UNIT OVERVIEW

BIOMEDICAL ENGINEERING

Listed below is a summary of the activities in this unit. The total teaching time as listed is 13–18 periods of approximately 45–50 minutes each (approximately 2–3 weeks if you teach the activities as recommended every day).

Activity Description	Topics	Advance Preparation	Assessment	Teaching Periods
1. **Investigation: Save Fred!** Students are introduced to the process of engineering by solving a simple physical problem. The activity elicits and builds on students' ideas about how to develop a successful solution.	engineering, engineer, scientist LITERACY	Gather gummy candies.		1–2
2. **Investigation: Me, An Engineer?** By simulating an injury to the dominant arm, students use their ingenuity and some simple supplies to invent solutions to problems they encounter accomplishing everyday tasks. Through the experience, students consider the practical needs of people with disabilities and the impact of biomedical engineering.	biomedical engineer	Gather clothing, shoes, hair clips, dolls, boxes, glue, scissors, tape; set up stations; prepare Student Sheets.		1–2
3. **Reading: Bionic Bodies** Students explore the application of biomedical engineering through the case studies of three individuals. These cases show that individual needs, desires, and values help drive the development of new technologies.	constraint, criteria, biomedical engineering LITERACY, MATHEMATICS	Prepare Student Sheet.	EXP A2	1–2
4. **Design: Artificial Bone Model** Students are challenged to design, build, and test models of an artificial bone to meet criteria. They analyze the quantitative data from different prototypes and combine ideas to optimize their designs.	criteria, constraint, model, prototype, variable, optimize LITERACY, MATHEMATICS	Gather balances, digital scale, pennies; cut strips of paper; set up testing stations; prepare Student Sheets.	ENG Proc.	2–3
5. **Design: Artificial Heart Valve** Students apply the engineering design process to developing a model for an artificial heart valve. Students create initial prototypes, test, evaluate, and redesign their solutions in an iterative engineering design process.	engineering design process, aortic valve, model, prototype, variable, optimize LITERACY	Gather plastic bins, sponges, mops, scissors, tape, colored pencils; construct sample valves; prepare Student Sheets.	ENG Proc. E&T A5	2–3
6. **Reading: The Work of an Engineer** Students explore the discipline of engineering in more detail. They read about the interplay between science, engineering, and technology in the development of new products.	technology, engineering design process, engineer, scientist LITERACY	Prepare Student Sheet.	E&T A4	1–2

BIOMEDICAL ENGINEERING (continued)

Activity Description	Topics	Advance Preparation	Assessment	Teaching Periods
7. **Investigation: Snack Bar** Students evaluate the ingredients of various snack bars to determine how each design best meets criteria. Then they design a snack bar to meet particular nutritional need of a specific medical condition.	carbohydrate, fat, protein, criteria, constraints, evaluating designs MATHEMATICS	Prepare Student Sheets.	ARG Proc., A4	1–2
8. **Laboratory: Investigating Biomechanics** Students explore the biomechanics of muscles and tendons in a chicken wing as background knowledge to later design a gripping device. This information on the structure and function of a wing is used to develop a model of movement.	biomimicry, function, structure, tendon	Buy chicken wings; gather bleach, garbage bags, forceps, dissection scissors and trays.	MOD A2	1–2
9. **Design: Get a Grip** Students use the approach of biomimicry to design, test, evaluate, and redesign a mechanical gripping device to meet criteria. They use a reiterative process to optimize the device in one of two ways.	design, structure, function model, robotics, engineering design process, optimize LITERACY	Gather pennies, scissors; set up testing stations; prepare Student Sheet.	ENG Proc.	2–3

A#: Analysis item number
Proc.: Procedure
ARG: Engaging in Argument from Evidence
COM: Communication Concepts and Ideas
E&T: Evidence and Trade-offs
EXP: Constructing Explanations
MOD: Developing and Using Models

NGSS UNIT OVERVIEW

BIOMEDICAL ENGINEERING

Performance Expectation MS-ETS1-1: Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

Performance Expectation MS-ETS1-2: Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

Performance Expectation MS-ETS1-3: Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

Performance Expectation MS-ETS1-4: Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an optimal design can be achieved.

