PLTW Environmental Sustainability Course Framework

PLTW Framework - Overview

PLTW Frameworks are representations of the knowledge, skills, and understandings that empower students to thrive in an evolving world. The PLTW Frameworks define the scope of learning and instruction within the PLTW curricula. The framework structure is organized by four levels of understanding that build upon each other: Knowledge and Skills, Objectives, Domains, and Competencies.

The most fundamental level of learning is defined by course Knowledge and Skills statements. Each Knowledge and Skills statement reflects specifically what students will know and be able to do after they've had the opportunity to learn the course content. Students apply Knowledge and Skills to achieve learning Objectives, which are skills that directly relate to the workplace or applied academic settings. Objectives are organized by higher-level Domains.

Domains are areas of in-demand expertise that an employer in a specific field may seek; they are key understandings and long-term takeaways that go beyond factual knowledge into broader, conceptual comprehension.

At the highest level, Competencies are general characterizations of the transportable skills that benefit students in various professional and academic pursuits. As a whole, the PLTW Frameworks illustrate the deep and relevant learning opportunities students experience from PLTW courses and demonstrate how the courses prepare students for life, not just the next grade level.

To thrive in an evolving world, students need skills that will benefit them regardless of the career path they choose. PLTW Frameworks are organized to showcase alignment to in-demand, transportable skills. This alignment ensures that students learn skills that are increasingly important in the rapidly advancing, innovative workplace.

Essential Questions

1.1 - 1	Why are food insecurity, a lack of clean water, and the need for renewable energy sources problems worth solving?
1.1 - 2	How might the human condition be improved through biological and environmental engineering?
1.1 - 3	How can genetically modified organisms provide environmentally friendly and sustainable solutions to ensure food security for a growing world population; provide affordable, renewable energy; and provide clean, safe drinking water?
1.1 - 4	Why is it important for scientists and engineers to work together to solve problems?
1.1 - 5	How does ethics affect environmental sustainability solutions?
2.1 - 1	Why is water necessary for survival?
2.1 - 2	What are the human consequences resulting from a lack of a clean water supply?
2.1 - 3	How can biological engineering of organisms be used to help provide clean, safe drinking water?
2.1 - 4	What factors affect a region's ability to access clean, safe drinking water?
2.2 - 1	What is clean water? Can water consisting of anything other than 100% water be considered clean?

2.2 - 2 Why is it important to routinely test water that is used for drinking or recreational purposes?

2.2 - 3 How does the quality of drinking water affect human health?

2.3 - 1 How do you determine which micro-organisms are most effective at cleaning up a given pollutant?

2.3 - 2 What are the limitations, risks, and benefits of using biological organisms to clean up environmental pollutants?

2.4 - 1 How can wastewater be treated so that the resulting effluent causes no harm to the environment or people?

2.4 - 2 What are the roles that different types of biological organisms can play in helping clean contaminated water?

2.4 - 3 How can developing countries improve the availability of clean drinking at the local level?

2.4 - 4 How can wastewater treatment and fish aqua-culture be combined into one integrated system that cleans water while simultaneously producing fish for food?

2.4 - 5 Why is the availability of clean drinking water such a challenge in so many parts of the world?

3.1 - 1 How can genetically modified organisms help feed a growing world population?

3.1 - 2 Why is it important for scientists and engineers to work together to solve problems?

3.1 - 3 How might human health be improved by biological and environmental engineering?

3.1 - 4 How can engineers create solutions that contribute to sustainable food production?

3.2 - 1 Why can changes in the DNA sequence affect an organism?

3.2 - 2 How do scientists use knowledge of cellular structure to extract the DNA from cells?

3.2 - 3 How might a change in DNA impact the associated protein?

3.2 - 4 How do scientists use knowledge of the process of DNA replication that occurs naturally in cells to replicate segments of DNA in the lab?

3.2 - 5 How can scientists determine whether an organism’s genes have been manipulated?

3.3 - 1 How do scientists manipulate the DNA inside of cells?

3.3 - 2 Why do scientists have to choose specific restriction enzymes to use in gene manipulation?

3.3 - 3 What are the roles of microbes in biotechnology?

3.3 - 4 Why are plasmids used in genetic manipulation?

3.3 - 5 What information can be learned from reading a plasmid map?

3.3 - 6 How can one determine the success of a ligation experiment?

3.4 - 1 How has our world been changed by genetic engineering?

