1- Introduction to Engineering as a Field of Study

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Belleville Public Schools

Curriculum Guide

Engineering Principals

Unit 1 - Introduction to Engineering as a field of Study

Belleville Board of Education

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Unit Overview

Engineers apply physical and chemical laws and principles and mathematics to design millions of products and services that we use everyday. Engineers also play a significant role in the design and maintenance of a nation's infrastructure, including communication systems, public utilities and transportation. Engineers consider important factors such as cost, efficiency, reliability, and safety when designing products and services Engineers perform tests to make certain that the products they design withstand various conditions and situations. Engineers work for private industries, departments of agriculture, defense, energy, and transportation. Good engineers are problem solvers and have a firm grasp of the fundamental principles of engineering which they can use to solve many different problems. There are more than 20 different engineering disciplines recognized by the professional societies. Most engineering degrees are granted in civil, electrical, and mechanical engineering. Civil engineering is the oldest engineering discipline, while electrical and electronic engineering is the largest engineering discipline.

Enduring Understanding

- Engineering Design is process.
- Engineers frame and define the scope and limitations of a project before they solve it.
- Common constraints of any engineering problem are time, money and materials.
- Engineers rarely work alone and creative problem solving is usually a group endeavor.
- Prototypes and models play an important role in proving a concept or solution to a problem.
- Technology is the product of engineering, and defines any manufactured object or process that meets a human want or need for all peoples for all times
- That proper documentation, and the engineering notebook are essential to the design process for several reasons, including the protection of intellectual property.
- Manufacturing processes set the life cycle for any object, and include constraints, optimizations, and trade offs.
- Every manufactured object can be seen as a system, with input, process, output and feedback loops.
- That people play a role in large systems as various stakeholders, e.g. customers who pay for the object.
- That the US Patent and Trademark office was founded with the US constitution to protect inventors and entrepreneurs
- That there are 3 types of patents, for inventions, designs, and plants, which have a limited life, 20 years.
- That separate laws protect trade secrets, which cannot be patented.
- That Trademarks used for branding can be symbols, phrases, colors, smells or sounds, and last for the item's lifetime
- That engineering societies serve the profession by setting standards for professionalism, technology, and ethics.
- That engineers usually specialize in disciplines, where they apply Engineering Design to specific basic sciences to create and innovate technology for the benefit of society.
- That machines change the nature of the equation for work, W = F x D, but accomplish the same amount of work required for a task by creating an input/output ratio of force or distance called mechanical advantage.

Essential Questions

- How do engineers make use of basic science and measurement?
- What is engineering design method?
- What is technology?
- What is a constraint?
- What is meant by optimization and trade-off?
- How do engineers use brainstorming and methods of creative problem solving?
- What is a prototype?
- How do engineers document their work?
- What is a system, and what are its components?
- What is a feedback loop and when is it open or closed?
- What is included in a system's life cycle?
- How do engineers use engineering design to plan a project?

- How do engineers use engineering design method to analyze a system and solve a problem with it?
- How do engineers use engineering design to reverse engineer an existing system to understand or repair it?
- What is intellectual property?
- What is the difference between an invention and an innovation?
- How do engineers use project management to plan a small business?
- How does the engineering profession serve society?
- What are Engineering Disciplines and how do engineers apply their craft?
- What is work?
- What is mechanical advantage and how does change the nature of work?
- What are machines, and simple machines?
- What is efficiency?
- What is a gear ratio and how do engineers use it?
- What are the elements of structure and how to do engineers use them?
- What do the laws of conservation of mass and energy mean to engineers?
- How do engineers make use of Ohm's law?
- How do engineers make use of parallel and series circuits?
- What is the difference between AC and DC current and how do engineers make use of each?
- How do engineers use the energy of sound waves?

Exit Skills

- 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.
- Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
- Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.
- Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.
- 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.
- 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.

New Jersey Student Learning Standards (NJSLS-S)

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.
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.
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.
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.
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.
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 motion of particles (objects) and energy associated with the relative position of particles (objects).
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.
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).
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.
HS-PS4-1	Use mathematical representations to support a claim regarding relationships among the frequency, wavelength, and speed of waves traveling in various media.

Interdisciplinary Connections

MA.A-SSE.A.1a	Interpret parts of an expression, such as terms, factors, and coefficients.
MA.A-SSE.A.1b	Interpret complicated expressions by viewing one or more of their parts as a single entity.

