2 - Foundations of Engineering

Content Area: **Science**
Course(s): **Engineering Principles**
Time Period: **Sept-June**
Length: **30 Days**
Status: **Published**

Title Section

Department of Curriculum and Instruction

Belleville Public Schools

Curriculum Guide

Engineering Principals

2 - Foundations of Engineering

Belleville Board of Education

102 Passaic Avenue

Belleville, NJ 07109

Prepared by: Joy Elaine Alfano, PhD

Dr. Richard Tomko, Ph.D., M.J., Superintendent of Schools

Ms. LucyAnn Demikoff, Director of Curriculum and Instruction K-12

Ms. Nicole Shanklin, Director of Elementary Education K-8, ESL Coordinator K-12

Mr. George Droste, Director of Secondary Education

Board Approved: September 21, 2020

Unit Overview

Engineers need to have good written and oral communication skills and must be able to express thoughts, present concepts, or provide findings. When analyzing an engineering problem you must define the problem, simplify the problem by making assumptions and estimations, perform the analysis and verify the results. Written reports are integral in engineering as are oral technical presentation skills and graphical communication. Professional Engineering societies have established guidelines, standards, and rules that govern the conduct of their members and also assist in interpreting ethical dilemmas that are submitted. The NSPE's code of Ethics for Engineers includes a preamble, fundamental canons, rules of practice and professional obligations. This unit overviews the ethics structure that engineering students and engineers follow. Engineers must develop a good grasp on fundamental dimensions.

Enduring Understanding

- Engineers are expected to express thoughts, present a concept for a product, provide an engineering analysis of a problem and its solution, or show findings from experimental work.
- When you analyze an engineering problem, there are four steps that must be followed: define the problem, simplify the problem by making assumptions and estimations, perform the analysis and verify the results.
- Engineering use drawings to convey their ideas and design information. These drawings provide important information such as shape of a product, size, type of material used and assembly steps along with how parts fit together and for fabrication purposes.
- The dimension of time can be divided into both small and large portions, such as seconds, minutes, hours, days, months, year etc.
- Significant digits represent and convey the extent to which recorded or computed data is dependable.
- We can use words to explain our observations or use another language, such as mathematics and formulas, to express the findings.
- Coordinate units to locate things is respect with a known origin, the most common is the Cartesian coordinate system
- Radians and strain represent the ration of two lengths. Radians represent the ratio of an arc length to radius of the arc and is unit-less. When a piece of material in a shape of rectangular bar is subjected to a tensile load and the material will deform. The ration of deformation length to original length of the bar is called strain which is also unit less.
- The areas of common shapes such as triangles etc are obtained using simple area formulas - for irregular shapes the approximation methods such as the Trapezoidal rule.
- Buoyancy effect can be used to measure the exterior volume of objects with irregular shapes. Solid modeling software programs provide information such as magnitude the area and the volume.
- The second moment of area is known as the area moment of inertia, and is an important property of an area that provides information on how hard it is to bend something. For common geometric shapes, areas moment of inertia formulas may be used.
- A branch of civil engineering deals with the design and layout of highways, roads, and streets and the location and timing of traffic control devices that move vehicles efficiently.
- Mass provides a quantitative measure of how many molecules or atoms are in a given object along with provides a measure of resistance to transnational motion.
- In engineering, to show how light or heavy materials are, we use properties such as density, specific weight, specific gravity, and specific volume.
- Mass

Essential Questions

- What are the basic steps that are involved in the solution of engineering problems?
- What is the importance of reporting and what are the main components of an engineering report?
- What are some of the important concepts that you should consider when preparing for an

oral presentation and how to you communicate engineering graphical information?

- What is engineering ethics and why is it important to have established guidelines, standards, and rules - give at least two examples of the fundamental canons of the NSPE's Code of Ethics?
- What is the importance of conversion from one system of measurement to another?
- What is dimensional homogeneity and why is it so important in the engineering field?
- What is the difference between a component and a system?
- What are physical laws and what are they based on?
- What is the importance of a system of units and lengths, and why do engineers need radians and strains?
- What are the different methods that you use to estimate and approximate?
- What are the important roles of volume in engineering analysis and design?
- How has time measured and how has its measurement evolved? What are the benefits of daylight savings time and time zones?
- Describe periodic events and explain traffic flow, density, and average speed?
- Explain what is meant by angular acceleration?
- Explain what the value of mass moment of inertia represents and what the value of momentum represents?
- Explain the conservation of mass principle?

