problem and their science and mathematics knowledge.

Before the Activity
- Make copies of the duplication masters:
  - 6.A Generating Ideas Prompts (1 per student)
  - 6.C Evidence-Based Reasoning (1 per student)
  - 6.E Build Your Testing Procedure (1 per student)
  - 6.F Coding Support (1 per student)
- Project or display a large version of 6.B EBR Graphic Description so students can see what needs to be included

Classroom Instruction

Introduction

1. **Tie to the engineering problem.** Remind students that in 5.C Client Memo 2 the client clarified the constraints and the need from students. **Ask:** *How do you think the last math lesson would help us solve our client's problem?* Help students understand the connection between continuity and monitoring stress.
2. **Identify where they are in the engineering design process (Plan). Ask:** *What phase of the design process do you think we will be in today?* Students will plan their designs and then build/ try them.

Activity

3. **Identifying new criteria and constraints.** Review 5.C Client Memo 2 as a class to identify an updated set of criteria and constraints.
4. **Individual brainstorming time.** Allow time for students to complete a free-write in their digital notebooks exploring potential solutions to the design challenge. They should begin to think about pros and cons for each of their proposed solutions based on the new criteria and constraints from the client.
5. **Complete planning document individually.** Have students fill out the 6.A Generating Ideas Prompts with their two best design ideas. After they have time to brainstorm and complete the planning document individually students will need to present their ideas to their design team.
6. **Work in groups to identify two ideas.** In their groups, students will need to select or integrate their individual ideas to come up with two they want to flesh out as a team.
7. **Elaborate on the clients requirements. Say:** *Think back to the last client memo we received.* **Ask:** *What were some of the new criteria or constraints they gave us?* **Say:** *To be able to plan your designs you will need to know the options you can use when coding your micro:bits. They already gave us options for what math concepts (inputs) we can use to tell the micro:bit when to intervene in the stress cycle. Revisit the last client memo or your notebooks and circle the options you can use. Additionally, there is a list of signal options (outputs) for which the client has already generated the coding.* Project or write down the following table for the class so students can copy the information in their notebooks.

Assessments

Activity Embedded Assessment

Pay attention to how students collaborate to plan and justify their design decisions. Evaluate their teamwork skills by watching how they try out their solutions and debug together when they experience challenges.

Post-Activity Assessment

Use the 6.D EBR Example as a guide to assess students' ability to justify their design decisions on the 6.C Evidence-Based Reasoning template.

Duplication Masters

- 6.A Generating Ideas Prompts
- 6.B EBR Graphic Description
- 6.C Evidence-Based Reasoning
- 6.E Build Your Testing Procedure
- 6.F Coding Support

Educator Resources

- 6.D EBR Example

Inputs	Outputs
Continuity	Display ‘X’
Maximum and Minimum	Countdown from a set time
Zeros and Intercepts	Play music

8. **Refine group plans.** Give groups time to refine their two ideas based on the new information about the coding presets.
9. **Introduce evidence-based reasoning. Say:** *Engineers use evidence to make decisions, so you're going to fill out an evidence-based reasoning graphic throughout this lesson to justify your design to the client.* Display the 6.B EBR Graphic Description so students are able to reference what will go in each section.
10. **Introduce the concept of simplifying assumptions. Say:** *Engineers usually don't deal with every single aspect of a problem at once because that makes the problem too difficult to solve. Instead, they make a complex problem simpler, sometimes by ignoring some of the details of the problem and sometimes by pretending certain things are true about the problem when they actually aren't.* **Ask:** W*hat are some parts of our engineering challenge that we can make simpler?* This may be a difficult concept for students, so provide an example or two if students struggle.
    a. Simplifying assumptions (things to ignore): aesthetics/appearance, durability (how well it withstands wear and damage). In this case a good simplifying assumption is to assume heart rate is a direct indication of stress level.
    b. Simplifying assumptions (assume certain things are true when they aren't): materials used in the classroom are similar to those the client has.
9. **Explain what information goes in each of the remaining sections.** Have students guess what kind of information they think should go in the "Design Idea," "Data/Evidence," and "Justification" sections of the EBR graphic. This could include:
    a. Design Idea: Listing inputs and outputs and corresponding values for the inputs.
    b. Data/Evidence: Observations and data that show why you think your intervention design makes sense. Example: data from measuring resting heart rate.
    c. Justification: Complete the sentences that state why you think your design will be successful. These sentences should refer to the problem, criteria, constraints, design idea, and data/evidence.
10. **Complete evidence-based reasoning.** Provide students with time to complete 6.C Evidence-Based Reasoning with their

teammates. They should use their top two design ideas and use those to fill out the template. Make sure students provide evidence for their design decisions.