Activity Description	Disciplinary Core Ideas	Science and Engineering Practices	Crosscutting Concepts	Common Core State Standards
1. **Investigation: Save Fred!** Students are introduced to the process of engineering with a scenario that engages them in solving a simple problem. The activity elicits and builds on students' ideas about how to develop a successful solution. The processes used by scientists and engineers are compared and contrasted.	MS-ETS1.A MS-ETS1.B	Asking Questions and Defining Problems		
2. **Investigation: Me, an Engineer?** Students are challenged to design tools and strategies to solve the practical problem of using one arm to complete daily tasks. Within the criteria and constraints of the problems, students navigate the environment and optimize their solutions. The activity concludes with an opportunity for students to define and analyze a design problem in their everyday lives.	MS-ETS1.A MS-ETS1.C MS-ETS1.B	Asking Questions and Defining Problems	Structure and Function Interdependence of Science, Engineering, and Technology Influence of Science, Engineering, and Technology on Society and the Natural World	
3. **Reading: Bionic Bodies** Students explore the application of biomedical engineering through the case studies of three individuals. These cases show that individual needs, desires, and values help drive the technologies and the limitations of their use. Students read about the role of criteria and constraints in the design process. Students are formally assessed on Performance Expectation MS-ETS1-1.	MS-ETS1.A	Asking Questions and Defining Problems	Interdependence of Science, Engineering, and Technology Influence of Science, Engineering, and Technology on Society and the Natural World Structure and Function	ELA/Literacy: RST 6-8.1 RST 6-8.9 RST.6-8.2

BIOMEDICAL ENGINEERING (continued)

Activity Description	Disciplinary Core Ideas	Science and Engineering Practices	Crosscutting Concepts	Common Core State Standards
4. **Design: Artificial Bone Model** Students are challenged to design, build, and test models of an artificial bone to meet criteria. They analyze the quantitative data from different prototypes and combine ideas to optimize their design. The hands-on experience demonstrates the engineering design process without it yet defined.	MS-ETS1.A MS-ETS1.B MS-ETS1.C MS-LS1.A	Asking Questions and Defining Problems Developing and Using Models Constructing Explanations and Designing Solutions Analyzing and Interpreting Data Using Mathematics and Computational Thinking	Structure and Function	Math: MP.2 6.RP.A.1 7.RP.A.2 ELA/Literacy: SL8.4
5. **Design: Artificial Heart Valve** Students apply the engineering design process to developing a model for an artificial heart valve. After reading about the societal need for this technology, students create initial prototype designs. Students test and evaluate their designs before redesigning them. They optimize their solutions in an iterative process that identifies the best characteristics of each prototype. Students compare designs with their peers and evaluate which ones meet the criteria and constraints of the problem. Students are formally assessed on Performance Expectation MS- ETS1-3.	MS-ETS1.B MS-ETS1.C MS-LS1.A	Asking Questions and Defining Problems Developing and Using Models Construction Explanations and Designing Solutions Analyzing and Interpreting Data Engaging in Argument from Evidence	Influence of Science, Engineering, and Technology on Society and the Natural World Structure and Function	Math: MP.2 ELA/Literacy: SL8.4
6. **Reading: The Work of an Engineer** Students explore the discipline of engineering in more detail. They read about the interplay between science, engineering, and technology in the development of new products. They consider the positive benefits and negative environmental consequences of biomedical advances. Students are formally assessed on Performance Expectation MS-ETS1-1.	MS-ETS1.A	Asking Questions and Defining Problems	Interdependence of Science, Engineering, and Technology Influence of Science, Engineering, and Technology on Society and the Natural World Connections to Nature of Science	ELA/Literacy: RST 6-8.1 RST.6-8.9 RST.6-8.2 WHST.6-8.9

BIOMEDICAL ENGINEERING (continued)