Exit Skills

1. Understand and apply fundamental dimensions is everyday life and in problems
2. Application of The SI Units in addition to US Customary System
3. Complete exercises in which students use converted values in order to complete a problem or project
4. Express all numbers in correct significant digits
5. Able to measure, calculate, and approximate length and length related variables
6. Understand and apply radians and strain representation
7. Calculate the area, volume, and second moment of area
8. Express and apply the flow of traffic and engineering variables involving length and time
9. Choose materials based on properties such as density, specific weight, specific gravity, and specific volume
10. Use mass flow rates to determine how much of a material or fluid is used during a period of time
11. Analyze an engineering design in terms of Mass Moment of Inertia, Momentum, and Conservation of Mass
12. Utilize Force and Newtons Laws in Mechanics along with Moment, Torque, Work, Pressure, Stress, and Linear Impulse

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.1	Interpret expressions that represent a quantity in terms of its context.
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
MA.A-SSE.B.3	Choose and produce an equivalent form of an expression to reveal and explain properties of the quantity represented by the expression.
MA.A-SSE.B.3a	Factor a quadratic expression to reveal the zeros of the function it defines.
MA.A-SSE.B.3b	Complete the square in a quadratic expression to reveal the maximum or minimum value of the function it defines.
MA.A-SSE.B.3c	Use the properties of exponents to transform expressions for exponential functions.

LA.RST.11-12.1	Accurately cite strong and thorough evidence from the text to support analysis of science and technical texts, attending to precise details for explanations or descriptions.
LA.RST.11-12.2	Determine the central ideas, themes, or conclusions of a text; summarize complex concepts, processes, or information presented in a text by paraphrasing them in simpler but still accurate terms.
LA.RST.11-12.3	Follow precisely a complex multistep procedure when carrying out experiments, taking measurements, or performing technical tasks; analyze the specific results based on explanations in the text.
LA.RST.11-12.7	Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., quantitative data, video, multimedia) in order to address a question or solve a problem.
LA.RST.11-12.8	Evaluate the hypotheses, data, analysis, and conclusions in a science or technical text, verifying the data when possible and corroborating or challenging conclusions with other sources of information.
LA.RST.11-12.9	Synthesize information from a range of sources (e.g., texts, experiments, simulations) into a coherent understanding of a process, phenomenon, or concept, resolving conflicting information when possible.

Learning Objectives

1. Explain why engineers need to have good written and oral communication skills an engineer
2. Describe the basic steps that you need to follow to solve an engineering problem
3. Explain different modes of written communication in engineering and their purpose
4. describe the key concepts that must be followed when giving an oral presentation
5. Realize the importance of graphical communication such as drawings, in conveying ideas and design information
6. Explain what is meant by engineering ethics
7. Give examples of fundamental canons and rules of practice
8. Apply engineering ethics to situations.
9. Explain what they mean and give examples
10. describe what system of units represent and give examples of measurement
11. Explain and perform calculations using the correct amount of significant digits.
12. State and give examples of physical laws and observations.
13. Describe the role of length in engineering analysis and design, as well as its units, measurements, and calculation
14. Explain what is meant by radians and strain - both length related quantities and their and their role in engineering analysis and design
15. describe the role of volume in engineering analysis and design as well as its units, calculation, and measurement
16. Explain what is meant by second moment of area - its role in engineering analysis and design and its calculation.
17. Realize is a fundamental dimension and is needed to describe many engineering problems, situations, and processes, and explain the difference between a steady and a transient process
18. Describe how time is measured and how its measurement has evolved
19. Explain what we mean by a period or a frequency and how they are related to the

fundamental dimension of time

20. Describe traffic variables such as flow, density, and average speed that make use of the fundamental dimension of time
21. describe engineering quantities such as speed, acceleration, and volume flow rate that are based on the fundamental dimensions of length and time.
22. Explain what is meant by mass, give examples of its units, and describe its important roles in engineering analysis and applications
23. describe how these terms are used to show how light or heavy materials are
24. explain what is meant by mass flow rate and how it is related to volume flow rate
25. describe what is meant by mass moment of inertia and its role in rotational motion
26. explain hat is meant by momentum
27. describe the conservation of mass for an engineering situation
28. Explain what is meant by force, give examples of different types of forces in engineering analysis and design.
29. Explain what is meant by mechanics and describe Newton's first, second, and third laws
30. Describe the tendency of an unbalanced force which results in rotating, bending, or twisting an object along with how it is quantified
31. Describe the tendency of an unbalanced force which could result in moving an object through a distance and show how it is calculated
32. Explain how pressure and stress provide measures of intensities of force over areas
33. Describe the net effect of an unbalanced force acting over a period of time
34. Describe the role of temperature in engineering analysis and design and its units and measurement
35. Explain what causes head transfer and the models of heat transfer and demonstrate knowledge of the R value
36. Describe factors that define thermal comfort
37. Explain what the heating values of fuels represent
38. Explain what is meant by thermal energy and preform an energy consumption audit
39. Show proficiency in solving problems in thermal expansion and specific heat
40. Describe the role of current as a fundamental dimension in engineering analysis
41. Explain what is meant by electrical circuits and give examples of its components
42. Describe the role of motors in our everyday life and give examples of types of motors
43. Explain lightning terminology and give examples of different lightning systems and their power consumption rates
44. Describe how we quantify what it takes to move things, lift things, and heat or cool things
45. Describe the conservation of energy principle
46. Describe what is meant by power and explain the difference between work energy and power
47. Explain what is meant by efficiency and how efficiency is defined for a power plant and automobile engine and electric motor

