Verona Public School District
Curriculum Overview

STEM

(Science, Technology, Engineering, Math)

Curriculum Committee Members:
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Supervisor:
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Curriculum Developed:
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Board Approval Date:
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Verona Public Schools Mission Statement:

The mission of the Verona Public Schools, the center of an engaged and supportive community, is to empower students to achieve their potential as active learners and productive citizens through rigorous curricula and meaningful, enriching experiences.

Course Description:

STEM is the first half of a suggested STEM/STEAM full year course. This course teaches professional communication, design skills, and combines concepts of Science, Technology, Engineering, and Math through research, design and iterative project based learning. In STEM, the fabrication room is a laboratory rather than a traditional workshop, where emphasis is placed on experimentation, observation, reflection. This course is intended for any student interested in taking additional Technology courses at VHS. Computer aided design, traditional and digital fabrication including a laser cutter or 3D printer may be utilized.

Prerequisite(s):

C+ in Previous Math Course

Verona High School STEM

Standard 8: Technology Standards

8.1: Educational Technology: *All students will use digital tools to access, manage, evaluate, and synthesize information in order to solve problems individually and collaborate and to create and communicate knowledge.*	**8.2: Technology Education, Engineering, Design, and Computational Thinking - Programming:** *All students will develop an understanding of the nature and impact of technology, engineering, technological design, computational thinking and the designed world as they relate to the individual, global society, and the environment.*
X A. Technology Operations and Concepts **X** B. Creativity and Innovation **X** C. Communication and Collaboration D. Digital Citizenship **X** E. Research and Information Fluency **X** F. Critical thinking, problem solving, and decision making	**X** A. The Nature of Technology: Creativity and Innovation **X** B. Technology and Society **X** C. Design **X** D. Abilities for a Technological World E. Computational Thinking: Programming

SEL Competencies and Career Ready Practices

Social and Emotional Learning Core Competencies: *These competencies are identified as five interrelated sets of cognitive, affective, and behavioral capabilities*	**Career Ready Practices:** *These practices outline the skills that all individuals need to have to truly be adaptable, reflective, and proactive in life and careers. These are researched practices that are essential to career readiness.*
Self-awareness: The ability to accurately recognize one's emotions and thoughts and their influence on behavior. This includes accurately assessing one's strengths and limitations and possessing a well-grounded sense of confidence and optimism.	**X** CRP2. Apply appropriate academic and technical skills. CRP9. Model integrity, ethical leadership, and effective management. CRP10. Plan education and career paths aligned to personal goals.
Self-management: The ability to regulate one's emotions, thoughts, and behaviors effectively in different situations. This includes managing stress, controlling impulses, motivating oneself, and setting and working toward achieving personal and academic goals.	CRP3. Attend to personal health and financial well-being. **X** CRP6. Demonstrate creativity and innovation. **X** CRP8. Utilize critical thinking to make sense of problems and persevere in solving them. CRP11. Use technology to enhance productivity.
Social awareness: The ability to take the perspective of and empathize with others from diverse backgrounds and cultures, to understand social and ethical norms for behavior, and to recognize family, school, and community resources and supports.	**X** CRP1. Act as a responsible and contributing citizen and employee. CRP9. Model integrity, ethical leadership, and effective management.
Relationship skills: The ability to establish and maintain healthy and rewarding relationships with diverse individuals and groups. This includes communicating clearly, listening actively, cooperating, resisting inappropriate social pressure, negotiating conflict constructively, and seeking and offering help when needed.	**X** CRP4. Communicate clearly and effectively and with reason. CRP9. Model integrity, ethical leadership, and effective management. CRP12. Work productively in teams while using cultural global competence.
Responsible decision making: The ability to make constructive and respectful choices about personal behavior and social interactions based on consideration of ethical standards, safety concerns, social norms, the realistic evaluation of consequences of various actions, and the well-being of self and others.	CRP5. Consider the environmental, social, and economic impact of decisions. CRP7. Employ valid and reliable research strategies. **X** CRP8. Utilize critical thinking to make sense of problems and persevere in solving them. CRP9. Model integrity, ethical leadership, and effective management.