MA.A-SSE.B	Write expressions in equivalent forms to solve problems
LA.RH.11-12.7	Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., visually, quantitatively, qualitatively, as well as in words) in order to address a question or solve a problem.
LA.RH.11-12.8	Evaluate an author's claims, reasoning, and evidence by corroborating or challenging them with other sources.
LA.RH.11-12.9	Integrate information from diverse sources, both primary and secondary, into a coherent understanding of an idea or event, noting discrepancies among sources.
LA.RH.11-12.10	By the end of grade 12, read and comprehend history/social studies texts in the grades 11-CCR text complexity band independently and proficiently.

Learning Objectives

1. Give examples of products and services that engineers design that make our lives better
2. Describe what engineers do and give examples of common careers for engineers
3. Describe the important traits of successful engineers
4. Give examples of common engineering disciplines and how they contribute to the comfort and betterment of our everyday lives
5. Compare and Contrast the differences in high school and college learning
6. Describe effective ways to manage your schedule
7. Explain the study habits and strategies that would lead to good academic performance
8. Describe why it is important to join engineering organizations and explore different engineering organizations that are available to join
9. Realize the importance of a graduation plan
10. Explain the basic steps that engineers follow to design something and to arrive at a solution to a problem
11. Describe what is meant by sustainability and its role in design and explain the roles of engineering economics and materials in engineering design
12. Explain what is meant by a design team and describe the common traits of good teams and explain how good teams manage conflicts
13. Describe the process that engineering managers use to ensure that a project is completed on time and within the allocated budget
14. Describe why we need standards and codes and give examples of standards and codes organizations in the United States and Abroad
15. Describe the drinking water, indoor and outdoor air sources of pollutants and the water and air quality standards in the United States

Suggested Activities & Best Practices

Measurement activity - Students will measure the room in teams with different devices, meter sticks and tape measures, in feet and inches and in meters and centimeters and convert the feet to meters and meters to feet. Student teams will then compare the differences in their measurements for error analysis to determine accuracy and precision.

Writing for Engineering - Students will examine samples of 3rd person active voice writing, such as in cookbooks. They will then practice documentation by writing a step by step procedure for a simple task, such as opening a locker, and describing a common device, a bicycle, to Galileo or Newton, someone who has never seen one.

Creative Problem solving and Engineering documentation - Students propose solutions to a list of five "brain teaser" problems. Some of have a single solution and some have multiples. After solving the problems as a class exercise students must write a step by step solution for each one in their engineering notebooks.

Brainstorming Activity - In groups, students brainstorm and research 3 of 6 engineering challenges which are poorly defined. Each one is missing vital information, such as cost and other constraints. Students must identify, and prioritize, missing parameters for each scenario.

Assessment Evidence - Checking for Understanding (CFU)

Chapter Quizzes and Tests (Summative)

Socratic Questioning (Formative)

Lab Journal (Alternative)

Common Department Benchmark (Benchmark)

Oncourse Assessment Tools (Formative)

Do Now and Exit Tickets (Formative)

- Admit Tickets

- Common Benchmarks
- Compare & Contrast
- Define
- Describe
- Evaluate
- Evaluation rubrics
- Exit Tickets
- Explaining
- Illustration
- Journals
- KWL Chart
- Multimedia Reports
- Newspaper Headline
- Quizzes
- Self- assessments
- Socratic Seminar
- Surveys
- Teacher Observation Checklist
- Think, Pair, Share
- Top 10 List
- Unit review/Test prep
- Unit tests
- Web-Based Assessments
- Written Reports

Primary Resources & Materials

Moaveni, Saeed. *Engineering Fundamentals: an Introduction to Engineering*. Cengage Learning, 2016.

Ancillary Resources

Ancillary Resources

Teacher and Publisher supplied power points, notes, guides, labs, and worksheets

Resource manuals

Internet Resources

Computer Activities

American Academy of Environmental Engineers - www.aaees.org

American Institute of Aeronautics and Astronautics - www.aiaa.org

American Instate of Chemical Engineers www.aiche.org

The American Society of Agricultural and Biological Engineers - www.asabe.org

American Society of Civil Engineers - www.asce.org

American nuclear Society - www. ans.org

American Society of Heating, Refrigeration and Air Conditioning Engineers - www.ashrae.org