NOTE: If students are stuck here, remind them that criteria are the requirements, or goals, of the designed solutions and constraints are things that limit design possibilities.

11. **Reflect on EBR activity.**
12. **Connect to the EDP. Ask:** *Which phase of the engineering design process have we spent time on today? How do you know we used this phase? What should we do next?* Students should identify that after planning their designs using their math knowledge, they will be moving on to the “Try” phase next.

    NOTE: If you are splitting this lesson up into multiple days, this is a good stopping place before they try out their designs and code the micro:bit.
13. **Assemble and code micro:bit prototype.** Pass out the 6.F Coding Support sheet to help students code their planned designs using micro:bit makecode.
14. **Determine testing procedure for stress intervention. Say:** *Use the 6.E Build Your Testing Procedure examples to create a procedure which you will be using in the next lesson. This will need to be a list that you can walk through with members of a different group to test your design.*

Closure

15. **Connect to EDP. Ask:** *Which phases of the engineering design process did we use today? How do you know you used those phases? What will we be doing next?* Explain that students will use their experiment protocol in the next lesson to test then redesign their solutions. Remind them that they are trying to develop the best possible solution to the client’s problem, and as is the case for professional engineers, the first idea or solution is rarely the best.

6.A Generating Ideas Prompts

Solution Ideas	Pros of idea	Cons of idea	Address Criteria?	Meet Constraints?	Rank ideas
Idea 1:			yes / no	yes / no	
Idea 2:			yes / no	yes / no	

Make changes based on your analysis:

6.B EBR Graphic Description

<table>
<tr><th colspan="2">Problem including Constraints & Criteria</th></tr>
<tr><td colspan="2">Problem: the engineering problem the client asked you to solve
Criteria: the requirements, or goals, of the designed solutions
Constraints: things that limit design possibilities</td></tr>
<tr><th colspan="2">Simplifying Assumptions (if any)</th></tr>
<tr><td colspan="2">Ways to make a complex problem simpler -
Things we ignore to focus the design or simplify analysis</td></tr>
<tr><th>Idea #_____</th><th>Data/Evidence</th></tr>
<tr><td>• Description of the design
• Drawings of the design, different views better
• Dimensions (sizes)
• Label materials in design (show where they are used)
• Interesting features</td><td>Observations and data that show why you think your design will work

Examples:
• Data from science or mathematics lessons/labs/experiments
• Total cost of design</td></tr>
<tr><th colspan="2">Explanation, Justification, Reasoning</th></tr>
<tr><td colspan="2">Complete sentences that state why you think your design will be successful. These sentences should refer to the problem, criteria, constraints, idea, and data/evidence.</td></tr>
</table>

6.C Evidence-Based Reasoning

Problem including Criteria & Constraints • Explain the client's problem that needs a solution and why it is important to solve. • List criteria and constraints you will use to decide if your solution is working.
Problem: **Criteria:** **Constraints:**
Simplifying Assumptions (if any) • List things that might be important but you have decided not to worry about in order to focus the solution or simplify the analysis of the solution

Design Idea #1 • Plan including drawing, labels of materials used, and labels of what each part does.	**Data/Evidence** • List science/mathematics learned and/or results of tests that support your design idea.

Justification - Why do you think this design idea will work? • Explain how your data and evidence support your design idea in order to meet criteria/constraints.

Design Idea #2 • Plan including drawing, labels of materials used, and labels of what each part does.	**Data/Evidence** • List science/mathematics learned and/or results of tests that support your design idea.

Justification - Why do you think this design idea will work? • Explain how your data and evidence support your design idea in order to meet criteria/constraints.

6.D EBR Example

Problem including Constraints & Criteria	
Problem: high school students are too stressed **Criteria:** an experiment procedure to test an intervention to reduce stress **Constraints:** use a micro:bit, heart rate sensor, and perform a function that interrupts a negative stress cycle	
Simplifying Assumptions (if any)	
The only way we will measure stress is heart rate. The stress tests also do not take additional external stress into account.	
Design Idea # 1	**Data/Evidence**
Performing choir songs is stressful, we suggest holding my thumb for 10 seconds, then releasing with a breath, as a stress interrupter. We will use the heart rate monitor to check if stress levels decrease at the time of use and with resumed practice.	**We found a website says stretching and contracting my muscles will help with stress. We think that if we look for the maximum stress point during the first experiment it will give us a number to alert the user if they reach it.**
Explanation, Justification, Reasoning	
If a singer focuses on something else other than how stressed/nervous they are, we think it will be easier to sing.	