Standard 9: 21st Century Life and Careers

9.1: Personal Financial Literacy: *This standard outlines the important fiscal knowledge, habits, and skills that must be mastered in order for students to make informed decisions about personal finance. Financial literacy is an integral component of a student's college and career readiness, enabling students to achieve fulfilling, financially-secure, and successful careers.*	**9.2: Career Awareness, Exploration & Preparation:** *This standard outlines the importance of being knowledgeable about one's interests and talents, and being well informed about postsecondary and career options, career planning, and career requirements.*	**9.3: Career and Technical Education:** *This standard outlines what students should know and be able to do upon completion of a CTE Program of Study.*
A. Income and Careers B. Money Management C. Credit and Debt Management D. Planning, Saving, and Investing **X** E. Becoming a Critical Consumer F. Civic Financial Responsibility G. Insuring and Protecting	A. Career Awareness (K-4) B. Career Exploration (5-8) **X** C. Career Preparation (9-12)	A. Agriculture, Food & Natural Res. **X** B. Architecture & Construction C. Arts, A/V Technology & Comm. D. Business Management & Admin. E. Education & Training F. Finance G. Government & Public Admin. H. Health Science I. Hospital & Tourism J. Human Services K. Information Technology L. Law, Public, Safety, Corrections & Security **X** M. Manufacturing N. Marketing **X** O. Science, Technology, Engineering & Math P. Transportation, Distribution & Log.

Course Materials

Core Instructional Materials: *These are the board adopted and approved materials to support the curriculum, instruction, and assessment of this course.*	**Differentiated Resources**: *These are teacher and department found materials, and also approved support materials that facilitate differentiation of curriculum, instruction, and assessment of this course.*
• Multiple Intelligence Quiz • Fluid Intelligence Practical Activities • Guided STEM Professions Research Report • Shop Safety Contract listing procedures • Shop Safety Quiz online assessment at ProProfs • Measurement Materials & Quiz to 1/32" inch including measuring methods for accuracy vs. precision. • Miter Saw Operation & Safety • Table Saw Operation & Safety • Drill Press Operation & Safety • Hand Drills Operation & Safety • Band Saw Operation & Safety • The Science of Speed Research	• Alternate Fluid Intelligence Practical Activities • Exemplars of STEM Professions Research Report • Shop Safety Quiz with visual context and limited answer choices • Measurement Study Materials and Quiz down to ⅛" • Demonstrations of layout methods to minimize math and maximize accuracy including bisecting corners method. • Graphic organizer for parts of core machinery • Graphic organizer for common tools • Video content for CO2 Dragster Racing and Fabrication • Exemplar Drawings for the CO2 Dragster Car • Patterns for the CO2 Dragster Car • Exemplar Demonstration, handling and modeling for the CO2 Dragster Car

• Speed Vs. Acceleration Practical • CO2 Dragster Project Brief & Rubric • Spinning Tops Project Brief & Rubric	• Example Problems and Solutions for Calculating Speed and Acceleration • Modified Speed and Acceleration Quiz • Exemplars for the Spinning Top • Exemplar CAD drawings for the Spinning Top • Spinning Top Patterns

Unit Title / Topic: STEM Boot Camp	Unit Duration: 4 weeks

Stage 1: Desired Results

Established Goals:

2014 New Jersey Core Curriculum Content Standards - Technology

8.2.12.D.1
Design and create a prototype to solve a real world problem using a design process, identify constraints addressed during the creation of the prototype, identify trade-offs made, and present the solution for peer review.
8.2.12.D.5
Explain how material processing impacts the quality of engineered and fabricated products.

