intelitek

INTRODUCTION TO ENGINEERING PROBLEM SOLVING

Introduction:

SCOPE

Each unit includes:

1. Core Content: Provides theoretical background and knowledge.
2. Student Activity: Designed for groups of 4 students that have a kit and access to Coderz. The student activity is based on PBL with worksheets that provide the data and evaluation for each activity.

The course is based on:

1. Next Generation Science Standards (NGSS) in:
   - Forces and Interactions
   - Energy
   - Engineering Design
   - Science and Engineering Practices
2. K-12 Computer Science Standards (CSTA – Computer Science Teachers Association) at Level 3 in Computing Practice & Programming.
3. Common Core Standards for Mathematical Practice.
4. Iowa University - Engineering Problem Solving I academic course.

The mapping to these standards and items can be found in the Learning Objectives section at the end of this document.

COURSE DESIGN

The curriculum is designed so that each subsequent project is less structured and provides less instruction.

During the projects, a scenario is presented with a problem that needs to be solved. The robots provide the learning environment, and the unit tasks create the learning path. Learning and knowledge acquisition are derived from the problems that arise. These projects provide the required knowledge or ways of acquiring it for completing the projects. Problem Based Learning and Project Based Learning methods are thus implemented.

Many of the tasks and assignments in the course are to be completed in teams of four students.

Outline Summary

Unit Titles:

1. Living in a STEAM World

Project 1: Planetary Rover

In this set of activities, the students build a planetary rover according to given instructions. After building and moving it, they start to explore it from various STEAM aspects.

2. Building a Planetary Rover – PushBot

3. Driving the Planetary Rover – PushBot

4. Exploring Planetary Rover Motion 1

5. Exploring Planetary Rover Motion 2

6. Exploring Electrical Motors 1

7. Exploring Electrical Motors 2

8. Exploring Gears

9. Landing a Planetary Rover

10. Center of Gravity

11. Thermodynamics

Project 2: Material Handling Robot

In this set of activities, the students start to implement the knowledge attained from the first set of activities. The tasks are relatively easy and focus on the incorporation of all the previously learned knowledge to an object or product. Students learn to program the robot using Java. They experience using sensors and strategies for solving problems.

Unit Titles:

12. Sensor

13. Forklift

14. Navigation

15. Conclusion

Tools

- **Kit of Parts**:
  - Based on the TETRIX FTC Competition Set and the FTC Electronics Modules and Sensors Set.
- **Programming Interface**: Coderz
  - The student will write programs in Coderz using the Blocks interface and Java programming, and will run programs on the simulator and on the physical robot.
- **Instructor's Resource PDFs** are provided where necessary to:
  - Describe each unit.
  - Explain the teacher's involvement when required, for example, to play a video or divide students into groups.
  - Explain the grading for each unit.
- **Portfolio**:
  - Throughout the course, students will add notes, screenshots of programs, photos of robot builds and other useful engineering information as instructed to their portfolio, which they will be able to take with them after completing the course.

National Standards / Learning Objectives

NGSS - FORCES AND INTERACTIONS	PROJECT
HS-PS2-1 Analyze data to support the claim that **Newton's second law** of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.	Project 1
HS-PS2-2 Use mathematical representations to support the claim that the total **momentum** of a system of objects is conserved when there is no net force on the system.	Project 1
HS-PS2-3 Apply scientific and engineering ideas to design, evaluate, and refine a device that **minimizes** the **force** on a macroscopic object during a **collision**.	Project 1
HS-PS2-4 Use mathematical representations of **Newton's Law** of Gravitation and **Coulomb's Law** to describe and predict the gravitational and electrostatic forces between objects.	Project 1
HS-PS2-5 Plan and conduct an investigation to provide evidence that an electric current can produce a **magnetic field** and that a changing magnetic field can produce an electric current.	Project 1

NGSS - ENERGY	PROJECT
HS-PS3-1 Create a computational model to calculate the change in the energy of one component in a system when the change in energy of the other component(s) and energy flows in and out of the system are known.	Project 1
HS-PS3-2 Develop and use models to illustrate that energy at the macroscopic scale can be accounted for as a combination of energy associated with the motions of particles (objects) and energy associated with the relative position of particles (objects).	Project 1
HS-PS3-3 Design, build, and refine a device that works within given constraints to convert one form of energy into another form of energy.	All projects
HS-PS3-4 Plan and conduct an investigation to provide evidence that the **transfer of thermal energy** when two components of different temperature are combined within a closed system results in a more uniform energy distribution among the components in the system (second law of thermodynamics).	Project 1
HS-PS3-5 Develop and use a model of two objects interacting through electric or magnetic fields to illustrate the **forces between objects** and the changes in energy of the objects due to the interaction.	Project 1

