GEARS-IDS Invention and Design System

Educational Standards and Objectives

The **GEARS-IDS Invention and Design System** is a customizable science, math, engineering and technology education tool. This product engages student teams and teachers in the process of inventing engineering challenges and then creating the technology to meet the challenge. Through this process students and teachers acquire technical literacy and academic proficiencies that are described federal and state educational standards for math, science, engineering and technology.

The developers of the **GEARS Invention and Design System** realize that students and teachers gain deeper understanding through personal, passionate and active involvement in the process of thinking and doing. The **GEARS Invention and Design System** provides a catalyst for meaningful engagement in learning, and provides the opportunity for students to share what they know and are able to do.

Content and Performance Standards

Students and teachers who use the GEARS-IDS products to design and engineer machines and mechanisms capable of playing exciting and academically sophisticated games acquire knowledge and demonstrate skills in the following areas:

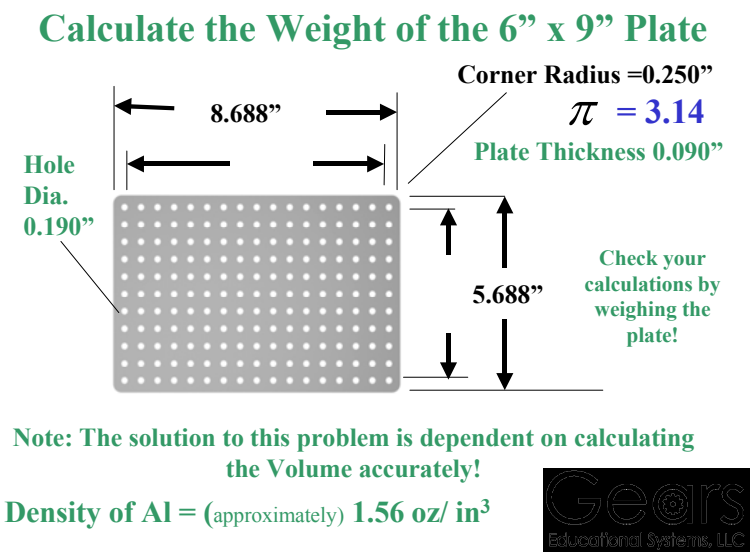
Mathematics
Physical Science
Engineering and Technology

Mathematics

Content Standard

Mathematics is the language of science and technology. Issac Newton described how forces act and how objects move by creating mathematical models that allowed scientists and engineers to predict the behavior of real world objects like the flight of an arrow, or the orbit of a planet. The process of designing and creating technology is enhanced by the degree to which we understand and can apply mathematical principles.

GEARS-IDS products can be used as tools to teach basic algebra and geometry at the same time that students are engaged in the process of engineering construction and design.



Performance Standards

- Linear measurement using feet and inches as well as meters, centimeters and millimeters.
- Weight measurement using pounds and ounces as well as kilograms and grams.
- Identify and use the correct order of operations on real numbers, including the associative, commutative, and distributive properties.
- Add, subtract, multiply and divide exponents
- Solve engineering problems that can be modeled using linear, reciprocal, or exponential functions.
- Create tables, graphs and symbols to visualize data and develop solutions to engineering related problems.
- Describe and explain how the relative sizes of a sample and the population affect the validity of predictions from a set of data.
- Use algebraic statements to predict mechanical and electrical performance and solve technical problems that involve pressure, work, rate, and force.

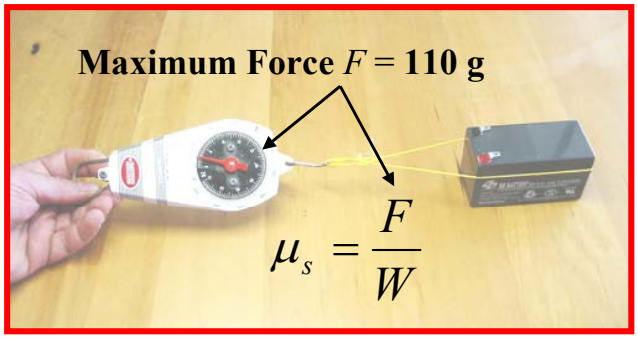
- Use estimation to judge the reasonableness of results of computations and of solutions to problems involving real numbers
- Use geometry to solve problems involving perimeters, surface areas and volumes of simple and compound shapes.
- Solve simple triangle problems using the triangle angle sum property and/or the Pythagorean theorem.
- Use sine, cosine and tangent to solve simple right angle geometry problems

Physical Science

Content Standard

The reciprocal relationship between science and technology is obvious and inescapable. Science is the study of how the world works, and it both drives and is driven by technological innovation and evolution. Students and teachers who participate in engineering challenges, apply fundamental scientific principles to the design and construction of the mechanisms that they create.

Record the Maximum Force *(F)*
(Before the Battery Begins to Move)



Students and teachers engaged in the creative process of inventing mechanisms using GEARS components such as batteries, motors, wheels, axles, pneumatic actuators and electronic controllers have an excellent opportunity to research and discover the underlying scientific principles that govern and the performance and function of the machines they design.