Suggested Activities & Best Practices

- Lab Reports
- Prototyping
- Problem Based Learning Experience
- PowerPoints with Notes
- Homework and Classwork Activities
- Group Activities
- In Class Discussion
- Do Nows and Closures
- Class PollingObservation

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

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 Institute 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 Online - 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

Gizmos

Near POD

Google Classroom

JamBoards

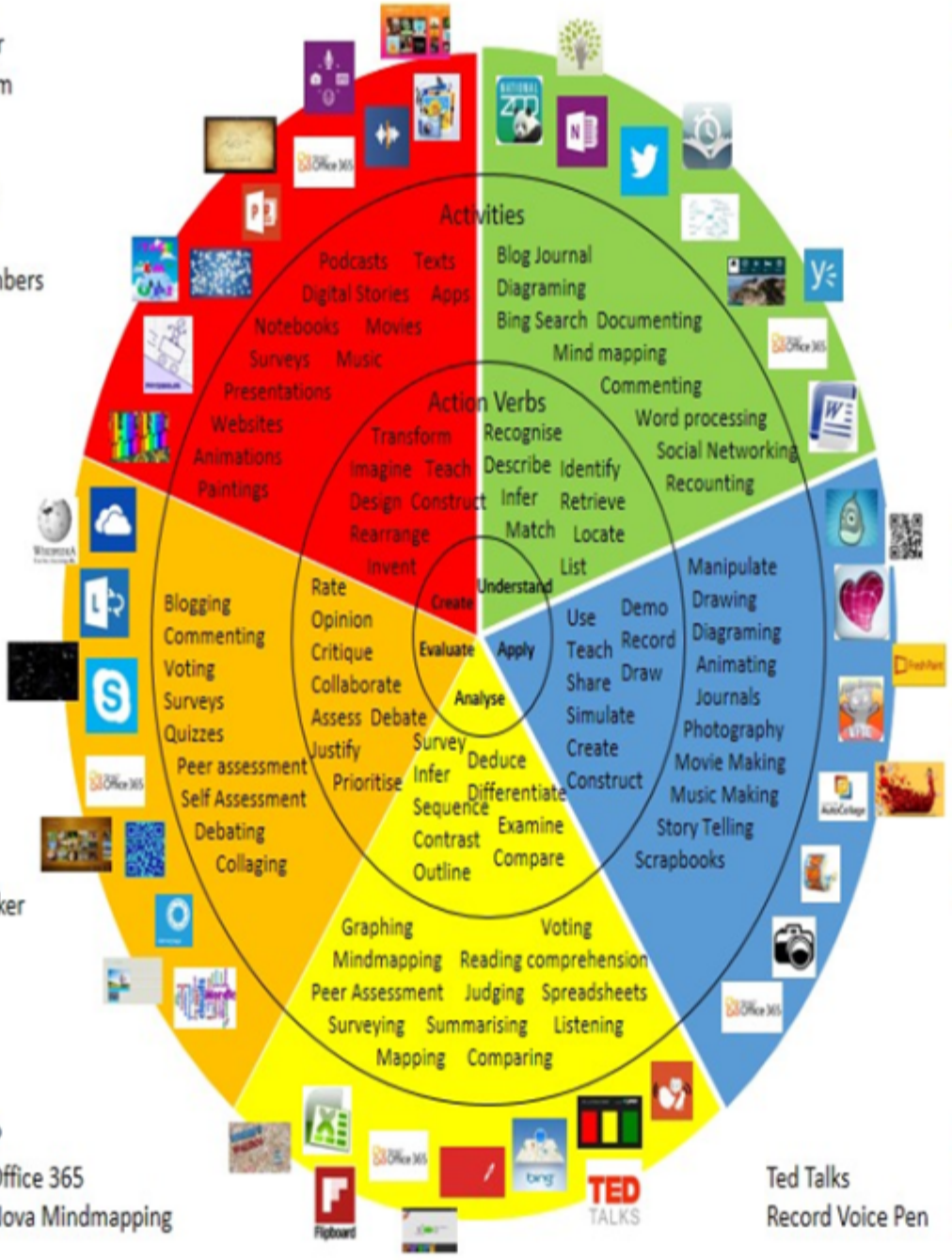
3D Printer

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

- 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.

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.E.1	Produce a position statement about a real world problem by developing a systematic plan of investigation with peers and experts synthesizing information from multiple sources.
TECH.8.1.12.E.2	Research and evaluate the impact on society of the unethical use of digital tools and present your research to peers.
TECH.8.1.12.E.CS1	Plan strategies to guide inquiry.
TECH.8.1.12.E.CS2	Locate, organize, analyze, evaluate, synthesize, and ethically use information from a variety of sources and media.
TECH.8.1.12.E.CS3	Evaluate and select information sources and digital tools based on the appropriateness for specific tasks.
TECH.8.1.12.E.CS4	Process data and report results.

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

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