Name______________________________________ Date______________ Period __________

6.E Build Your Testing Procedure

Types of Inputs:

- Continuity
- Maximums and Minimum Values,
- Zeros and Intercepts,
- Rates of Change

Types of Outputs:

- Audio: Middle C Tone, Ascending Scale, Descending Scale
- Visual: Display ‘X’, Countdown from a set time, Scrolling Message to User

Sample Experimental Activities:

Watching 2 clips of 2 different types of shows for 1 minute.

What was Your average Heart Rate For Video 1?

What was Your Average Heart Rate for Video 2?

Design a stress coping strategy for your choice of Stress Indicator

Perform your stress management technique while performing the more stressful task.

What are some of your observations? Are there any changes between the first session and the second one, now with the stress mitigation techniques?

Sports

Sports Stress Video:

https://youtu.be/zxbz3DDQzHU

Playing Sports Example: Wastepaper basketball – Using Scrap Paper and a trashcan, students could make 15-20 shots within a minute

Name____ Date_______________ Period __________

6.E Build Your Testing Procedure

Video Games

Example Action Game Link:

https://acelisweaven.github.io/arrow-hero

Example Puzzle Game Link:

https://www.mathsisfun.com/games/towerofhanoi.html

TV

Gameshow Clip #1

DISNEY+ | Category | JEOPARDY!

https://youtu.be/6B27x7-0-xg

Gameshow Clip #2

Minute To Win It - Stack it FTW! Clip

https://youtu.be/4EGYapV2i3c?t=89

Name____ Date________________ Period ___________

6.F Coding Support

Resting Heart Rate

https://makecode.microbit.org/S53869-89758-79188-16063

Input: Continuity | Output: 'X'

https://makecode.microbit.org/_D1H7LMJMk6rc

Input: Continuity | Output: Play Music

https://makecode.microbit.org/S87531-60341-04675-02285

Input: Continuity | Output: Countdown

https://makecode.microbit.org/S36241-88459-89374-70795

Input: Intercepts | Output: 'X'

https://makecode.microbit.org/_XJXFiVah4EAV

Inputs: Intercepts | Output: Play Music

https://makecode.microbit.org/S00993-81219-13318-96619

Inputs: Intercepts | Output: Countdown

https://makecode.microbit.org/S32940-75998-42909-85979

Name____ Date_______________ Period __________

6.F Coding Support

Input: Maximums | Output: ‘X’

https://makecode.microbit.org/_06xLmU8gDMX4

Input: Maximums | Output: Play Music

https://makecode.microbit.org/S11942-45074-38571-38048

Input: Maximums | Output: Countdown

https://makecode.microbit.org/S50644-88170-71430-85701

Input: Minimums | Output: ‘X’

https://makecode.microbit.org/_KDVReP7zCKa1

Input: Minimums | Output: Play Music

https://makecode.microbit.org/_0D9dwsUJwJp1

Input: Minimums | Output: Countdown

https://makecode.microbit.org/S38722-22650-73294-46683

LESSON SEVEN:

Lesson Objectives
Students will be able to:
- Test and evaluate solutions to the engineering design challenge
- Redesign existing solutions using math evidence from testing

Materials
Per classroom
- EDP Poster

Per group
- Micro:bit
- Heart rate sensor
- (3) Alligator clip wires
- Micro-USB cord

Per student
- EDP slider and paperclip
- Laptop or equivalent device
- Engineering notebook

Time Required
One 45-minute lesson

Standards Addressed
IAS Science and Engineering Practices
- SEP.3, SEP.4, SEP.5, SEP.6, SEP.7

IAS Integrated STEM
- HS.CC.2, HS.CC.3, HS.DM.2, HS.DM.3, HS.IPS.1

Key Terms
- evidence-based reasoning
- test
- redesign

Lesson Summary
In this lesson groups will work together to test their designs. They will evaluate the methods of stress intervention and redesign using results from student testing and math-based reasoning.