American Society of Mechanical Engineers - www.asme.org

Biomedical Engineering Society - www.bmes.org

Institute of electrical and Electronics Engineers - www.ieee.org

The Institute of Industrial Engineers - www.iienet2.org

National Academy of Engineering - www.nae.edu

National Science Foundation - www.nsf.gov

National Society of Black Engineers - www.nsbe.org

National Society of Professional Engineers - www.nspe.org

Society of Automotive Engineers - www.sae.org

Society of Hispanic Professional Engineers - www.shpe.org

Society of Manufacturing Engineers - www.sme.org

Society of Women Engineers - www.swe.org

Tau Beta Pi - All Engineering Honor Society - www.tbp.org

NASA Centers Ames Research Center - www.arc.nasa.gov

Dryden Flight Research Center - www.dfrc.nasa.gov

Goddard Space Flight Center - www.gsfc.nasa.gov

Jet Propulsion Laboratory - www.jpl.nasa.gov

Johnson Space Center - www.jsc.nasa.gov

Kennedy Space Center - www.larc.nasa.gov

Free Patents On line - http://www.freepatentsonline.com/

National Academy of Engineering Grand Challenges - http://www.engineeringchallenges.org/

Try Engineering - http://tryengineering.org/

Teach Engineering - https://www.teachengineering.org/

USPTO kids - http://www.uspto.gov/kids/

National Technology Students Association and NJ TSA - http://www.tsaweb.org/ and http://njtsa.pages.tcnj.edu/