21st Century Life and Career Skills

9.1.12.A.1
Apply critical thinking and problem-solving strategies during structured learning experiences.
9.1.12.B.2
Create and respond to a feedback loop when problem solving.
9.1.12.B.3
Assist in the development of innovative solutions to an onsite problem by incorporating multiple perspectives and applying effective problem-solving strategies during structured learning experiences, service learning, or volunteering.
9.2.12.A.1
Analyze the relationship between various careers and personal earning goals.
9.2.12.A.2
Identify a career goal and develop a plan and timetable for achieving it, including educational/training requirements, costs, and possible debt.
9.3.12.C.2
Characterize education and skills needed to achieve career goals, and take steps to prepare for postsecondary options, including making course selections, preparing for and taking assessments, and participating in extracurricular activities.
9.3.12.C.4
Use online resources to examine licensing, certification, and credentialing requirements at the local, state, and national levels to maintain compliance with industry requirements in areas of career interest.

Architecture & Construction Career Cluster

9.4.12B.24
Employ technological tools to expedite workflow.
9.4.12.B.(1).1
Demonstrate communication skills and strategies that are used to work effectively with potential clients and others

Transfer Goals:

Students will be able to <u>independently</u> and critically evaluate the strengths and weaknesses of resources, and solutions while implementing the Engineering Design Cycle.

Students will understand that:

- Engineering is an Iterative Process
- The process of Engineering uses the Design Cycle
- Technology is the Artifact of Engineering
- STEM includes both Engineering and Technology, Process & Artifact
- STEM is Multi-Disciplinary
- STEM applications can be Functional and Creative
- STEM Solutions should consider Human, Natural & Capital Resources
- Human ability is a Resource.
- Different types of Intelligence can contribute equally to STEM Solutions
- Safe Fabrication procedures conserve human resources
- Planning is a critical and necessary step
- All steps of fabrication should planned before begun
- It is important to prioritize either accuracy *or* precision *before* beginning to Fabricate
- There are numerous ways & equipment that can be used to achieve the same goal
- Different categories of Materials have some common physical properties
- Material physical properties greatly affect structural ability
- Fasteners are selected based on availability, material integration, duration of use & strength
- Knowledge comes from research, observation, action, and reflection

Essential Questions:

- How does a STEM approach impact solving a problem in general? How does it impact your Education?
- What is intelligence? How important is it? Am I stuck with what I have?
- What are the things I have control over when collaborating with others?
- How do I communicate/present successfully?

Students will know:

- Types of Intelligence listed in Multiple Intelligence Categories such as: Spatial/Visual, Linguistic, Logical / Mathematical, Interpersonal, Intrapersonal, Musical, Bodily–Kinesthetic
- Graphical Design Strategies such as: Repetition, Rhythm, Rule of ⅓'s, Padding, Contrast, Bleeding, Text Variation, Organizational Hierarchy, Selective Color Use, Kerning, Summative Imagery etc.
- The 3 Top Public and Private Schools that hold undergraduate programs in their STEM career interest
- The cost to attend College at each University for their STEM career interest
- Qualifications and educational/certification requirements for their STEM career interest
- The starting, median, and maximum earning potential for their STEM career interest
- The daily work responsibilities of their STEM career interest
- The difference between accuracy and precision
- How to read a measuring tape to an accuracy of 1/16"
- The difference between cross cutting and rip cutting
- What a fence is used for in Fabrication

Students will be able to:

- Collaborate with members of a group with different expertise to solve complex problems.
- Identify, Reflect and React to personal categorical strengths and areas of improvement.
- Identify, Reflect and React to categorical strengths and areas of improvement of group, during collaborative design, fabrication and presentation
- Create a Graphical Presentation that both contains a structured Graphical Hierarchy of information and Creates Interest within intended audience
- Communicate a STEM solution using both drawing and notation
- Use Fabrication machinery safely without danger to themselves or those around them
- Prioritize accuracy or precision prior to Fabrication
- Use best practices when handling any tools to minimize risk, realize the design intent, and adhere to intended tolerances.
- Define the meaning of important material property terms
- Create a graphic organizer for different fasteners that uses Duration VS. Strength as dependents
- Strategically select materials and fasteners suited to a specific task

