Gears
Educational Systems, LLC

Design your own engineering education program with The GEARS-IDS™ Invention and Design System

The Engineering Education Opportunity

- **Students and teachers construct knowledge through active engagement in activities they perceive as personally relevant.**
- **Passion enhances learning.**
- **Students and teachers make choices about what they learn, how much they learn and how they learn best. Working together, students and teachers can design richly rewarding and diverse educational environments that produce a multitude of learning opportunities.**
- **Learning as a team, Students and Teachers are capable of achievement levels far beyond what is presently imagined.**
- **Designing and building stuff is fun.**
- **The best way to learn how real machines and machine components work, is to work with real machines and machine components.**
- **The best way to learn how to apply math and physics principals to the design and engineering of a machine, is to apply math and physics principals to the design and engineer of machines.**
- **The more you know, the more you are capable of learning**

The Engineering Education Materials

The GEARS-IDS™ Invention and Design System is a real engineering system made from real engineering components, not plastic toy parts.

- **Industrial grade pneumatic components scaled for classroom activities and school budgets.**
- **A selection of high torque, automotive quality gear head motors.**
- **Heavy duty aluminum and stainless steel structural components, designed to withstand years of classroom use and experimentation.**
- **Open architecture and robust design permits GEARS-IDS™ users a nearly limitless selection of easily replaceable and readily available industrial components.**

The Engineering Education Method

Engineering success is predicated in great part on knowledge. In order to design and build competitive machines it is necessary to understand how the machine subassemblies and components work..

The GEARS-IDS™ Invention and Design System components are real engineering tools, not toys. Engineering success depends on students and teachers knowing how to identify and use these components. The producers of The GEARS-IDS™ Invention and Design System have developed 4 activities that will guide students through the set-up and use of these components and will result in the construction of a working electro-mechanical athlete that can be used to play a competitive game. Students can use the machine they create, or they can elect to use their engineering skills to develop an improved machine, or even reinvent the design challenge. The possibilities are endless, and the machines and games you can invent are limited only by time and knowledge.

Students who participate in these four activities will acquire the fundamental engineering skills they need to create competitive game playing machines.

The GEARS-IDS™ Engineering Activities

- **Build a Drive Train and Chassis**
- **Build a Pneumatics Test Stand**
- **Configure a Control System**
- **Create the Design Challenge Game and the Mechanical Athlete to Play it.**

The Engineering Education Analysis

Assessment is a critical component of a good educational program. The developers of The GEARS-IDS™ Invention and Design System are teachers and students. They understand that good assessment strategies are mapped to a particular program.

Assessment begins with the establishment of an essential set of questions **(Anticipatory Set)** that frame the challenge, and ends with development of performance criteria.

Anticipatory Set

Anticipatory sets are the essential questions asked of the engineering participants as a means of focusing their thinking and heightening involvement.

What is the design objective?

Developing the game and rules.

What are the limitations?

Are you familiar with the kit components and the materials/supplies provided?
How effectively can you utilize these resources to meet the design objective?

Can you conceive a possible solution?

What will your machine do to win?
What capabilities will you give it?
What capabilities can you give it?

Can you visualize a possible solution?

Can you visualize your solution and communicate it to others?
Can you represent your designs with sketches, 2D and 3D CAD drawings and 3D renderings and animations?

Can your Idea/machine compete?

Play with your idea and see how it interacts and compares with other participants designs.
Discuss design problems and the solutions you develop.

How can you assess your efforts?

How well did your robot perform?
How closely were you able to come to completing your ideas about what your machine could and would do?
What are the machines/design strengths and weakness'?
Which design did you like best and why?

How will the instructor evaluate your efforts?

Compile a journal/web-page "Portfolio" in the form of a three ring binder to be shown to your peers and your instructor.
Include the rules, personal and class notes, work sheets, Hand outs, examples of your best sketches, 2D, 3D and animated prototypes.
Present Pictures or video and a personal assessment of your efforts.
Your design journal should provide enough information to allow others to repeat your journey of discovery and invention.

Assessment: Understanding the "Deliverables"

The Notebook/web-page accounts for 80% of the grade.

The break down looks like this:

10pts
A narrative describing a chronology of your involvement in the design and fabrication of the Table top Robot. Include personal thoughts, feelings and insights that you feel should be shared

10pts
The design process is documented clearly with combined photo and text.

10pts
The assigned "virtual kit" renderings are present and printed in color.

10pts
The assigned working drawings are present and fully dimensioned.

10pts

Sketches are present and demonstrate the thinking processes leading to the creation of the machine and or selected subassemblies.