Activity Description	Disciplinary Core Ideas	Science and Engineering Practices	Crosscutting Concepts	Common Core State Standards
7. **Investigation: Snack Bar** Students examine food that has been designed for specific medical conditions. They evaluate designs using a systematic process to determine how each design meets the needs of a specific condition. The evaluation depends on mathematical reasoning and analyzing data to find the solution that best meets the criteria. Then students develop their own snack bar designs to address the needs of another condition. Students are formally assessed on Performance Expectation MS- ETS1-2.	MS-ETS1.B MS-ETS1.A MS-LS1.C	Engaging in Argument from Evidence Constructing Explanations and Designing Solutions Using Mathematics and Computational Thinking	Interdependence of Science, Engineering, and Technology Influence of Science, Engineering, and Technology on Society and the Natural World	Math: MP.2 7.EE.3
8. **Laboratory: Investigating Biomechanics** Students explore the biomechanics of muscles and tendons in a chicken wing as background knowledge to later design a gripping device. This information on the structure and function of a wing is used to develop a model of natural movement. Students are introduced to the concept of biomimicry, which is a popular engineering approach that leads to a more limited, but often successful, solution.	MS-ETS1.A MS-ETS1.B MS-LS1.A	Developing and Using Models Constructing Explanations and Designing Solutions Connections to Nature of Science	Structure and Function	
9. **Design: Get a Grip** Students use the approach of biomimicry to design, test, evaluate, and redesign a mechanical gripping device to meet criteria. They use the engineering design process to optimize the device in one of two ways. In doing so, they investigate the relationship between structure and function of the device and how the technology they developed can be applied. Students are formally assessed on Performance Expectation MS-ETS1-4.	MS-ETS1.A MS-ETS1.B MS-ETS1.C MS-LS1.A	Asking Questions and Defining Problems Developing and Using Models Using Mathematics and Computational Thinking Constructing Explanations and Designing Solutions	Structure and Function Interdependence of Science, Engineering, and Technology Influence of Science, Engineering, and Technology on Society and the Natural World	ELA/Literacy: SL8.4

PHENOMENA, DRIVING QUESTIONS AND STORYLINE

BIOMEDICAL ENGINEERING

How can science, technology, and engineering, be used to solve medical problems?

Phenomenon	Driving Questions	Guiding Questions	Activities	PE	Storyline/Flow (How an activity leads to subsequent activities)
Many people have medical conditions.	How can engineering be used to improve the lives of those living with medical conditions?	What tools and strategies can you design to deal with a broken arm? (Activity 2)	2, 3, 4, 5, 7	MS-LS2-4 MS-LS2-5 MS- ETS1.A MS- ETS1.B	Solving problems is something that we do every day. One of the most common processes used to find solutions to problems is known as engineering. One type of engineering, biomedical engineering, focuses on engineering devices or processes to help those with medical conditions. Biomedical engineers engage in a multi- step non-linear iterative process that makes use of scientific knowledge and technology in order to find solutions that meet the needs (criteria) of the medically afflicted within certain limits (constraints). Once solutions to biomedical problems are engineered, engineers often look for ways to optimize their solutions. Common examples of optimization are: making a device cheaper, stronger, or better at specific functions.
		How has the development of artificial body parts changed lives? (Activity 3)			
		How can you design a prototype of an artificial bone that is strong yet light and flexible? (Activity 4)			
		How can you design a heart valve prototype out of common materials? (Activity 5)			
		Can you design a snack bar to meet the needs of people with specific medical conditions? (Activity 7)			

PHENOMENA, DRIVING QUESTIONS AND STORYLINE

BIOMEDICAL ENGINEERING

How can science, technology, and engineering, be used to solve medical problems?

Phenomenon	Driving Questions	Guiding Questions	Activities	PE	Storyline/Flow (How an activity leads to subsequent activities)
Scientists and engineers use technologies. Technologies are often developed by engineers and scientists.	How do new technologies get developed?	What tools and approaches can be used to solve a problem? (Activity 1)	1, 4, 5, 6, 8, 9	MS-ETS1-1 MS-ETS1-2 MS-ETS1-3 MS-ETS1-4	Solving problems is something that we do every day. One of the most common processes used to find solutions to problems is known as engineering. One type of engineering, biomedical engineering, focuses on engineering devices or processes to help those with medical conditions. Biomedical engineers engage in a multi- step non-linear iterative process that makes use of scientific knowledge and technology in order to find solutions that meet the needs (criteria) of the medically afflicted within certain limits (constraints). Once solutions to biomedical problems are engineered, engineers often look for ways to optimize their solutions. Common examples of optimization are: making a device cheaper, stronger, or better at specific functions.
		How can you design a prototype of an artificial bone that is strong yet light and flexible? (Activity 4)			
		How can you design a heart valve prototype out of common materials? (Activity 5)			
		How are science, engineering, and technology related? (Activity 6)			
		How does the structure of an arm or wing affect its function? (Activity 8)			
		How can you make a mechanical grabber that can pick up and move an object? (Activity 9)			