● What a guard is used for in Fabrication ● An optimal margin of safety ● When materials should be clamped or viced ● That Pinch Points and Blade exposure are mechanical conditions are responsible for most accidents with machinery and can be limited over avoided. ● The similarities & differences between Brittle, Malleable, and Ductile ● The similarities & differences between Transparent, Translucent & Opaque ● The similarities & differences between Hard, Strong, Durable & Tough ● Examples of successful electrical and thermal insulators and conductors ● Common properties of Ceramics, Metals, Polymers, Naturals and Composites ● Conditions that require the use of Temporary, Permanent, or Semi-Permanent Fasteners ● Optimal uses and procedures for Chemical & Mechanical Fasteners ● That effective critique is always constructive, uncovers possibilities, and must provides evidence about the how and whys of success.	● Select basic fabrications steps to realize a specific design intent ● Design and Fabricate with material and fastener limitations in mind. ● Optimize the use of a material's inherent structural properties ● Organize and Present a 3-5 min. technical presentation of their project ● Create a Constructive Critique that identifies and gives evidence for why something is successful, or *how it could be more successful if…..* ● Respond to a Verbal Critique

Stage 2: Acceptable Evidence

Transfer Task

Material & Fastener Challenge- Students select a material and a fastener type from a prepopulated list, then design and create a self supporting structure which highlights the physical properties of the students resources….and…..appears to defy gravity.

Other Evidence of Learning

Digital Journals/Blogs- Throughout the course students will respond to prompts that will document learning of important concepts, and skills.
Performance Assessments- Students design, construct, and test solutions to various technological challenges. Student work cooperatively to complete design activities and deliver presentations. Students are evaluated using performance and process rubrics.
Summative Assessments- Students complete minor pre/post content knowledge assessments, as well frequent do nows and closing exercises to target immediate critical knowledge.

Stage 3: Activities to Foster Learning

Learning Activities

Week 1 Defining the Course

Students will help define important concepts to the course such as Engineering, The Design Cycle, Technology, & STEM through hands on challenges, reflection and discussion. STEM will be understood as an engaging, rigorous course involving theory from multiple disciplines, experimentation & reflection.

Students will begin an online Blog Account which will serve as their Engineering Journal to document understanding, and present their research.
A long term assignment includes: Research, identify and communicate through a written document, a career for which STEM education is useful. (Homework)

Week 2 Different kinds of Smart?

Students will identify areas of personal human resource strength in a Multiple Intelligence Test

Students will witness personal success through a series of activities focused on different types of intelligence and collaboration

Students will reflect on personal and group strengths and areas in need of improvement through a series of collaborative problem solving exercises..

Week 3 Measurement, Tools & Safety

Students will demonstrate use and accuracy of common measurement tools in a practical exercise.

Students will identify the theory and operation of common machine components used in fabrication.

Students will attend safety demonstrations, read and return safety contract and pass a safety assessment.

Week 4 Materials & Fasteners

Students will determine the role of material science in solving a structural problem. (Pair/Share)

Students will complete a competitive vocabulary building exercise.(Pair/Share)

Students will compete in a competitive material analysis exercise. (Small Group/Lg. Group)

Unit Title / Topic: Digital Fabrication & Physical Optimization	Unit Duration: 14 Weeks

Stage 1: Desired Results

Established Goals:

2014 New Jersey Core Curriculum Content Standards - Technology

8.2.12.C.5
Create scaled engineering drawings of products both manually and digitally with materials and measurements labeled.
8.2.12.C.6
Research an existing product, reverse engineer and redesign it to improve form and function.
8.2.12.D.3
Determine and use the appropriate resources (e.g., CNC (Computer Numerical Control) equipment, 3D printers, CAD software) in the design, development and creation of a technological product or system.
8.2.12.D.4
Assess the impacts of emerging technologies on developing countries.

