Example PLTW materials, handed out to teachers to take home

Principles of Engineering

2002

(Third Edition)

Project Based Education

John Dewey theorized that learning should not only prepare one for life, but should also be an integral part of life itself. Stimulating real problems and real problem-solving is one function of project based learning. Projects assist students in succeeding in life because they allow learners to apply multiple intelligences in completing a project that has meaning and that they can be proud of.

This is substantiated by the recent research and developments in education which have lead to instructional innovations designed to make the classroom into a learning environment which is more responsive to the varying learning needs and interests of individual students. Using projects as learning vehicle students are expected to work cooperatively on complex and open-ended tasks as well as to follow directions in step by step learning.

Project work and systematic instruction can be seen as providing complementary learning opportunities. Students will know how to use a skill but also when to use it. They will learn to recognize, for themselves, the contexts in which a skill might be useful and what purposes it most appropriately will serve. In step by step, systematic instruction students will acquire the skills they need and then apply those skills in meaningful contexts by solving problems posed in projects.

Through projects students demonstrate mastered skills and knowledge, rather than parroting phrases or concepts on short answer, multiple choice, true/false sets of evaluations. For this reason authentic assessment is a viable option. This assessment can take the form of structured observations, checklists, rubrics, and portfolios to match the activities the students use to demonstrate content mastery.

The curricula created by Project Lead the Way, Inc.® for the various courses embrace the educational tenets of project based learning. Students develop solutions to solve the problems posed by the essential and key questions stated in each Unit and Section overview.

In addition, these projects allow students to:

- Demonstrate an understanding of subject content;
- Investigate and engage in meaningful activities;
- Become independent learners;
- Make their own connections between posed questions and prior learning;
- Use real life technologies and resources;
- Obtain ownership of their learning; and,
- Exhibit growth in areas often ignored: social and life skills, self-management skills and the ability to learn on one's own.

Attachment 7, solicited for clarification/background

Curriculum Overview

This document is intended to be a complete teaching curriculum, not just a guide or an outline. The curriculum is composed of units, which contain lessons and activities. The resource guide materials are integrated, via links, into the curriculum to make it easier for instructors to have access to the teaching tools they need.

Each Unit begins with: Concepts, an Anticipatory Set, Essential Questions, a list of the Lessons included in the Unit, and a description of Unit Evaluations. The Concepts are the broad learning objectives for the unit. The intent of the Essential Questions, in combination with the Anticipatory Set, is to create a framework for students to focus their learning. Course specific projects can be developed by the students to solve problems posed by the questions. The Essential Questions and the Anticipatory set should be communicated to the students at the beginning of every Unit to establish with the students the focus of the unit's learning objectives.

Each Unit is composed of lessons. Included in the Lessons are: Concepts (specific to this Lesson), Performance Objectives with aligned Mathematics, Science and Technology National Standards, an Anticipatory Set, Key Terms, Key Questions, an Activity Guide (a Day-by-Day Lesson plan), in addition to the resources available to the instructor (Word Documents, PowerPoint presentations, and textbook references). Each Lesson is to begin with the instructor presenting the Lesson's Anticipatory Set and Key Questions to the students for them to think about, and then develop solutions to, at the end of the Lesson. Through them, students focus their thoughts, learn skills, and apply those skills to solve problems, a key tenet of project-based learning.

This curriculum is designed to be taught to high school students within a "typical" high school schedule. This means that a class which meets each day for 40 minutes, 175 days a year should be able to cover the content of this course. Some minor adjustments will need to be made by those schools that teach under a "double block" system. For the most part this will simply entail combining two "days" worth of activities into one.

Major Concepts

Overview: Concepts are the principles, theories and recurring themes important to a student's educational development. They are foundational to students truly understanding what is essential to know in the curriculum. Teachers are constantly using concepts to help students understand the "why" that supports what they are learning.

1. Skillful researchers are proficient with the technologies and strategies used to gather, organize, document, and disseminate information.
2. Consideration of the ethical, environmental, social, and economic impacts of the engineering design process is essential to being a responsible, involved citizen.
3. Mathematics is the body of knowledge used to describe the scientific principles that happen naturally in the world, and technology is the application of these principles to produce products and services to benefit society.
4. Individual contributions to group processes facilitate the solving of complex problems and the achievement of common goals.
5. Critical thinking involves using a variety of established and original problem-solving techniques.
6. The use of the design process to analyze and solve problems has greatly improved the quality of, and the speed at which, new products are created.
7. Project success is dependent on problem identification, planning and the allocation of resources.
8. Individuals who accept the responsibility of continuous self-evaluation will benefit from personal growth and professional development, increasing their employability.
9. In order to solve complex problems, systems which monitor and correct performance must be developed.