Technology Infusion

Technology Infusion

Gizmos

Near POD

Google Classroom

JamBoards

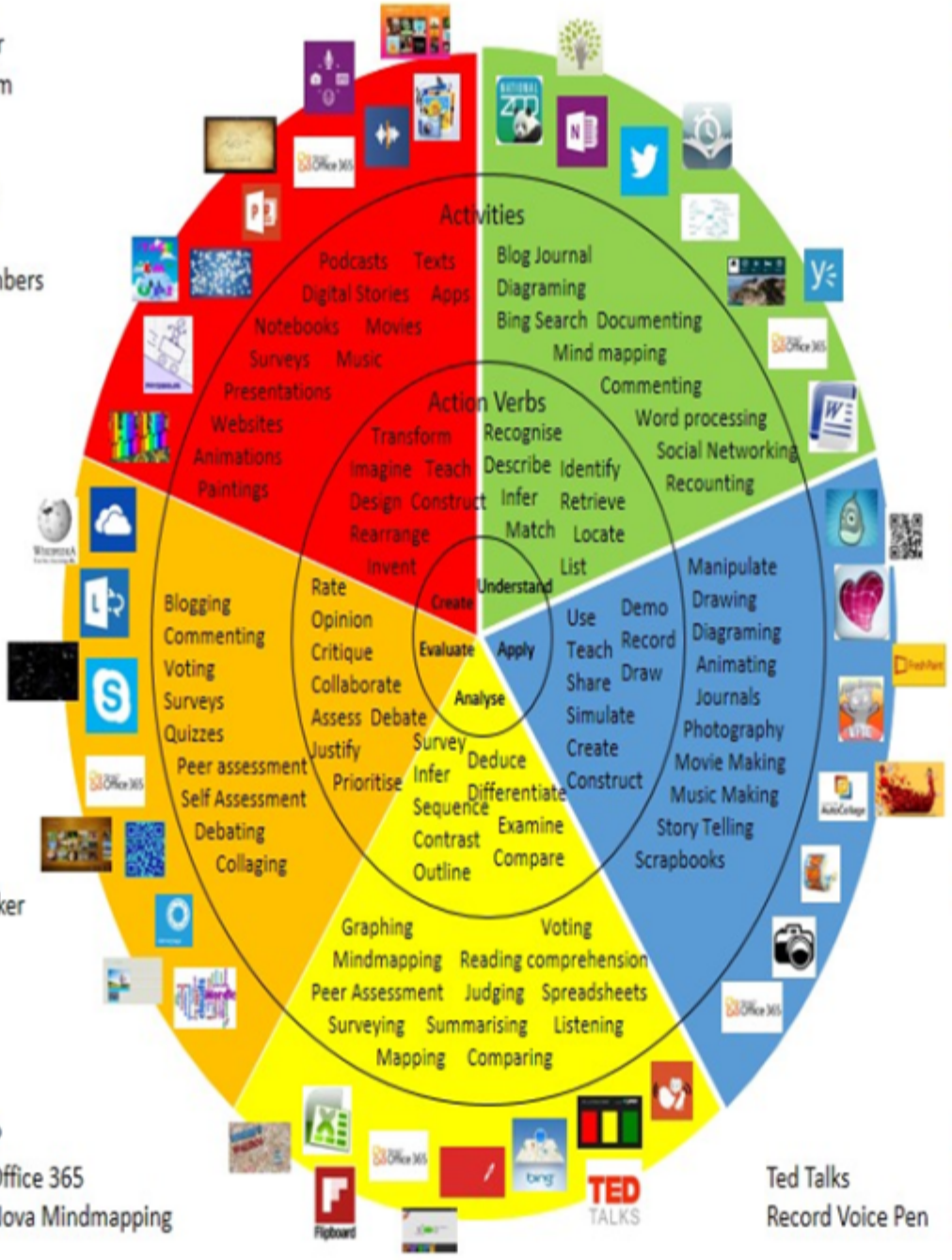
3D Printer

CAD

Win 8.1 Apps/Tools Pedagogy Wheel

Podcasts
Photostory 3
Kid Story Builder
Music Maker Jam
Paint A Story
Office 365
MS PowerPoint
Stack 'Em Up
NqSquared Numbers
Physamajig
Xylophone 8

Wikipedia
Skydrive
Lync
SkyMap
Skype
Office 365
Puzzle Touch
Easy QR
Memorylage
Life Moments
Word Cloud Maker



Where's Waldo?
MS Excel Office 365
Flipboard Nova Mindmapping

Ted Talks
Record Voice Pen

Originally taken from http://www.coetail.com/vzimmer/files/2013/02/iPadagogy-Wheel.001.jpg
And adapted for Windows 8.1 devices by Charlotte Beckhurst @CharBeckhurst

Alignment to 21st Century Skills & Technology

Mastery and infusion of **21st Century Skills & Technology** and their Alignment to the core content areas is essential to student learning. The core content areas include:

- English Language Arts;
- Mathematics;
- Science and Scientific Inquiry (Next Generation);
- Social Studies, including American History, World History, Geography, Government and Civics, and Economics;
- World languages;
- Technology;
- Visual and Performing Arts.

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.
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21st Century Skills/Interdisciplinary Themes

- Communication and Collaboration
- Creativity and Innovation
- Critical thinking and Problem Solving
- ICT (Information, Communications and Technology) Literacy
- Information Literacy
- Life and Career Skills
- Media Literacy

CRP.K-12.CRP1.1	Career-ready individuals understand the obligations and responsibilities of being a member of a community, and they demonstrate this understanding every day through their interactions with others. They are conscientious of the impacts of their decisions on others and the environment around them. They think about the near-term and long-term consequences of their actions and seek to act in ways that contribute to the betterment of their teams, families, community and workplace. They are reliable and consistent in going beyond the minimum expectation and in participating in activities that serve the greater good.

CRP.K-12.CRP2.1	Career-ready individuals readily access and use the knowledge and skills acquired through experience and education to be more productive. They make connections between abstract concepts with real-world applications, and they make correct insights about when it is appropriate to apply the use of an academic skill in a workplace situation.
CRP.K-12.CRP3.1	Career-ready individuals understand the relationship between personal health, workplace performance and personal well-being; they act on that understanding to regularly practice healthy diet, exercise and mental health activities. Career-ready individuals also take regular action to contribute to their personal financial well-being, understanding that personal financial security provides the peace of mind required to contribute more fully to their own career success.
CRP.K-12.CRP4.1	Career-ready individuals communicate thoughts, ideas, and action plans with clarity, whether using written, verbal, and/or visual methods. They communicate in the workplace with clarity and purpose to make maximum use of their own and others' time. They are excellent writers; they master conventions, word choice, and organization, and use effective tone and presentation skills to articulate ideas. They are skilled at interacting with others; they are active listeners and speak clearly and with purpose. Career-ready individuals think about the audience for their communication and prepare accordingly to ensure the desired outcome.
CAEP.9.2.12.C.1	Review career goals and determine steps necessary for attainment.
CAEP.9.2.12.C.2	Modify Personalized Student Learning Plans to support declared career goals.
CAEP.9.2.12.C.3	Identify transferable career skills and design alternate career plans.
CAEP.9.2.12.C.4	Analyze how economic conditions and societal changes influence employment trends and future education.
CAEP.9.2.12.C.5	Research career opportunities in the United States and abroad that require knowledge of world languages and diverse cultures.
CAEP.9.2.12.C.6	Investigate entrepreneurship opportunities as options for career planning and identify the knowledge, skills, abilities, and resources required for owning and managing a business.
TECH.8.1.12.B.2	Apply previous content knowledge by creating and piloting a digital learning game or tutorial.
TECH.8.1.12.B.CS1	Apply existing knowledge to generate new ideas, products, or processes.
TECH.8.1.12.B.CS2	Create original works as a means of personal or group expression.
TECH.8.1.12.C.CS1	Interact, collaborate, and publish with peers, experts, or others by employing a variety of digital environments and media.
TECH.8.1.12.C.CS2	Communicate information and ideas to multiple audiences using a variety of media and formats.
TECH.8.1.12.C.CS3	Develop cultural understanding and global awareness by engaging with learners of other cultures.
TECH.8.1.12.C.CS4	Contribute to project teams to produce original works or solve problems.