21st Century Life and Career Skills
Architecture & Construction Career Cluster

9.4.12B.24
Employ technological tools to expedite workflow.
9.4.12.B.(1).1
Demonstrate communication skills and strategies that are used to work effectively with potential clients and others

Transfer Goal:

Students will be able to <u>independently</u> use their learning to….manipulate the mass, volume, area, dimension, shape and other physical characteristics of a dynamic machine toward optimization through use of digital fabrication & the design cycle.

Students will understand that:

- Laser Cutters will not create 3 Dimensional objects, Students create 3 Dimensional objects from 2 Dimensional parts
- The varying width of the light beam and the heat of the laser will have physical effects on the cutting media that will need to be designed for.
- Laser Cutting present certain controllable hazards like radiation, fumes and particulates which necessitate all operation to be performed by the instructor.
- Digital Fabrication can provide greatly improved precision over traditional fabrication
- Depending on the design intent, traditional fabrication may still be better than digital fabrication, because of the speed of fabrication, the inability to work with certain media, maintain a certain quality, finish or creation of certain shapes.
- Digital Fabrication can provide parts and part assemblies that are out of scale, strength and stability compared to the design intent.
- Digital Fabrication requires thorough preplanning to maintain design integrity
- Beautiful machines are not always functional machines, and functional machines are not always beautiful, but machines that are both create intrigue and delight
- Manipulating even minor physical characteristics of a machine can greatly change its performance
- Many times, Less is more….Fewer parts often make for a more consistent, efficient and durable machine.
- Even though surface area isn't supposed to effect frictional coefficients….it usually does.
- Translation or Rotation, in any direction not intended, should be controlled
- Vehicles that are meant to go straight, are designed differently than vehicles that are meant to turn.
- Placement of Center of Mass in a Vehicle greatly changes performance
- A first design will almost never be as successful, as designs that include reflection and redesign.
- Certain parts and part assemblies require more precision than other.
- Optimization requires careful observation and reflection
- Optimization has limiting reagents and sometimes they change.

Essential Questions:

- How are economics and engineering interrelated?
- What are the critical problems of the world around us, and how can they be helped through optimization?
- What are the potential positive and negative impacts of ever more sophisticated and reliable digital fabrication, on: consumer jobs, cost of goods, creative freedom, education, fashion, rate of technological development….etc.

Students will know:

- Basic AutoCAD software commands and workflow for Digital Fabrication
- The capabilities and operating procedures of the Laser Cutter
- Layer management & File Organization Techniques
- Newton's 3 Laws of Motion Including a working Knowledge of Inertia, Moment of Inertia, Acceleration, & Normal Force
- Radius of Gyration determines the object's average mass from an axis of rotation, and whose quantity is dependent on cross sectional shape.
- A Larger Radius of Gyration or distribution of mass to the outside of a shape will decrease acceleration, but increase momentum and vice versa.
- Radius, Mass, & Speed are positively related to Angular Momentum
- Force has multiplication effect over area
- Angular Momentum will work to offset gravitys pull/torque/moment of a top downward.
- Friction is dependent on Mass, Material Interactions, and Normal Force

Students will be able to:

- Manipulate the mass, volume, area, dimension, shape and other physical characteristics of a dynamic machine toward optimization through use of digital fabrication & the design cycle.
- Draw Complete Orthographic Drawings including: TOP, FRONT, SIDE & Sectional Views in AutoCAD software.
- Design layered 2D sectional parts to reconstruct a 3D whole digital model.
- Design and fabricate a spinning top through a mixture of traditional and digital fabrication, that will spin for longer than a minute.
- To maintain dimensional and quantity constraints as imposed on project during duration.
- Reduce the surface friction of material/material interactions of a machine.
- Reduce frontal or rotational drag of a machine.