Principles of Engineering

Unit 1: Definition and Types of Engineering

Lesson 1.1 Engineers as Problem Solvers
- 1.1.1 Past, Present and Future

Lesson 1.2 Engineering Team

Lesson 1.3 Careers in Engineering
- 1.3.1 Engineering
- 1.3.2 Engineering Technology
- 1.3.3 Distinction between Engineering and Engineering Technology

Unit 2: Communication and Documentation

Lesson 2.1 Sketching

Lesson 2.2 Technical Writing
- 2.2.1 Engineer's Notebook
- 2.2.2 Technical Reports
- 2.2.3 Style

Lesson 2.3 Data Representation and Presentation

Lesson 2.4 Presentations

Unit 3: Design Process

Lesson 3.1 Product Development
- 3.1.1. Problem Identification
  - 3.1.1.1. Design Brief
- 3.1.2. Problem Analysis
- 3.1.3. Information Gathering
- 3.1.4. Alternative Solutions and Optimization
- 3.1.5. Modeling
- 3.1.6. Testing and Evaluation
- 3.1.7. Presentation of Solution

Unit 4: Engineering Systems

Lesson 4.1 Mechanisms
- 4.1.1. Mechanical Advantage
- 4.1.2. Simple Machines
  - 4.1.2.1. Levers
  - 4.1.2.2. Inclined Plane
  - 4.1.2.3. Wedge
  - 4.1.2.4. Wheel and Axle
  - 4.1.2.5. Pulley
  - 4.1.2.6. Screw
- 4.1.3. Gears
- 4.1.4. Cams
- 4.1.5. Linkages

Lesson 4.2 Thermodynamics
- 4.2.1 Units
- 4.2.2 Forms of Energy
  - 4.2.2.1 Mechanical
  - 4.2.2.2 Chemical
  - 4.2.2.3. Electromagnetic
  - 4.2.2.4. Nuclear
  - 4.2.2.5. Thermal
  - 4.2.2.6. Solar
- 4.2.3 Energy Conversion
- 4.2.4 Cycles
  - 4.2.4.1 Open
  - 4.2.4.2 Closed
- 4.2.5 Efficiency
- 4.2.6 Energy Loss
  - 4.2.6.1. Conduction
  - 4.2.6.2. Convection
  - 4.2.6.3. Radiation
- 4.2.7 Heat Engines
  - 4.2.7.1 Steam
  - 4.2.7.2 Internal Combustion
  - 4.2.7.3 Turbines

Lesson 4.3 Fluid Systems
- 4.3.1. Hydraulic Systems
  - 4.3.1.1 Pascal's Law
  - 4.3.1.2Components
- 4.3.2. Pneumatic Systems
  - 4.3.2.1 Boyle's Law
  - 4.3.2. 2Components

Lesson 4.4 Electrical Systems
- 4.4.1. Electrical Theory
  - 4.4.1.1. Sources of Electromotive Force
  - 4.4.1.2. Ohms Law
  - 4.4.1.3. Kirchhoff's Laws
  - 4.4.1.4. Watt's Law
- 4.4.2. Metering Devices
- 4.4.3. Motors and Generators
  - 4.4.3.1. DC Motor
    - 4.4.3.1.1. Permanent Magnet
    - 4.4.3.1.2. Electromagnet
    - 4.4.3.1.3. Components
  - 4.4.3.2. DC Generator
  - 4.4.3.3. AC Generator
    - 4.4.3.3.1. Single Phase
    - 4.4.3.3.2. Three Phase

4.4.3.4. AC Motor
4.4.3.4.1. Synchronous
4.4.3.4.2. Induction
4.4.3.5. Transformers
4.4.3.5.1 Single Phase
4.4.3.5.2. Multi-Phase
4.4.3.6. Electric Transmission Systems