3.4 - 2 How can biological engineering ensure crop production that is sustainable?

3.4 - 3 How can biological engineering of organisms be used to feed a growing world population while protecting the environment?

3.4 - 4 How do we decide if the benefits of genetically modifying organisms outweigh the risks?

3.4 - 5 How should we decide whether or not to use genetically modified crops?

3.4 - 6 Is it ethical to genetically modify organisms?

3.4 - 7	Should genetically modified organisms be allowed to be patented?
4.1 - 1	Should biofuels be used as a replacement for fossil fuels?
4.1 - 2	How can biofuels help mitigate climate change?
4.1 - 3	What are the benefits and potential negatives of using biofuels?
4.1 - 4	What variables need to be considered when making decisions about the use of energy resources?
4.1 - 5	How can we produce biomass for fuel without competing with food production?
4.1 - 6	What are the environmental impacts of biofuel production?
4.2 - 1	How does one determine the best system (equipment and methods) for growing algae with the goal of producing biofuels from the algae?
4.2 - 2	What are the most efficient processes and tools for the biomanufacture of biofuels?
4.2 - 3	What is the role of biomanufacturing in helping provide sustainable energy?
4.2 - 4	How does one determine the optimal set of conditions for supporting and maximizing growth of an organism in a biomanufacturing context?
4.3 - 1	What are the most efficient processes and tools for biomanufacturing ethanol biofuels?
4.3 - 2	What are the environmental impacts of using large amounts of corn, cellulose, or sugar for the production of ethanol?
4.3 - 3	What are the social impacts of using large amounts of corn, cellulose, or sugar for the production of ethanol?
4.4 - 1	What are the advantages and disadvantages of biofuels derived from algae or cellulosic sources compared to biofuels derived from other sources?
4.4 - 2	In your opinion, what is the best biofuel? Why?
4.4 - 3	Why is it important to develop sources of renewable energy?
4.4 - 4	How can a life cycle analysis be used to determine the viability of a biomanufacturing operation?

Competencies, Domains, Objectives, Knowledge and Skills

Transportable Knowledge and Skills

Core workplace skills that students and workers need to acquire, that can be used across all stages of a career, and that, because of their universal utility, are transportable from job to job, from employer to employer, across the economy.

Career Readiness (CAR):

Engineers use professional skills and knowledge to pursue opportunities and create sustainable solutions to improve and enhance the quality of life of individuals and society.

CAR-A. Understand the educational, professional, and technical skills required for professional engineering practice.

CAR-A.1 Describe the educational and professional licensure requirements for engineering practice and engineering professionals.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☑	☐	☐	☐	☐	☐	☐	☐	☐	☐

CAR-B. Describe the role of engineers in society.

CAR-B.1 Define engineering as the creation of solutions (such as new and improved products, technologies, systems and processes) to meet the needs of people and society.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☑	☐	☐	☐	☐	☐	☐	☑

CAR-B.2 Investigate engineering successes and failures and their impact on individuals and society.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☑	☑	☐	☐	☐	☑	☐	☐	☑	☐	☐	☐	☐

CAR-C. Describe and distinguish among the different disciplines of engineering.

CAR-C.1 Explain that engineering disciplines continue to evolve and emerge as new interdisciplinary fields or sub-disciplines to better meet the needs of society.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☑	☑	☐	☑	☐	☐	☑	☐	☐	☐	☐	☑	☐

CAR-D. Discuss and analyze some of the persistent global engineering challenges to sustain growing populations and improve lives.

CAR-D.1 Explain that some engineering challenges are persistent such as providing access to clean water, providing a sustainable food supply, energy, sanitation, and health care to growing populations.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☑	☑	☑	☑	☐	☑	☐	☐	☑	☐	☐	☐	☑

CAR-D.2 Identify and describe some of the “Grand Challenges” defined by the National Academy of Engineering as current, global engineering challenges and describe their implications to society.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☑	☑	☐	☐	☐	☑	☐	☐	☐	☐	☐	☐	☐

Communication (COM):

Engineering practice requires effective communication with a variety of audiences using multiple modalities.

COM-A. Communicate effectively with an audience based on audience characteristics.

COM-A.1 Adhere to established conventions of written, oral, and electronic communications (grammar, spelling, usage, and mechanics).