Background
Teacher Background
Engineers often need to validate their solutions in some way, either through prototyping, or other ways of demonstrating the solution as a proof of concept. Students will also be challenged to write a procedure that someone from outside of their team is able to understand and execute.

Before the Activity
- Make copies of the duplication masters:
    - 7.A Post-Test Evaluation (1 per student)
    - 7.B Redesign (1 per student)
    - 7.C Client Memo 3 (1 per student)

Classroom Instruction
Introduction
1. **Revisit the EDP.** This Lesson Goes over the Test and Decide (also called Evaluate) steps of the Engineering Design Process.
2. **Introduce the activity. Say:** *Today we will be testing solutions generated from other teams. You will be taking notes of your experiences in you engineering notebooks, and using the evaluation criteria to give the team an idea of how their solution does or does not solve the client problem, and ways that their solutions can be improved.*

Activity
3. **Have students test another team's solution.** Students will be in teams, testing and evaluating the designs of other teams. Have the teams trade procedures and test them both at the same time.
4. **Evaluate the effectiveness of the solutions.** Students will record the effectiveness of the other teams' solution, and answers to the reflection prompts on what their peers have recorded for them. Students will use an evaluation criteria to provide insight to other teams on how to improve their designs. Have students take notes on the other team's solution as they test it and make sure they share their results so the original

team can evaluate and redesign their solution.

5. **Brainstorm changes to improve the design solution.** Based on the testing results, have students fill out 7.A Post-Test Evaluation for their design. Then they should reflect and use their engineering notebooks to plan out improvements to their designs.
6. **Redesign methods of stress intervention.** After student groups plan how they will make changes to improve their design to better meet the criteria and constraints, have students physically make their changes. After they have redesigned, they should go through the testing process again but each group can test their own design this time.
7. **Reflect on redesigning.** Have student groups fill out 7.B Redesign based on their last round of testing. This reflection gives students a chance to decide on a final solution to the client's problem.

Closure

8. **Connect to the EDP. Ask:** *What phase of the engineering design process do you think we will be in for the next lesson? Do you feel like we are able to make a successful recommendation to the client yet? Why or why not?*
9. **Read duplication master 7.C Client Memo 3. Ask:** *What is the client asking us to do?* Explain to students that they will be using the next class time to prepare their presentations and will be given more clear guidelines as mentioned in the client memo.

Assessments
Activity Embedded Assessment
Students being able to have their procedures tested will be a way to evaluate comprehension.

Duplication Masters
- 7.A Post-Test Evaluation
- 7.B Redesign
- 7.C Client Memo 3

7.A Post-Test Evaluation

Analyze your solution based on:	The results from your tests	The expected results based on what you learned before planning	Whether or not your solution addressed the criteria and met the constraints
What went well?			
What needs improvement?			

Based on your analysis of your test results, the expected results, and the criteria and constraints, what improvements to your solution do you want to make and why?

7.B Redesign

Analyze your redesign based on:	The results from your tests	The expected results based on what you learned before planning	Whether or not your solution addressed the criteria and met the constraints
What went well?			
What needs improvement?			

1. Did your redesign improve your solution? Why or why not?

2. If you could do another redesign, how would you try to improve your solution?

7.C Client Memo 3

Dear Engineers,

Thank you for your work in evaluating your final designs to help us reduce stress for high school students. As you finalize your decision, I would like each team to prepare a presentation describing your design, the procedure you developed to use your design, the results you found based on your experiments, and whether or not you would recommend your final design to be developed by our organization. This is your opportunity to convince the other design teams that your design is the best, so please ensure you use the guidelines I have attached when preparing your presentation.

Sincerely,

Art Beet

Art Beet
Consulting Engineer – Mental Health Outreach
Revitalizing Lives in Educational Facilities (RELIEF)

LESSON EIGHT:

Lesson Objectives
Students will be able to:
- Communicate science, technology, engineering, and mathematics ideas
- Present their solution to the client's problem
- Use evidence-based reasoning to support their engineering decisions
- Connect careers in microelectronics to their suggestion

Materials
Per classroom
- EDP Poster

Per group
- PowerPoint or equivalent software

Per student
- EDP slider and paperclip
- Laptop or equivalent device
- Engineering notebook

Time Required
Two 45-minute classes

Standards Addressed
IAS Science and Engineering Practices
- SEP.6, SEP.7, SEP.8

IAS Integrated STEM
- HS.CC.1, HS.CC.2, HS.CC.3, HS.DM.3, HS.IDL.3

Key Terms
- criteria
- constraint
- communication

Lesson Summary

In this lesson students will use the evidence and data they have collected to present their method of stress intervention to the client. After the presentations, the teacher will justify the importance of the unit using current events in the microelectronics field, emphasizing the high workforce demand. Connections in microelectronics include cars, video game consoles, instant-replay, etc.)

