GEARS-IDS Invention and Design System

Educational Objectives and Standards

The **GEARS-IDS Invention and Design System** is a customizable science, math and engineering, education tool. This product engages student teams and teachers in the process of inventing engineering games and designing and building the machines to play them. Through this process students and teachers acquire technical literacy and academic proficiencies described in math, science and technology frameworks published by state and federal departments of education.

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.

Educational Objectives

Students and teachers who use the GEARS-IDS products to design and engineer machines and mechanisms capable of playing fun, exciting and academically sophisticated games learn skills and concepts in the following areas:

Mathematics
Physical Science
Engineering and Technology
Manufacturing and Transportation Technology

These competencies and learning objectives are listed below

Mathematics

- 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 problems

Physical Science

- 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.
- Create a free body force diagram with only co-linear forces to show forces acting on an object, and determine the net force on it.

- Measure static and kinetic friction and describe how they differ and 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.
- 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.
- 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.
- Identify and use the appropriate standard international units of measurement for energy, work, power, and momentum. Convert units between systems.
- 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 a 12 volt sealed lead acid battery.
- Identify and use the appropriate standard international units of measurement for pressure. Convert units between systems.
- Create and/or use a spread sheet 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

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 and existing knowledge and practices.

- Use the GEARS-IDS Invention and Design System to participate in the process of engineering design. This process includes: Identify the problem, Research the problem, Develop possible solutions, Select the best possible solution, Construct a prototype, Test and evaluate, Communicate the solution(s), and Modify and redesign.
- 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.
- Produce 3D Solid Model assembly drawings of mechanisms designed and built using the GEARS-IDS Components.
- 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.

Manufacturing and Transportation

- Identify, select and use common tools safely and efficiently.
- Identify and select appropriate materials and components.
- 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.
- Gear ratios and drive systems.

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Competency and Skill Areas Supported by GEARS-IDS Products

GEARS-IDS products put the fun and excitement back into learning by engaging the creativity and imagination of students and teachers alike.

GEARS-IDS products are particularly well suited for integrated lessons and class projects that motivate students and teachers to develop and use math, science and engineering skills to solve engaging problems. These educational tools can be used in stand-alone unit activities or as the foundation for a yearlong study of engineering and design.

The GEARS-IDS course of study includes lessons and activities that prepare students to participate in the engineering and design of competitive machines. The course can be organized into modules focused on developing the skills and understanding needed to build competitive machines.

Students and teachers can use the GEARS-IDS Invention and Design System to create a variety of machines and mechanisms that include models of medieval trebuchets, radio controlled game playing machines or fully autonomous automated robots. Students and teachers can easily create exciting engineering challenges similar to those played at engineering colleges and on TV!

Students and teachers who participate in these activities learn the necessary math, science and principals of engineering they need to create competitive machines. These include: The application of physics principles, mathematical reasoning and the iterative process of experimenting, building, modifying and playing with ideas. In addition students and teachers learn the benefits of organizing themselves into engineering teams, and clearly communicating their thoughts and ideas. These are the skills needed to successfully complete the challenge, as well as the skills needed for career success.

The following is a listing of skills, competencies and concepts developed by students and teachers who use the GEARS-IDS Invention and Design System.

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Mathematics
- Algebraic manipulations
- Geometric constructions
- Perimeter, Area and Volume Calculations

Design Skills
- Seeing with the minds eye
- Design methodologies
- Strategies and concepts

Drawing Skills
- Sketching
- 2D CAD
- 3D Models
- Working drawings
- Precision Measurement

Material Science
- Stress/Strain
- Shape and structure

Power Transmission
- Sprockets, chains, gears and pulleys

DC Motors
- Magnet basics
- Electromagnets Motor theory and Construction
- Make a working motor.
- RPM
- Torque
- Horse power
- Internal resistance
- Stall torque
- Power
- The relationship between Speed and torque curves
- Efficiency

Computer Applications
- Spread sheets
- Graphic and photo processing
- Presentation Software
- Design and visualization
- Computer animation
- Digital imaging

Physical Science
- Simple Machines
- Mechanical Advantage
- Friction
- Density
- Units and measurement
- Motion
- Velocity
- Acceleration
- Kinematics
- Force and pressure
- Electricity fundamentals
- Magnetism
- Work/Power/Energy

Tools and Materials
- Basic Tools and shop safety
- Identify and use common tools
- Form, shape, cut and fasten
- Materials

Basic Electricity/Electronics
- Amperes
- Volts
- Watts
- Reading a meter
- Soldering and connecting
- Wires
- Components
- Circuits
- Ohm's Law

Pneumatics
- Identify select and use components
- Properties of compressed air
- Pneumatic safety
- Units of measure
- Understanding Gas Laws
- Pressure vs. Flow
- Actuators
- Mounting Cylinders
- Sizing Cylinders
- Speed Control
- Directional valves
- Controlling single acting cylinders
- Pneumatic Symbols
- Pneumatic Science
- Pneumatic History