Performance Standards

- Distinguish between vector quantities like velocity, acceleration and force, and scalar quantities like speed and mass and weight.
- Draw vectors and be able to add them graphically in problems involving displacement and force diagrams.
- Distinguish the difference between speed, velocity and constant acceleration, and solve problems related to speed, velocity and acceleration.

- Create and interpret graphs of motion that include position vs. time, speed vs. time, velocity vs. time, and constant acceleration vs. time.
- Explain the difference between mass and weight.
- Describe the relationship between mass and inertia.
- Interpret and apply Newton's laws of motion in the design and construction of solutions to engineering challenges.
- Create a free body force diagram with co-linear forces acting on an object, and determine the net force on it.
- Measure static and kinetic friction and describe how they differ, what they depend on and how they affect the motion of objects.
- Measure and describe the acceleration due to gravity, and describe why objects of differing masses fall at the same rate.
- Measure and calculate the forces and motion of the mechanisms you construct. Identify and use standard international units of measurement for force, mass distance, speed, acceleration, and time, and convert units from different systems
- Use GEARS-IDS components to create mechanisms examples that illustrate the law of conservation of energy through the creation of simple machines and mechanisms.
- Use GEARS-IDS components to create a trebuchet project that provides an example of how energy can be transformed from kinetic to potential and vice versa.
- Describe multiple examples of energy conversions that occur during the operation of a GEARS-IDS Robot.
- Construct mechanisms that illustrate the relationship between energy, work, and power.
- Measure and calculate the work, power and energy produced by the mechanisms you build. Identify and use the appropriate standard international units of measurement for energy, work, power, and momentum. Convert units between systems.
- Use the GEARS batteries and motors to describe and provide examples of how stationary and moving charge particles result in the phenomenon known as electricity and magnetism.
- Build and describe the operation of a fixed magnet DC motor.
- Measure and describe current, voltage, resistance, and use Ohm's law to describe the relationship between them.
- Analyze circuits and find the current at any point and the potential difference between any two points in the circuit) using Ohm's law.
- Measure the current, voltage, and energy capacity in amp hours of the 12 volt sealed lead acid battery provided in the GEARS-IDS kit of parts.

- Identify and use the appropriate standard international units of measurement for pressure. Convert units between systems.
- Create and/or use a spreadsheet program that calculates the force of a pneumatic cylinder with respect to piston area and applied pressure.
- Use the GEARS-IDS Components to construct a working pneumatic system and use Boyle's law to produce a mathematical model (or spread sheet) of the pneumatic system performance.
- Compare and contrast the differences between the mathematical model of a pneumatic system and the actual measured performance.
- Construct working models of simple machines and lever systems that illustrate torque and mechanical advantage.
- Compute the torques acting on a balanced and unbalanced lever system.

Engineering and Technology

Content Standard

Engineers use tools and knowledge to develop, adapt and apply technology to the solution of problems. Engineers develop the best possible solutions to technical problems given the constraints of time, resources, budgets, knowledge, power and weight. Engineering and the creation of technology is a process. This process is clearly documented and easily observed. The engineering design process is a close cousin of the scientific method and it is part of the product development cycle of nearly every manufactured item on earth. Engineering design involves practical problem solving, research, development, and invention and requires designing, drawing, building, testing, and redesigning. Engineering is an iterative process that requires the assimilation of academic knowledge, practical experience, an understanding of existing technology and technological practices and the ability to clearly articulate and describe ideas and concepts.

Performance Standards

- Use the GEARS-IDS Invention and Design System to participate in the process of engineering design. This process includes: Identifying the problem, understanding the constraints, researching information, developing possible solutions, selecting the best possible solution, constructing prototypes, testing and evaluating, communicating the solution(s), and modifying and redesigning.
- Draw and sketch GEARS-IDS components using hand drawing techniques or CAD workstations to demonstrate knowledge of pictorial and multi-view drawings, dimensioning and symbols and CAD techniques using 3D solid models and parametric modeling techniques.
- Create and interpret plans, diagrams, and working drawings in the construction of a GEARS-IDS prototype mechanism.
- Develop an engineering challenge or competitive game and design and construct a machine to play the game.
- Analyze, correct and improve the performance of a competitive machine.
- Use computer graphic, word processing and multimedia tools to document and present the engineering processes, and strategies you used in the creation of a solution to an engineering challenge.
- Maintain a notebook or website of pictures and text detailing the chronology of the design, fabrication and game playing strategies used.
- Identify, select and use common tools safely and efficiently.
- Develop and use fabrication skills and fastening systems.
- Form, bend, shape, cut and join a variety of materials to improve the quality and performance of the mechanisms built with the GEARS-IDS Invention and Design System.
- Design create and trouble shoot electrical circuits and components.
- Measure amperage voltage and current with a Multimeter.
- Create and read electrical circuit diagrams and schematic symbols.
- Design, create and troubleshoot pneumatic circuits and components.
- Create and read pneumatic circuit diagrams and schematic symbols.
- Use the GEARS-IDS components to build a motor dynamometer. Determine the motor power and efficiency and use it to analyze the relationship between motor torque and current, as well as voltage and RPM.
- Analyze and calculate the mechanical advantage and predict the performance of various drive system ratios and strategies using direct drive, chain and sprocket or 4 wheel pulley drives.