21st Century Skills

- Civic Literacy
- Environmental Literacy
- Financial, Economic, Business and Entrepreneurial Literacy
- Global Awareness
- Health Literacy

Differentiation

Small Group Instruction

Study Guides

Project Based Learning

Differentiations:

- Small group instruction
- Small group assignments
- Extra time to complete assignments
- Pairing oral instruction with visuals
- Repeat directions
- Use manipulatives
- Center-based instruction
- Token economy
- Study guides
- Teacher reads assessments allowed
- Scheduled breaks
- Rephrase written directions
- Multisensory approaches
- Additional time
- Preview vocabulary
- Preview content & concepts
- Story guides
- Behavior management plan
- Highlight text
- Student(s) work with assigned partner
- Visual presentation
- Assistive technology
- Auditory presentations
- Large print edition
- Dictation to scribe
- Small group setting

Hi-Prep Differentiations:

- Alternative formative and summative assessments
- Choice boards

- Games and tournaments
- Group investigations
- Guided Reading
- Independent research and projects
- Interest groups
- Learning contracts
- Leveled rubrics
- Literature circles
- Multiple intelligence options
- Multiple texts
- Personal agendas
- Project-based learning
- Problem-based learning
- Stations/centers
- Think-Tac-Toes
- Tiered activities/assignments
- Tiered products
- Varying organizers for instructions

Lo-Prep Differentiations

- Choice of books or activities
- Cubing activities
- Exploration by interest
- Flexible grouping
- Goal setting with students
- Jigsaw
- Mini workshops to re-teach or extend skills
- Open-ended activities
- Think-Pair-Share
- Reading buddies
- Varied journal prompts
- Varied supplemental materials

Special Education Learning (IEP's & 504's)

Quiz and Test Study Guides

Graphic Organizers

Powerpoints posted on google classroom

- printed copy of board work/notes provided
- additional time for skill mastery
- assistive technology
- behavior management plan
- Center-Based Instruction
- check work frequently for understanding
- computer or electronic device utilizes
- extended time on tests/ quizzes
- have student repeat directions to check for understanding
- highlighted text visual presentation
- modified assignment format
- modified test content
- modified test format
- modified test length
- multi-sensory presentation
- multiple test sessions
- preferential seating
- preview of content, concepts, and vocabulary
- Provide modifications as dictated in the student's IEP/504 plan
- reduced/shortened reading assignments
- Reduced/shortened written assignments
- secure attention before giving instruction/directions
- shortened assignments
- student working with an assigned partner
- teacher initiated weekly assignment sheet
- Use open book, study guides, test prototypes

English Language Learning (ELL)

Peer to assist students

Allow tests and quizzes to be taken in ESL room with extra time

Students allowed to use electronic devices for translation

Word Lists provided

- teaching key aspects of a topic. Eliminate nonessential information
- using videos, illustrations, pictures, and drawings to explain or clarif
- allowing products (projects, timelines, demonstrations, models, drawings, dioramas, poster boards, charts, graphs, slide shows, videos, etc.) to demonstrate student's learning;
- allowing students to correct errors (looking for understanding)
- allowing the use of note cards or open-book during testing
- decreasing the amount of workpresented or required
- having peers take notes or providing a copy of the teacher's notes
- modifying tests to reflect selected objectives
- providing study guides
- reducing or omitting lengthy outside reading assignments
- reducing the number of answer choices on a multiple choice test
- tutoring by peers
- using computer word processing spell check and grammar check features
- using true/false, matching, or fill in the blank tests in lieu of essay tests