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☑	☑	☑	☑	☑	☑	☐	☐	☑	☐	☑	☑	☑

COM-A.2 Follow acceptable formats for technical writing and professional presentations.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☑	☑	☑	☑	☑	☑	☐	☐	☑	☐	☑	☑	☑

COM-A.3 Describe how the size and characteristics of an audience will affect communication.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☑	☐	☐	☐	☐	☑	☐	☐	☑	☐	☑	☑	☑

COM-A.4 Modify the content, format, level of technical detail, and length of communications to meet the needs of the audience.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☑	☐	☐	☑	☐	☑	☐	☐	☑	☐	☑	☑	☑

COM-A.5 Properly cite references for all communication in an accepted format.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☑	☑	☑	☑	☐	☑	☐	☐	☑	☐	☑	☑	☑

COM-A.6 Clearly label tables and figures with units and explain the information presented in context.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☑	☑	☑	☑	☑	☑	☐	☐	☑	☐	☑	☑	☑

COM-A.7 Describe characteristics important to oral delivery of information (volume, tempo, eye contact, articulation, and energy). Vary these elements of delivery to convey and emphasize information and engage the audience.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☑	☑	☑	☑	☑	☑	☐	☐	☑	☐	☑	☑	☑

Collaboration (COL):

Demonstrate an ability to function on multidisciplinary teams.

COL-A. Facilitate an effective team environment to promote successful goal attainment.

COL-A.1 Describe the various individual roles and interdependence of a collaborative team.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☑	☑	☑	☑	☑	☑	☐	☐	☑	☐	☑	☑	☑

COL-A.2 Solicit, negotiate, and balance diverse views and beliefs to reach workable solutions.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☑	☐	☐	☑	☑	☑	☐	☐	☑	☐	☑	☑	☑

COL-A.3 Identify, describe, and justify a diverse composition of engineering (and other) disciplines that might work together to address challenges (including the Grand Challenges of Engineering).

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☑	☐	☐	☐	☐	☐	☐	☐	☐	☐	☑	☑	☑

COL-B. Contribute individually to overall collaborative efforts.

COL-B.1 Describe one’s individual role and expectations of performance within the team.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☑	☑	☑	☑	☑	☑	☐	☐	☑	☐	☑	☑	☑

COL-C. Manage project timelines and resources as part of an engineering design process.

COL-C.1 Select and use a system of collaborative tools, such as cloud-based tools, document sharing, and video and text functions, to successfully complete a project.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☑	☑	☑	☑	☑	☑	☐	☐	☑	☐	☑	☑	☑

Competencies, Domains, Objectives, Knowledge and Skills

Ethical Reasoning and Mindset (ERM):

Successful engineering professionals exhibit personal and professional characteristics and behaviors that involve consideration of the impact of their work on individuals, society, and the natural world.

ERM-A. Apply ethical consideration to engineering decision making.

ERM-A.1 Explain that engineers have a responsibility to serve the public interest, his/her clients, and the profession with a high degree of honesty, integrity, and accountability.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☑	☑	☐	☐	☑	☑	☐	☐	☐	☐	☐	☐	☐

ERM-B. Assess an engineering ethical dilemma.

ERM-B.1 Explain that engineering solutions can have significantly different impacts on an individual, society, and the natural world. The nature of these impacts can be environmental, economic, social, political, health and welfare.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☑	☑	☐	☐	☑	☑	☐	☐	☐	☐	☐	☐	☐

ERM-B.2 Identify an ethical dilemma that has positive and negative outcomes resulting from an engineering decision or series of decisions.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☑	☐	☐	☐	☐	☑	☑	☑	☐	☐	☐	☐	☐

ERM-C. Strive to create sustainable solutions to meet the needs of society, without compromising the ability of future society to meet their needs.

ERM-C.1 Identify principles that help guide development of sustainable solutions. Considerations for sustainable development include people, planet, and profit.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☑	☑	☐	☐	☐	☑	☐	☐	☐	☐	☐	☐	☑

ERM-C.2 Describe the life cycle of a product or service and identify energy consumption and wastes and emissions that are produced in the process.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☑	☐	☐	☐	☑	☐	☐	☐	☐	☐	☐	☐	☑

Competencies, Domains, Objectives, Knowledge and Skills

Critical and Creative Problem-Solving (CCP):

The skills necessary for students to generate ideas and solutions to problems.

CCP-A. Explain and justify an engineering design process.