Stage 2: Acceptable Evidence

Transfer Task

The Spinning Top -Students will optimize a spinning top to distribute mass for maximum effective angular momentum. Students will select material interactions and condition surfaces for minimum coefficient of friction. Students will design the mass & diameter a spindle for maximum kinetic energy transfer. Students will optimize the height/placement of COM, and the true of the spindle to create the smallest moment/torque due to gravitational pull.

CO2 Dragster - Students will skillful test and optimize the reduction and distribution of mass, and the frontal drag of a CO2 dragster to gain maximum acceleration and linear stability. Students are given the opportunity to use digital fabrication to take optimization to the limits of their imagination.

Digital Journals/Blogs- Throughout the course students will respond to prompts that will document learning of important concepts, and skills.
Performance Assessments- Students design, construct, and test solutions to various technological challenges. Student work cooperatively to complete design activities and deliver presentations. Students are evaluated using performance and process rubrics.
Summative Assessments- Students complete minor pre/post content knowledge assessments, as well frequent do nows and closing exercises to target immediate critical knowledge.

Stage 3: Activities to Foster Learning

Learning Activities

Week 1: What is a Digital Fabrication?
Students will explore key concepts and terminology how Digital Fabrication is changing the world. Students will be introduced to the Laser Cutter & 3D printer and learn how each functions including workflow, design constraints and uses.

Week 2: The Physics behind Gyroscopic Motion (The Spinning Top)
Simple Physics Terms are introduced with hands on exercises to demonstrate the notion of each.
Students will research the physics behind the spinning top, create a poster explaining any important vocabulary and or concepts.

Week 3: Digital Drawing with AutoCAD*
After looking at some exemplars, students create 3 ideas for their top and select one to develop.
Students learn Basic CAD commands to create top, front, and sectional views of their design.

Week 4: Cutting and Assembly
Students will drawings to the instructor for laser cutting and then assemble the pieces selecting the proper fasteners.

Week 5: Initial Test and Optimization
Students will test, optimize and redesign their top to achieve longer spin time.

Week 6: Final Test & Evaluation
Students will create predictions, evaluate their designs and finally reflect on their own design, their predictions and their results.

Week 7: CO2 Dragster Intro
Students will research the physics behind the CO2 dragster through comparative analysis, exemplar case studies, and wind tunnel experiments.
Students read through Official CO2 racer rules and guidelines in small groups to determine required spatial constraints. Students then use these spatial constraints to design their Dragster.

Week 8: Fabrication
Students transfer their digital drawing to wooden blocks and complete the rough material reduction.

Week 9: Assembly
Students design assemble and tweak the hardware of the CO2 dragster for maximum performance. Students make predictions about design choices they can make related to hardware and how this should affect performance. They will reflect on these choices later.

Week 10: Testing & Optimizing
Students test their machines, compare to their peers, and reflect on assumptions regarding design choices. They have the ability to redesign their machine to achieve greater function, or apply a finish to reduce frontal drag.

Week 11: Redesign with Digital Fab Option
Students redesign their vehicles analyzing their results and are given a tutorial and option to redesign their vehicle using the 3D printer or laser cutter.

Week 12: Fabrication of New Design
Students work to either transfer their new model to the

Week 13: Assemble New Design
Students design assemble and tweak the hardware of the CO2 dragster for maximum performance. Students make predictions about design choices they can make related to hardware and how this should affect performance. They will reflect on these choices later.

Week 14: Final Results and Documentation
Students will test their dragsters, compare their results to their peers, evaluate both their preconceptions about their their design earlier design choices and document the project as well as their final conclusions.
Students increase proficiency with VEX IQ Sensors and increase robot programming capabilities. Students complete various programming challenges.