NGSS – ENGINEERING DESIGN	PROJECT
HS-ETS1-1 Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.	Projects 2
HS-ETS1-2 Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.	Projects 2
HS-ETS1-3 Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics, as well as possible social, cultural, and environmental impacts.	Projects 2
HS-ETS1-4 Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.	Project 1

NGSS – SCIENCE AND ENGINEERING PRACTICES	PROJECT
Asking Questions and Defining Problems	All projects
Developing and Using Models	All projects
Planning and Carrying Out Investigations	All projects
Analyzing and Interpreting Data	All projects
Using Mathematics and Computational Thinking	All projects
Constructing Explanations and Designing Solutions	All projects
Engaging in Argument from Evidence	All projects
Obtaining, Evaluating, and Communicating Information	All projects

CSTA K12 – COMPUTER SCIENCE IN THE MODERN WORLD	PROJECT
Use various debugging and testing methods to ensure program correctness (e.g., test cases, unit testing, white box, black box, integration testing)	All projects
Select appropriate file formats for various types and uses of data.	All projects
Describe a variety of programming languages available to solve problems and develop systems.	All projects

CSTA K12 – COMPUTER SCIENCE IN THE MODERN WORLD	PROJECT
Explain the program execution process.	All projects
Describe techniques for locating and collecting small and large-scale data sets.	Project 2
Describe how mathematical and statistical functions, sets, and logic are used in computation.	All projects

CSTA K12 – COMPUTER SCIENCE CONCEPTS AND PRACTICE	PROJECT
Use advanced tools to create digital artifacts (e.g., web design, animation, video, multimedia).	Project 2
Classify programming languages based on their level and application domain	All projects
Explore principles of system design in scaling, efficiency, and security.	All projects (not only in computers)
Use data analysis to enhance understanding of complex natural and human systems.	Final project
Deploy various data collection techniques for different types of problems.	Project 2
Make sense of problems and persevere in solving them.	Project 2
Reason abstractly and quantitatively.	Project 2
Construct viable arguments and critique the reasoning of others. Model with mathematics.	Project 2
Use appropriate tools strategically. Attend to precision.	Projects 2
Look for and make use of structure.	Projects 2
Look for and express regularity in repeated reasoning.	Projects 2

COMMON CORE STANDARDS FOR MATHEMATICAL PRACTICE	PROJECT
CCSS.MATH.PRACTICE.MP1 Make sense of problems and persevere in solving them.	All projects
CCSS.MATH.PRACTICE.MP2 Reason abstractly and quantitatively.	All projects
CCSS.MATH.PRACTICE.MP3 Construct viable arguments and critique the reasoning of others.	Projects 2

[COMMON CORE STANDARDS FOR MATHEMATICAL PRACTICE]	PROJECT
CCSS.MATH.PRACTICE.MP4 Model with mathematics.	All projects
CCSS.MATH.PRACTICE.MP5 Use appropriate tools strategically.	All projects
CCSS.MATH.PRACTICE.MP6 Attend to precision.	All projects
CCSS.MATH.PRACTICE.MP7 Look for and make use of structure.	All projects
CCSS.MATH.PRACTICE.MP8 Look for and express regularity in repeated reasoning.	All projects

21ST CENTURY SKILLS	PROJECT
Learning and Innovation Skills: Creativity and Innovation	All projects
Learning and Innovation Skills: Critical Thinking and Problem Solving	All projects
Learning and Innovation Skills: Communication	All projects
Learning and Innovation Skills: Collaboration	All projects
Information, Media and Technology Skills: Information Literacy	
Information, Media and Technology Skills: ICT (Information, Communications and Technology) Literacy	All projects
Life and Career Skills: Flexibility and Adaptability	All projects
Life and Career Skills: Initiative and Self-Direction	All projects
Life and Career Skills: Social and Cross-Cultural Skills	All projects
Life and Career Skills: Productivity and Accountability	All projects
Life and Career Skills: Leadership and Responsibility	All projects

UNIVERSITY OF IOWA	PROJECT
An ability to apply knowledge of mathematics, science, and engineering.	All projects
An ability to design and conduct experiments, as well as to analyze and interpret data.	All projects
An ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.	Project 2

UNIVERSITY OF IOWA	PROJECT
An ability to function on multi-disciplinary teams.	Project 2
An ability to identify, formulate, and solve engineering problems.	Project 2
An understanding of professional and ethical responsibility.	Project 2
An ability to communicate effectively.	All projects
The broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context.	Project 2
A recognition of the need for, and an ability to engage in life-long learning.	All projects
a knowledge of contemporary issues	All projects
An ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.	All projects