CCP-A.1 Describe major steps of a design process and identify typical tasks involved in each step.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☑	☐	☐	☑	☑	☑	☐	☐	☑	☐	☑	☐	☑

CCP-A.2 Identify the step in which an engineering task would fit in a design process.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☑	☐	☐	☑	☑	☑	☐	☐	☑	☐	☑	☐	☑

CCP-A.3 Outline how iterative processes inform engineering decisions, improve solutions, and inspire new ideas.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☑	☑	☐	☐	☐	☐	☐	☐	☐	☑

CCP-A.4 Document a design process in an engineering notebook according to best practices.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☑	☐	☐	☑	☑	☑	☐	☐	☑	☐	☑	☐	☑

CCP-B. Collect, analyze and interpret information relevant to the problem or opportunity at hand to support engineering decisions.

CCP-B.1 Explain the role of research in the process of design.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☑	☑	☑	☑	☑	☐	☐	☑	☐	☑	☐	☑

CCP-B.2 Find relevant data in credible sources such as literature, databases, and policy documents.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☑	☑	☑	☑	☐	☑	☐	☐	☑	☐	☑	☐	☑

CCP-B.3 Explain the role of stakeholders and subject matter experts in the design process.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☑	☐	☐	☑	☐	☐	☐	☑	☐	☑	☐	☑

Competencies, Domains, Objectives, Knowledge and Skills

CCP-C. Synthesize an ill-formed problem into a meaningful, well-defined problem.

CCP-C.1 Explain the importance of carefully and specifically defining a problem or opportunity, design criteria, and constraints to develop successful design solutions.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☑	☐	☐	☑	☑	☑	☐	☐	☑	☐	☑	☐	☑

CCP-C.2 Identify and define visual, functional, and structural design requirements with realistic constraints against which solution alternatives can be evaluated.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☑	☐	☐	☑	☑	☐	☐	☐	☐	☐	☑	☐	☑

CCP-C.3 List potential constraints that may impact the success of a design solution. Examples include economic (cost), environmental, social, political, ethical, health and safety, manufacturability, technical feasibility, and sustainability.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☑	☐	☐	☑	☑	☐	☐	☐	☑	☐	☑	☐	☑

CCP-D. Generate multiple potential solution concepts.

CCP-D.1 Represent concepts using a variety of visual tools, such as sketches, graphs, and charts, to communicate details of an idea.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☑	☑	☑	☐	☐	☐	☐	☑	☐	☑

CCP-E. Develop models to represent design alternatives and generate data to inform decision making, test alternatives, and demonstrate solutions.

CCP-E.1 Describe the use of a model to accurately represent the key aspects of a physical system. Include the identification of constraints, such as cost, time, or expertise that may influence the selection of a model.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☑	☑	☐	☑	☑	☐	☐	☑	☐	☑

CCP-E.2 Define various types of models that can be used to represent products, processes or designs, such as physical prototypes, mathematical models, and virtual representations. Explain the purpose and appropriate use of each.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☑	☐	☑	☑	☐	☐	☑	☐	☐

Competencies, Domains, Objectives, Knowledge and Skills

CCP-F. Select a solution path from many options to successfully address a problem or opportunity.

CCP-F.1 Explain that there are often multiple viable solutions and no obvious best solution. Tradeoffs must be considered and evaluated consistently throughout an engineering design process.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☑	☐	☐	☑	☑	☐	☐	☐	☑	☐	☐	☐	☑

CCP-F.2 Develop and carry out a justifiable scheme to compare and evaluate competing solutions paths. A decision matrix is one tool used to compare and evaluate competing solutions based on design criteria.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☑	☐	☐	☑	☑	☐	☐	☐	☑	☐	☑	☐	☑

CCP-G. Plan and execute an investigation to collect valid quantitative data to serve as a basis for evidence and inform decisions.

CCP-G.1 Explain and identify independent and dependent variables and controls associated with an investigation.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☑	☐	☐	☐	☐	☐	☐	☑	☐	☐

CCP-G.2 Identify the data needed to answer a research question and the appropriate tools necessary to collect, record, analyze, and evaluate the data.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☑	☐	☐	☑	☑	☐	☐	☐	☐	☐	☑	☐	☐

CCP-G.3 Describe testing considerations necessary to ensure a valid, reliable, safe, and ethical investigation. Examples include considerations of cost, risk, time, as well as environmental, social, and personal impacts.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☑	☐	☐	☑	☑	☐	☐	☐	☐	☐	☑	☐	☑

CCP-H. Make judgements and decisions based on evidence.