At Risk

Provide modified test

Tutoring times offered

Allow students to correct test for partial credit

Extended time for assignments

- allowing students to correct errors (looking for understanding)
- teaching key aspects of a topic. Eliminate nonessential information
- allowing products (projects, timelines, demonstrations, models, drawings, dioramas, poster boards, charts, graphs, slide shows, videos, etc.) to demonstrate student's learning
- allowing students to select from given choices
- decreasing the amount of workpresented or required
- having peers take notes or providing a copy of the teacher's notes
- marking students' correct and acceptable work, not the mistakes
- modifying tests to reflect selected objectives
- providing study guides
- reducing or omitting lengthy outside reading assignments
- reducing the number of answer choices on a multiple choice test
- tutoring by peers
- using authentic assessments with real-life problem-solving
- using videos, illustrations, pictures, and drawings to explain or clarify

Talented and Gifted Learning (T&G)

Provide enrichment articles and assignments

Allow students to complete independent study assignments

- Above grade level placement option for qualified students
- Advanced problem-solving
- Allow students to work at a faster pace
- Higher order, critical & creative thinking skills, and discovery
- Multi-disciplinary unit and/or project
- Utilize exploratory connections to higher-grade concepts
- Utilize project-based learning for greater depth of knowledge

Sample Lesson

Enduring Understandings: Scientific Measurement is used during experimentation to collect data. Students must learn to express and evaluate measurements in a scientific way. The metric system is the system in which scientist's measure length, mass, and volume. Students will become familiar with the system of unites used for scientific measurement and apply dimensional analysis to solve conversion problems.

Lesson Rational: Scientists use research techniques to explore, examine, and extrapolate knowledge. Students must experience conduction experiments, collect data, examine data, and analyze data along with

expressing their finding in writing in a clear and well developed report.

Essential Questions: How do scientists use, express, and evaluate measurements in experiments?

Objectives: Students will be able to

1. Convert measurements to scientific notation
2. Distinguish among accuracy, precision, and give examples
3. Define the error of measurement
4. Determine the number of significant figures in a measurement and summarize rules
5. Determine the number of significant figures in a calculation and summarize the rules fro addition and subtraction

Anticipatory Set: What is the difference between accuracy and precision

Student Centered Inquiry-based Learning Procedure/Method:

1.) Anticipatory Set

2.) Didactic Presentation - Power Point

3.) Sample Problems

4.) Concept Check

Meaningful Closure: Socratic Questioning

Differentiation: Use of didactic and practical exercises are used in this lesson

Accommodations: Accommodations will be made as specified by IEP.

Pre, Formative and/or Summative Assessment Strategies Evaluations: Students will complete learning and concept checks with an accuracy of 100%.

Report, Reflect, Discuss:

Independent Practice/Upcoming Tasks: Reaction in a Bag

Integrated Cross Disciplinary Lesson: Mathmatics

SCI.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.
SCI.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.
CRP.K-12.CRP2.1	Career-ready individuals readily access and use the knowledge and skills acquired through experience and education to be more productive. They make connections between abstract concepts with real-world applications, and they make correct insights about when it is appropriate to apply the use of an academic skill in a workplace situation.
SCI.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.
CRP.K-12.CRP1.1	Career-ready individuals understand the obligations and responsibilities of being a member of a community, and they demonstrate this understanding every day through their interactions with others. They are conscientious of the impacts of their decisions on others and the environment around them. They think about the near-term and long-term consequences of their actions and seek to act in ways that contribute to the betterment of their teams, families, community and workplace. They are reliable and consistent in going beyond the minimum expectation and in participating in activities that serve the greater good.
CRP.K-12.CRP7.1	Career-ready individuals are discerning in accepting and using new information to make decisions, change practices or inform strategies. They use reliable research process to search for new information. They evaluate the validity of sources when considering the use and adoption of external information or practices in their workplace situation.
SCI.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.
CRP.K-12.CRP6.1	Career-ready individuals regularly think of ideas that solve problems in new and different ways, and they contribute those ideas in a useful and productive manner to improve their organization. They can consider unconventional ideas and suggestions as solutions to issues, tasks or problems, and they discern which ideas and suggestions will add greatest value. They seek new methods, practices, and ideas from a variety of sources and seek to apply those ideas to their own workplace. They take action on their ideas and understand how to bring innovation to an organization.