Lesson 4.5 Control Systems
4.5.1. Open Loop System
4.5.2. Closed Loop System
4.5.2.1 Sensors and Actuators
4.5.2.2. Basic Concept of Automation, FMS and System
Integration Programming
4.5.2.3 Flow Chart
4.5.2.4 PLC – Programmable Logic Control

Unit 5: Statics and Strength of Materials

Lesson 5.1 Statics
5.1.1 Strength of Shapes
5.1.2 Forces
5.1.3 Static Equilibrium
5.1.4 Vectors
5.1.5 Free body Diagrams
5.1.6 Moments
5.1.7 Reaction Forces
5.1.8 Trusses
5.1.9 Bridges
Lesson 5.2 Strength of Materials
5.2.1. Properties of Areas
5.2.1.1. Center of Gravity
5.2.1.2. Moments of Inertia
5.2.1.3. Calculating Mass Properties Using CAE Tools
5.2.2. Stress
5.2.3. Strain
5.2.4. Deflection

Unit 6: Materials and Materials Testing in Engineering

Lesson 6.1 Categories of Materials
6.1.1. Metals
6.1.2. Alloys
6.1.3. Nonmetals
6.1.4. Composites
Lesson 6.2 Properties of Materials
6.2.1. Chemical Properties
6.2.2. Physical Properties
6.2.3. Mechanical Properties
6.2.4. Dimensional Properties
Lesson 6.3 Production Processes
Lesson 6.4 Quality
6.4.1 Engineering Statistics
6.4.2 Precision Measurement Tools and Techniques
6.4.3 Statistical Process Control
Lesson 6.5 Material Testing Processes
6.5.1. Nondestructive Inspection and Testing
6.5.2. Destructive Testing

Unit 7: Engineering for Reliability

Lesson 7.1 Reliability
7.1.1. Determining Failure Rates
7.1.2. Identifying Critical Components
7.1.3 Redundancy
7.1.4 Risk Analysis
7.1.5 Factors of Safety
7.1.6 Liability and Ethics
Lesson 7.2 Case Study

Unit 8: Introduction to Dynamics/Kinematics

Lesson 8.1 Linear Motion
8.1.1. Displacement
8.1.2. Velocity
8.1.3 Acceleration
Lesson 8.2 Trajectory Motion
[redacted]

Written Report Rubric

Name: **Course:** **Project:**

Date: **Section:**

	1pt	2pt	3pt	SCORE
TITLE PAGE	60% or more of the components necessary for a complete title page exist.	80% or more of the components necessary for a complete title page exist.	All components required for the title page exist and are located correctly.	
ABSTRACT	Does not completely explain the report in a concise manner. Purpose and objective of the work is unclear.	Does not completely explain the report in a concise manner. Purpose of the work is stated.	Approximately one paragraph. Tells detailed information about the report. Contains objectives of the work.	
TABLE OF CONTENTS	Table of contents exists. But page numbers and sections are missing or inaccurate.	Table of contents exists but is missing page numbers or sections that are required.	Table of contents exists with page numbers and has all required sections of the report listed.	
INTRODUCTION	Wordy or lacking information. Material is not related to what is in the report.	Either wordy, lacking information or not related to the material in the report.	Short brief explanation of the activity.	
BACKGROUND	Student did no research beyond the classroom. Project is not unique.	Minimal work was done to research the topic. Evidence the project is unique is not shown.	Evidence that the student researched beyond the information given in class. Student has proven that his/her work is unique to the research.	
MATERIALS	60% of materials used are listed.	80% of materials used are listed.	All materials are listed.	
PROCEDURE	Step-by-step is out of order or parts are missing. Graphics are unnecessary or missing. Lacks detail to explain the procedure.	Step-by-step procedure exists. Some sketches, photos, schematics, equations, etc. are not necessary. Uses some pronouns. Some details missing.	The step-by-step process is laid out exactly as done by the student. Sketches, photos, schematics, equations, etc. are shown where appropriate. All procedures are explained in detail and written in the third person.	
RESULTS	Student results do not match their objectives. Evidence of how the results were obtained is lacking. There is no discussion of errors.	Student has proven results using credible evidence. The results support the objectives. Errors and suggestions are not discussed.	Student has explained the results using equations, tables, drawings etc. The results support the objectives. Possible errors are explained and suggestions for improvement have been made.	
CONCLUSION	Student has a summary that does not match the work in the activity.	Summary is too long or does not explain what the student accomplished.	Student has a summary of what he/she learned and what the activity was all about.	
APPENDIX	Drawings and Schematics are just thrown in the back, are not labeled or do not exist.	Appendix holds information that does not belong. Appendix is labeled incorrectly.	All large pieces of information are in an appendix. Each appendix is labeled and holds information such as schematics, and drawings.	
CITATIONS	Few sources that were used are cited and the format has not been followed.	Some of the sources the student used are not cited and are not formatted correctly.	All information gathered by the student has been cited with the proper format.	
			Total	