CCP-H.1 Evaluate evidence and arguments to identify deficiencies, limitations, and biases or appropriate next steps in the pursuit of a better solution.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☑	☐	☐	☑	☑	☐	☐	☐	☐	☐	☐	☐	☑

CCP-I. Demonstrate independent thinking and self-direction in pursuit of accomplishing a goal.

CCP-I.1 Plan and use time in pursuit of accomplishing a goal without direct oversight.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☑	☑	☑	☑	☑	☑	☐	☐	☑	☐	☑	☐	☑

CCP-I.2 Explain the limitations of one's knowledge and skills in pursuit of accomplishing a goal.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☑	☑	☑	☑	☐	☑	☐	☐	☑	☐	☑	☑	☑

CCP-I.3 Plan how to gain additional knowledge and learning to accomplish a goal.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☑	☑	☑	☑	☑	☑	☐	☐	☑	☐	☑	☑	☑

CCP-J. Demonstrate flexibility and adaptability to change.

CCP-J.1 Adapt to varied roles, job responsibilities, schedules, and contexts.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☑	☑	☑	☑	☑	☑	☐	☐	☑	☐	☑	☐	☑

CCP-K. Persevere to solve a problem or achieve a goal.

CCP-K.1 Describe why persistence is important when identifying a problem and/or pursuing solutions.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☑	☑	☐	☐	☐	☐	☐	☑	☐	☑

CCP-K.2 Accept failure as part of an evolution of individual growth and necessary to the expansion of the engineering profession.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☑	☑	☐	☐	☐	☐	☐	☑	☐	☑

CCP-K.3 Reflect critically on past experiences to inform future progress.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☑	☑	☑	☐	☐	☐	☐	☐	☐	☑

CCP-K.4 Explain that risk is necessary for progress and that engineers must work with an acceptable level of risk.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☑	☐	☐	☑	☐	☐	☐	☐	☐	☐	☐	☐	☐

Competencies, Domains, Objectives, Knowledge and Skills

Technical Knowledge and Skills

Every career field requires technical literacy and career-specific knowledge and skills to support professional practice.

Engineering Tools and Technology (ETT):

The practice of engineering requires the application of mathematical principles and common engineering tools, techniques, and technologies.

ETT-A. Using a variety of measuring devices, measure and report quantities accurately and to a precision appropriate for the purpose.

ETT-A.1 Explain that all measurements are an approximation of the true value of a quantity.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☑	☑	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

ETT-A.2 Explain and differentiate between the accuracy and precision of a measurement or measuring device.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☐	☑	☐	☐	☐	☐	☐	☐

ETT-A.2 Use dimensional analysis and unit conversions to transform data to consistent units or to units appropriate for a particular purpose or model.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☑	☑	☑	☐	☐	☑	☑	☐	☑	☑	☐	☐

ETT-A.3 Select and properly use the appropriate tool for accurately measuring specific volumes; i.e., micropipet, serological pipet, graduated cylinder, beaker, etc.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☑	☑	☑	☑	☐	☑	☑	☐	☐	☑	☑	☐

ETT-B. Use a spreadsheet application to help identify and/or solve a problem.

ETT-B.1 Populate a spreadsheet application with data and organize the data to be useful in accomplishing a specific goal.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☑	☐	☐	☐	☐	☑	☐	☐	☑	☑	☐	☐

ETT-B.2 Use the functions and tools within a spreadsheet application to manipulate, analyze, and present data in a useful way, including regression analyses and descriptive statistical analyses.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☑	☐	☐	☐	☐	☑	☐	☐	☑	☑	☑	☐

ETT-B.3 Use programming features (macros) in a spreadsheet.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☐	☐	☐	☐	☑	☐	☐	☐

ETT-C. Construct physical objects.

ETT-C.1 Describe a process to build a physical object based on a conceptual communication such as a drawing or description.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☑	☐	☑	☑	☐	☐	☑	☐	☐	☐	☑	☐	☐

ETT-C.2 Calculate ratios and proportions.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☑	☐	☑	☐	☐	☑	☐	☐	☑	☑	☐	☐

ETT-D. Apply mathematical models and interpret the output of models to test ideas or make predictions.