Background

Teacher Background

Communication is one of the most important skills for engineers or really any industry professional to have. We want students to be able to understand the client's problem and their own proposed solution so well that they are able to explain it to others who were not involved with the project. Students will be working together in their teams to produce a poster to communicate their solution. After the 'Decide' stage of the Engineering Design Process, engineers often have to communicate their redesigned solution to the client. Students must be able to articulate why their solution meets the client's criteria and explain how it fits within the constraints of the project. This is a great opportunity for students to practice using math vocabulary as they backup their decisions with evidence.

Before the Activity

- If allowing students to present using posters, gather and set up poster materials.
- If using PowerPoint or an equivalent software, it might be helpful to create a template before class that students can use to organize their thoughts.
- (Optional): If you are interested in learning more about the workforce needs in the microelectronics industry, reading over the CHIPS Act of 2022 is a good place to start. It will give the instructor more context when discussing microelectronics-related careers in engineering. https://www.commerce.senate.gov/services/files/592E23A5-B56F-48AE-B4C1-493822686BCB
- Print and make copies of the following duplication masters in the labeled amounts:
  - (1 per group) 8.A Communication Requirements
  - (1 per student) 8.C Content Post-Assessment

Classroom Instruction

Introduction

1. **Tie to the engineering challenge. Say:** *We are almost done solving this engineering design problem!* **Ask:** *Can anyone tell me about the problem? Who was our client? What problem did they want us to solve? What were the criteria and constraints of the problem?*
2. **Identify where they are in the engineering design process. (Decide)** Draw students' attention to the EDP poster and sliders. **Ask:** *What did you do in the previous class?* **Say:** *Throughout the entire engineering design process, we have been working in teams and communicating within your teams and with other teams in the class. Now you need to communicate to the client, Art Beet, so that they know about your design decisions and why it meets or does not meet their needs.*

Activity

3. **Review 7.A Client Memo 3. Say:** *Engineers often have to communicate their solution to the client. Remember the client has not been sitting with you each day watching you develop your procedures. You must explain why the criteria and constraints of the project are satisfied, and justify your design decisions using evidence.*
4. **Explain what is needed in the presentation.** Hand out 8.A Communication Requirements. Briefly describe what is required of the groups. If you have developed a template for your students share this now. Note that approximately six slides should be enough for groups to meet the communication requirements.
   a. Introduction of students
   b. Problem summary
   c. Importance of positive coping strategies
   d. Summary of design
   e. Test results
   f. Final design recommendation to the client
7. **Identify where they are in the engineering design process. (Communication) Ask:** *What stage of the engineering design process are we in now?* Facilitate a discussion about why communication with the client is vital to engineering design.
8. **Prepare design review presentations.** Students can take pictures of their engineering notebooks, testing process, or any previous activities to provide evidence in their chosen communication format.
9. **Groups present their designs.** Have final coded micro:bit

Assessments

Pre-Activity Assessment

Class discussion about what is important in a presentation.

Activity Embedded Assessment

Check for evenly distributed team participation in presentation.

Post-Activity Assessment

Final presentation assessed using 8.A Communication Requirements. Assess student understanding of the unit using the 8.D Content Post Assessment Key.

Duplication Masters

- 8.A Communication Requirements
- 8.B Client Memo 4
- 8.C Content Post-Assessment

Educator Resources

- https://www.commerce.senate.gov/services/files/592E23A5-B56F-48AE-B4C1-493822686BCB
- 8.D Content Post-Assessment Key

prototypes present at the time of the presentation activity for peers to view.