Unit 1 - Definition and Types of Engineering

Concepts

1. According to ABET, Engineering is the profession in which a knowledge of the mathematical and natural sciences, gained by study, experience , and practice, is applied with judgment, to develop ways to utilize, economically, the materials and forces of nature for the benefit of mankind.
2. Engineering is continuously adding to the core of human knowledge; every new invention and innovation is grounded in the work of people from previous generations.
3. To be a good engineer requires more that just a study of mathematics, science and technology. A firm grasp of history, economics, philosophy, ethics, foreign language, music and writing make a well rounded professional who will be lifelong learners and leaders.

Preface

Throughout history the human race has solved the problems facing it. When we first appeared on the planet, survival was our only concern. Finding things we could eat, places to stay warm and protection from predators occupied all of our time. In the early days, trial and error were the only methods available to solve problems. Over many thousands of years we learned that a sharp stick or a heavy rock would discourage predators. Our use of the natural materials around us to enhance our physical strength making our families safe was an early example of engineering.

From the pyramids of 5000 years ago to the space shuttle of today, engineers have played an essential role in creating the civilizations of history. In today's world, while professions such as law, medicine and law enforcement dominate the media, engineers quietly create the planes that take us safely and quickly to all parts of the world, the automobiles that need virtually no maintenance, the computer networks that give us instant access to the world's data bases, cellular phones to keep us in touch anywhere, as well as a vehicle to explore Mars. The engineer strives to give the user a product that is affordable, safe, durable, reliable and evermore useful.

The 21st century will demand better and faster computers and communication systems, faster and more efficient airplanes, and less costly but more effective medical diagnostic tools. These demands mean many more trained and capable engineers will be needed. This need has started to draw more women and minority engineers into the profession. Still, the engineering profession has been much less successful at bringing minorities and women into its ranks than law or medicine, for example. There still are many opportunities and incentives for these underrepresented groups to join the engineering profession.

The engineering field, as most other fields, offers opportunities for all types of personalities and interests. Those who enjoy working on computers to examine complex problems can be designers; those who like to work with their hands can be involved with manufacturing; those with strong people skills can move into management, sales, or customer support; those who want to be involved in helping people directly can work side by side with doctors to develop major new technologies.

Key Questions

1. In what ways do the discoveries of prehistoric engineers affect your life today?
2. Since most problems facing us today are too difficult to solve by yourself how can you work with others to come up with innovative solutions?
3. What process should you follow to become an engineer?

Lessons

1. Lesson 1.1 Engineers as Problem Solvers
2. Lesson 1.2 The Engineering Team
3. Lesson 1.3 Careers in Education

Unit Assessments

1. Students will be assessed on the accuracy and completeness of term definitions and notes on engineering history recorded in their lab notebooks.
2. Students will be evaluated on their responses to essential and key questions.

Unit 8 – Kinematics

Concepts

1. Kinematics is the study of motion allowing us to predict the path of an object when traveling at some angle with respect to the Earths surface. It is easy to calculate if the force of Gravity remains constant and we ignore the effects of air resistance.
2. Projectile motion follows a parabolic curve with the elevation being the Y axis and the distance displaced being the X axis. The velocity remains constant in the X direction but the Velocity in the Y direction changes with time in both magnitude and direction.

Anticipatory Set

In the early 1600's a man named Galileo threw away two thousand years of thinking and changed the way we all look at the world. Observing the world around him, he started applying mathematical equations to the way things moved. His famous experiment dropping differently weighted balls from the tower of Pisa was only one small example. He was excommunicated for his beliefs and teachings but persisted anyway. His work inspired many who followed including an Englishman named Newton who added greatly to the earlier works and brought about the publication of the Laws of Motion in his book ***Principia***.