ETT-D.1 Represent data for two quantitative variables on a scatter plot and describe how the variables are related.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☑	☐	☐	☐	☐	☐	☑	☑	☑	☐

ETT-D.2 In linear models, interpret the rate of change (slope) and the intercept (constant term) in the context of the data.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☑	☐	☐	☐	☐	☐	☑	☑	☑	☐

ETT-E. Apply system thinking to consider how an engineering problem and its solution fit into broader systems.

ETT-E.1 Explain that the framing of problems and defining assumptions make problems manageable in the context of larger systems.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☑	☐	☑	☐	☐	☐	☐	☐	☐	☑	☐	☐

ETT-E.2 List realistic considerations that constrain solutions within the broader system.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☑	☑	☐	☐	☐	☐	☑	☑	☐	☐

Competencies, Domains, Objectives, Knowledge and Skills

Foundations in Math and Engeneering Science (FMS):

Engineering practice requires an understanding of mathematical principles and scientific phenomena to solve problems.

FMS-A. Analyze environmental and physical factors related to safe drinking water.

FMS-A.1 Analyze the relationship between population growth and water resources.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☑	☑	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

FMS-A.2 Describe how human health is affected by the quality of drinking water sources.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☑	☑	☑	☑	☐	☐	☐	☐	☐	☐	☐	☐

FMS-A.3 Explain the characteristics of clean water.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☑	☑	☑	☐	☐	☐	☐	☐	☐	☐	☐

FMS-A.4 Explain why clean water is necessary for survival.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☑	☑	☑	☑	☐	☐	☐	☐	☐	☐	☐	☐

FMS-A.5 Describe common sources of drinking water contamination.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☑	☑	☑	☐	☐	☐	☐	☐	☐	☐	☐	☐

FMS-A.6 Explain contaminant cycling through an ecosystem.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☑	☑	☑	☐	☐	☐	☐	☐	☐	☐	☐	☐

FMS-A.7 Describe the types of water found on Earth and the relative amounts of each type.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☑	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

FMS-B. Describe infrastructure components and explain the processes used in private wells and public drinking water systems.

FMS-B.1 Describe the most common sources of drinking water in the United States and compare them to drinking water sources in other parts of the world.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☑	☑	☐	☐	☐	☐	☐	☐	☐	☐	☐

FMS-B.2 Describe the infrastructure components of private wells and public drinking water systems.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☑	☐	☐	☐	☐	☐	☐	☐	☐	☐

FMS-C. Use a variety of chemical and biological assays to detect contaminants in water.

FMS-C.1 Explain how water quality is quantitatively measured using chemical and biologically based testing processes.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☑	☑	☑	☐	☐	☐	☐	☐	☐	☐	☐

FMS-C.2 Perform and analyze a culture assay to detect coliform and E. coli in water.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☑	☑	☐	☐	☐	☐	☐	☐	☐	☐	☐

FMS-D. Identify appropriate wastewater treatment processes and designs to address common wastewater contaminants.

FMS-D.1 Explain the role of bacteria in water treatment.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☑	☐	☐	☐	☐	☐	☐	☐	☐	☐

FMS-D.2 Outline the stages of treatment that a typical modern sewage treatment plant uses to treat sewage water.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☑	☐	☐	☐	☐	☐	☐	☐	☐	☐

FMS-E. Identify and apply appropriate water remediation techniques to purify water.

FMS-E.1 Describe the interacting roles of bacteria, protozoa, and rotifers in a wastewater treatment “ecosystem.”

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☑	☐	☐	☐	☐	☐	☐	☐	☐	☐

FMS-E.2 Describe and provide examples of how physical, chemical, and biological processes work in the process of purifying contaminated water.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☑	☑	☐	☐	☐	☐	☐	☐	☐	☐

FMS-E.3 Explain how plants remove nitrates from contaminated water.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☑	☑	☐	☐	☐	☐	☐	☐	☐	☐	☐

FMS-E.4 Use the engineering design process to design, build, and test a water filtration system.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☑	☑	☐	☐	☐	☐	☐	☐	☐	☐

FMS-E.5 Design and perform an experiment to use phytoremediation to remove contaminants from water.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☑	☐	☐	☐	☐	☐	☐	☐	☐	☐

FMS-E.6 Design and conduct a scientific experiment to test a variable affecting the bacteria's ability to decompose oil.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☑	☐	☐	☐	☐	☐	☐	☐	☐	☐

FMS-F. Analyze environmentally and socially sustainable and unsustainable food production methods.