10. **Briefly reflect on presentations.** Have students write down one thing they noticed or connected to from each group's presentation or poster in their notebooks.
11. **Discuss how microelectronics are essential to healthcare. Ask:** *Why do you think microelectronics are important in healthcare? How would our lives be different without microelectronics?*
12. **Make connections to careers relating to microelectronics.** Help students understand why the microelectronics industry is relevant to their lives and communities. In states like Indiana and Ohio, there is a large influx of semiconductor positions ranging from technician to senior engineer. Discuss the investment the US government is making into microelectronics through bills like the CHIPS Act of 2022 https://www.commerce.senate.gov/services/files/592E23A5-B56F-48AE-B4C1-493822686BCB

Closure

13. **Revisit the engineering design challenge.** Discuss the client, the problem, what information led to their final design, and how criteria and constraints were included in the decision-making process.
14. **Provide feedback from the client.** This makes more sense to do a day or two after the students have presented. Read Duplication Master 8.B Client Memo 4 as a class. Reflect on the engineering design process and how the process was used throughout the unit.
15. **Have students complete 8.C Content Post Assessment.**
16. **OPTIONAL: Review the entire unit.** If time allows, the teacher may choose to review some of the material during the Learn lessons.

8.A Communication Requirement

- Students introduce themselves.
- Students summarize the client's problem including criteria and constraints.
- Students explain why it is important to monitor stress and have successful coping mechanisms
- Students describe their solution to the problem.
  - Describe the stress intervention procedure including the math concepts and associated code.
  - Explain the test results they found in lesson seven.
  - Provide a redesigned intervention method to the client.
- Students show data and evidence gathered and used in their design.
- Students justify their process design decisions using data/evidence.
- Students explain how the engineering design process, including redesign, was used to develop their solution.
- All team members have a role in the poster construction.
- Students demonstrate in-depth knowledge of the mathematical concept they chose.

8.B Client Memo 4

Dear Engineers,

I received your presentations this morning and have reviewed them. The designs you submitted will be extremely helpful in reducing teen stress in a variety of activities.

Future work in microelectronics careers: Thank you for your dedication to this engineering challenge and for all of the hard work that you did for my organization. I hope to have the opportunity to work with you again in the future.

Sincerely,

Art Beet

Art Beet
Consulting Engineer – Mental Health Outreach
Revitalizing Lives in Educational Facilities (RELIEF)

Name______________________________________ Date______________ Period __________

8.C Content Post-Assessment

1. How do you solve a polynomial for zeroes if there are four terms?

2. What are the x-intercepts for $f(x) = x^3 - 2x^2$? Show your work.

3. What is the difference between relative and absolute extrema?

4. Describe what can happen to stress levels when using different kinds of coping skills.

5. What is a micro:bit?

6. Describe one kind of a critical point in a continuous function?

Name____ Date_______________ Period __________

8.C Content Post-Assessment

7. Factor this function to its simplest form: $f(x) = x^3 + 15x^2 + 75x + 125$

8. What does the term, "microelectronics" mean?

9. How are microelectronics used in the field of algebra or pre-calculus?

10. What jobs would you be interested in that use microelectronics? Provide one example of how microelectronics is used in that job.

Name____ Date________________ Period ___________

8.D Content Post-Assessment Key

1. How do you solve a polynomial for zeroes if there are four terms?

   Factor by grouping.

2. What are the x-intercepts for $f(x) = x^3 - 2x^2$. Show your work.

   $f(x) = x^2(x - 2)$
   $x = 0$; $x = 0$; $x = 2$

   The x-intercepts are 0 and 2.

3. What is the difference between relative and absolute extrema?

   Relative extrema are all maximums and minimums within a given domain. The absolute extrema are the highest maximum and lowest minimum within a given domain.

4. Describe what can happen to stress levels when using different kinds of coping skills.

   Student answers may vary, but could include descriptions of the stress and coping cycle from lesson 1 or prolonged health impact with a lack of positive coping strategies.

5. What is a micro:bit?

   A micro:bit is a small, programmable device that contains a microcontroller and built in sensors.

6. Describe one kind of a critical point in a continuous function?

   Students answers may vary, but could include descriptions like the point where a function changes from increasing to descreasing or from decreasing to increasing.

Name____ Date_______________ Period __________

8.D Content Post-Assessment Key

7. Factor this function to its simplest form: $f(x) = x^3 + 15x^2 + 75x + 125$

   $f(x) = (x + 5)^3$

8. What does the term, “microelectronics” mean?

   Student answers may vary, but the formal definition of microelectronics is the design, manufacture, and use of microchips.

9. How are microelectronics used in the field of algebra or pre-calculus?

   There are many answers to this question, but one example could be using microelectronics to collect a specific type of data for graphical analysis.

10. What jobs would you be interested in that use microelectronics? Provide one example of how microelectronics is used in that job.

    Students’ answers will vary based on interest. Credit may be given as long as at least one job example is provided with their logic behind how that job uses microelectronics.