If we apply the Laws of Motion combined with the Vector and Scalar information we learned in Unit 5 we can predict with some accuracy the behavior of the flight of objects.

Essential Question

1. You have been assigned to design a 120 meter ski jump. A hill has been found with a 50 degree slope that can be used. The end of the jump should launch the jumper at an angle of 15 degrees above the horizontal. The average speed, of the skiers at the end of other ramp, is usually about 10 meters/second. How far up the hill should the take off be situated and what conditions should be considered?

Lessons

- Lesson 8.1 Linear Motion
- Lesson 8.2 Projectile motion

Unit Evaluation

1. Students will be evaluated on their ability to present and publish technical information verifying test results from a ballistic test.
2. Students will be assessed on the accuracy and completeness of term definitions and notes on kinematics recorded in their lab notebooks.
3. Students will be assessed on the design and completeness of the three fold flyer describing the operation of their ballistic device.
4. Students will be evaluated on the application of mathematical formulas to engineering problems associated with ballistic problems.
5. Students will be evaluated on the graphs produced to show trajectory information data gathered in testing.
6. Students will be evaluated on the accuracy and clarity of the calculations produced from their statistical data.
7. Students will be evaluated using performance and objective tests as well as written, oral and multimedia presentations.
8. Students will be evaluated on their responses to essential and key questions.

Lesson 8.1 - Linear Motion

Concepts

1. Dynamics is separated into two major divisions: Kinematics, which is a study of motion without reference to the forces causing the motion and kinetics, which relates the forces on bodies to their resulting motions.
2. The distance an objects travels over a time period is called Displacement. Velocity is found by dividing the displacement by the time interval of the displacement. Acceleration is the change in velocity divided by the time interval.
3. Displacement, Velocity and Acceleration are vector quantities.

Performance Objectives	Standards
Students will be able to explain the difference between distance traveled and displacement.	Science 2.4 Math 3.2 Math 9.2 Technology 4.1
Students will design and build a device for the purpose of conducting experiments of acceleration, displacement, and velocity.	Science 6.2 Math 6.1 Technology 3.3 Technology 5.3

Anticipatory Set

A great many math problems begin with a person leaving Chicago driving east at 50 miles an hour. What these word problems are doing is setting the stage for much more complicated problems such as sending a space craft to an asteroid or charting the course of a boat across the Atlantic. Early sailors needed to know how far they traveled in the course of a day and in what direction. It seems difficult to find something the size of Hawaii in the Pacific Ocean but early navigators figured out how to do it.

Key Terms

Acceleration	Displacement	Force
Gravity	Law of Gravitation	Newton's Laws
Newton's First Law	Newton's Second Law	Newton's Third Law
Particle	Velocity	

Key Questions

1. You and a friend are taking an eight mile canoe trip down the river. When you arrive at the river you find the average water speed is two miles an hour. You have asked friends to pick you up. How fast do you have to paddle to make the connection in three hours?
2. You have been asked to explain how distance traveled and displacement are different concepts to a group of seven year old students. How would you explain the concept to them and what examples would you use?

Activities

Day 1:
- Teacher will hand out the key question and assign a due date.
- Teacher will give introductory lesson on Newton's Laws. Displacement, Velocity and Acceleration.

Day 2:
- Teacher will finish lesson from the previous day and give lesson on Gravity.
- Teacher will introduce Ballistic Device problem and hand out Activity 8.1a Assignment requirements sheet.
- Students will break into groups, research and discuss options for devices.

Day 3:
- Teacher will hand out Activity 8.1b Rubric and review with students.
- Students will work on their designs for the ballistic device.

Day 4:
- Teacher will review timetable with students.
- Teacher will demonstrate a sample ballistic device.
- Students will finish initial designs and drawings.

Resources

Word Documents
Activity 8.1a Assignment
Activity 8.1b Rubric

PowerPoint
Sample Ballistic Devices

Reference Sources

Meriam, Kraige, Engineering Mechanics Volume 2 Dynamics, John Wiley & Sons, Inc.,NY, NY, ©2002 ISBN 0-471-40645-7

Oaks, Leone, Gunn, Engineering Your Future: An Introduction to Engineering, Great Lakes Press, St. Louis MO. ©2002 ISBN188101890-3