FMS-F.1 Analyze the advantages and disadvantages of genetically modified crops.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☑	☑	☑	☑	☐	☐	☐	☐

FMS-F.2 List and explain potential ways that crop plants might be improved through genetic manipulation.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☑	☑	☑	☑	☐	☑	☐	☐

FMS-F.3 Explain how transgenic plants could lead to positive and negative consequences to the environment and local ecosystem.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☑	☐	☑	☑	☐	☑	☐	☐

FMS-F.4 Describe the economic and socio-political issues associated with genetically modified food crops.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☑	☐	☐	☑	☐	☐	☐	☐

FMS-F.5 Investigate and summarize the ethical ramifications of genetic engineering and recombinant DNA technologies.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☑	☐	☐	☑	☐	☐	☐	☐

FMS-F.6 Analyze socially sustainable and unsustainable food production methods.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☑	☐	☐	☐	☐	☐	☐	☐

FMS-G. Understand and explain the meaning and value of food security.

FMS-G.1 Recognize that food security exists when all people at all times have access to sufficient, safe, nutritious food to maintain a healthy and active life.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☑	☐	☑	☑	☐	☐	☐	☐

FMS-H. Understand the structure and function of DNA.

FMS-H.1 Recognize that genetic information is contained in DNA molecules, which are double-helical structures with nucleotides.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☑	☑	☑	☑	☐	☐	☐	☐

FMS-H.2 Describe the relationship between chromosomes, DNA, genes, and proteins.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☐	☑	☑	☐	☐	☐	☐	☐

FMS-H.3 Illustrate the process of DNA replication.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☐	☑	☑	☐	☐	☐	☐	☐

FMS-H.4 Use the universal genetic code to determine the amino acids coded by a DNA sequence.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☐	☑	☑	☐	☐	☐	☐	☐

FMS-H.5 Illustrate transcription and translation.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☐	☑	☐	☐	☐	☐	☐	☐

FMS-H.6 Recognize that the DNA inserted into a plasmid may provide the code for a new protein.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☐	☐	☑	☑	☐	☐	☐	☐

FMS-H.7 Analyze resulting DNA fragments on a gel.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☐	☑	☑	☐	☐	☐	☐	☐

FMS-I. Apply the scientific techniques used in molecular biology.

FMS-I.1 Ligate DNA from two organisms to create a unique plasmid vector.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☐	☐	☑	☐	☐	☐	☐	☐

FMS-I.2 Isolate plasmid DNA from a bacterial cell and analyze the composition of the plasmid using restriction enzymes and gel electrophoresis.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☐	☐	☑	☐	☐	☐	☐	☐

FMS-I.3 Describe the process of gene cloning.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☐	☐	☑	☐	☐	☐	☐	☐

FMS-I.4 Map a plasmid in terms of the location of its restriction sites, sites that are recognized and cut by specific restriction enzymes.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☐	☐	☑	☐	☐	☐	☐	☐

FMS-I.5 Use proper laboratory techniques and safety protocols to extract and isolate DNA from food items.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☐	☑	☐	☐	☐	☐	☐	☐

FMS-I.6 Recognize that polymerase chain reaction (PCR) is a laboratory procedure that produces multiple copies of a specific DNA sequence.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☐	☑	☐	☐	☐	☐	☐	☐

FMS-I.7 Use proper laboratory techniques and safety protocols to insert a new plasmid into bacterial cells through the process of bacterial transformation.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☐	☐	☑	☐	☐	☐	☐	☐

FMS-I.8 Use proper laboratory techniques and safety protocols to separate DNA fragments using gel electrophoresis.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☐	☑	☑	☐	☐	☐	☐	☐

FMS-I.9 Recognize that plasmids that are cut with restriction enzymes can be joined or ligated to DNA (from any species) that has been cut with the same enzyme.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☐	☐	☑	☑	☐	☐	☐	☐

FMS-I.10 Recognize that the results of a ligation experiment can be gauged by restriction analysis of an extracted plasmid with subsequent visualization of resultant bands via electrophoresis demonstrating the number of gene inserts and the orientation of those in

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☐	☐	☑	☑	☐	☐	☐	☐

FMS-J. Develop and justify an argument for or against the use of genetic recombination methods in order to improve food security.

FMS-J.1 Develop logical and factual arguments in support of or against the creation and use of genetically modified organisms.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☑	☐	☑	☑	☐	☐	☐	☐

FMS-J.2 Investigate and summarize the ethical considerations of genetic engineering and recombinant DNA technologies.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☐	☐	☐	☑	☐	☐	☐	☐

FMS-J.3 Identify the ethical concerns with creating and using genetically modified organisms.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☐	☐	☑	☑	☐	☐	☐	☐

FMS-J.4 Recognize that genetically modified plants contain genes that have been physically moved or added to enhance a trait in that plant.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☑	☑	☑	☑	☐	☐	☐	☐

FMS-J.5 Calculate transformation efficiency to determine the success of a bacterial transformation experiment.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☐	☐	☑	☐	☐	☐	☐	☐

FMS-J.6 Describe methods used to produce transgenic plants.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☑	☑	☑	☐	☐	☐	☐	☐

Competencies, Domains, Objectives, Knowledge and Skills

FMS-K. Demonstrate a working knowledge of various sources of energy and their environmental and economic impact.

FMS-K.1 Identify and measure the amount and types of energy that students use in their daily lives.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☐	☐	☐	☐	☑	☐	☐	☐

FMS-K.2 Compare the burning of fossil fuels with the burning of biofuels in terms of the short and long-term effects on the atmospheric carbon cycle.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☐	☐	☐	☐	☑	☑	☐	☑

FMS-K.3 Explain the similarities and the differences between biofuels and fossil fuels.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☐	☐	☐	☐	☑	☑	☑	☑

FMS-K.4 Explain the differences between renewable and non-renewable sources of energy and provide examples of each.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☐	☐	☐	☐	☑	☑	☐	☐

FMS-L. Apply stoichiometric principles to the process of photosynthesis to predict and then compare to experimental results of oxygen/carbon dioxide production and consumption.

FMS-L.1 Explain how photosynthesis captures energy and CO2, and describe how this energy is stored in algae and plants and is the ultimate source of energy for both fossil fuels and biofuels.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☐	☐	☐	☐	☑	☐	☑	☐

FMS-L.2 Explain how cellular respiration is a balancing process with photosynthesis on our planet.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☐	☐	☐	☐	☑	☐	☐	☐

FMS-L.3 Interpret a biological growth curve by identifying and explaining each of the main phases of growth.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☑	☐	☐

Competencies, Domains, Objectives, Knowledge and Skills

FMS-M. Use simulations to make predictions.

FMS-M.1 Analyze the results of software simulations and models that vary the amounts and types of energy used to predict future energy needs.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☐	☐	☐	☐	☑	☑	☐	☐

FMS-N. Debate the positive and negative attributes of using algae and biological fee stocks as a fuel source.

FMS-N.1 Explain how algae that grew millions of years ago are the original source of most of the fossil fuels used today.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☑	☑	☑

FMS-N.2 Explain the characteristics necessary for certain algae and feed stocks to be used as a fuel source.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☑	☑	☑

FMS-O. Demonstrate efficient fuel production methods from renewable sources.

FMS-O.1 Perform a full life cycle analysis of a biofuels production facility.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☑	☐	☑

FMS-O.2 Identify the variables and the methods for completing a life cycle analysis of a biofuels biomanufacturing operation.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☑	☐	☑

FMS-O.3 Outline a sequence for scaling up a biomanufacturing process to commercial production capacity.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☑	☑	☑

FMS-O.4 Explain how enzymes function to promote more efficient chemical reactions.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☑	☑	☑

FMS-O.5 Describe and compare the systems used to cultivate algae.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☑	☐	☑

FMS-O.6 Outline the process and products of fermentation.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☑	☑

FMS-P. Plan various upstream and downstream processing methods to effectively design a biofuels manufacturing plant.

FMS-P.1 Identify the main types of algae used in biofuels production

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☑	☐	☑

FMS-P.2 Design a series of downstream processes for separating a product using an online simulation tool.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☑

FMS-P.3 Explain how different downstream separation and purification processes are used to separate a product from a mixture of components.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☑	☑	☑

FMS-P.4 Describe the two main phases of the biomanufacturing process.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☑	☐	☑

FMS-P.5 Analyze liquid paper chromatography results to identify the pigments in ink and plant samples and calculate the retention factor.

Lesson:	1.1	2.1	2.2	2.3	2.4	3.1	3.2	3.3	3.4	4.1	4.2	4.3	4.4
	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☑	☐	☐