10pts
Quizzes and related worksheets are present.

10pts

A minimum of 3 rendered solid model views (3) of your finished design are present.

10pts
Overall attractiveness and organization of the workbook.

20% of the grade is awarded to any group that fields a working robot.

Closure: GiveValue and Meaning to the Effort and Take Pleasure in the Process

The machinecompetition is the culminating activity. Participants should be given the opportunity to review each others work, to watch the video and to review the documentation of the events. In addition, participants will be encouraged to swap tales of their experiences and recount amusing and interesting anecdotal accounts of their learning adventure. The instructor would do well to take note of these interactions in an effort to improve the quality of the learning experience in the coming years.

An Example Engineering Program Outline

A Program for Young Engineers

Designing and building a competitive machine is a challenge that requires participants to extend existing skills and develop new ones. The manipulative skills needed to build competitive machine are gained through practice and understanding is accumulated through experience.

While it may be possible to design and build a competitive machine with little or no prior mechanical experience, it is neither practical nor especially safe. Competitive machine design is an engineering team sport. A caring coach prepares varsity athletes through the development of programs that condition the athletes and provides the players with the skills and knowledge to "play" the game. We call such programs "Practice".

Competetive machine sports require the development of a wide range of skills and knowledge. One way to develop a mechanical sports team is through individual "Practice" with "Electro-Mechanical Bread Boarding kits" like the The GEARS-IDS™ Invention and Design System.

Prototyping machine designs with the GEARS-IDS™ kit is an ideal way to gain a lot of experience in a very short amount of time, while conserving resources. The GEARS-IDS™ kits can be reconfigured hundreds of times and used by dozens of students. This makes them a very attractive and cost effective means of developing engineering skills. Skills that can provide competitive advantages in any of the dozens of mechanical sporting venues currently available.

In addition to working out mechanical design processes, GEARS-IDS™ kit users can integrate and program electronic controls, limit switches and sensors found on competitive and succesful machines.

Procedure: Engineering an Electro-Mechanical Athelete

A game is developed and students are challenged to build a robot-athlete using the The GEARS-IDS™ Invention and Design System. This electro-pneumatic and mechanical bread boarding system is specifically designed to be integrated with real

world parts and equipment. The expectation is that participating teams of students will design and build a sophisticated classroom scale machine capable of effecting a pre-determined game playing strategy.

Overview and Introduction

- Determine and explain student expectations.
- Review past projects
- Explain assignments and program timetable.

Let the Games Begin

Design the game. Challenge students to develop a sophisticated game that can be played by a machine that has these components and minimum capabilities:

Mobility
Moderate Power
Lifting Capabilities
Pushing Capabilities
Grasping and various other pick up strategies
Radio Control
Limited autonomous and semi autonomous functions
Others

Note: Great machine games might require simple or limited capabilites, but the game playing strategy can make the game a demanding strategic challenge. Consider these machine game guidelines when designing a game.

- The game should require machine motion in three axis.
- Create a game that requires offensive and defensive strategies.
- Multiple robots should be in play
- Points can be won or taken away by opposing machines.
- Develop a set of written rules
- Let the students have the lead in game design
- The floor makes an ideal playing field.
- Gaming pieces make games more fun. Create intersting environments for your machines to play in.

Notebook Requirements and Assessment

- Sketches, evidence of hard thinking and communicating
- Chronolgy, respecting the process of design

- Pictorial graphics, because it beats writing thousands of words
- Writing, because we forget quickly, and we want to leave a road map for ourselves and others.
- Solid Models: The primary design tool
- Photographs, because things happen fast in the world of design
- Detailed drawings

Introduce the GEARS-IDS™ kit

- Allowable parts and "rules" are discussed and agreed upon.
- Study the kit of parts, it will help you design a better game, and a better machine to play it.

Visualization Tools

- Learning to use the minds eye
- Sketching: High Tech Hieroglyphics
- 3 View drawing theory
- CAD Basics
- Solid Models
- Drawing from dimensioned prints
- Dial Calipers/Radius gauges and reverse engineerin
- Creating the "Virtual Kit of Parts"
- Blocking and detailing the road map of creation.

The Design Process

- The Five Budgets: Time, Power, Money, Weight, Knowledge
- The Great 8
- Design and the scientific method: Similarities and differences
- Design Journals, Documenting the Journey of Discovery.
- Subassemblies and Integration

Drive Trains and Chassis

- The physics of Mechanical Devices
- Evaluating and testing Batteries

- Evaluating Fixed magnet DC motors
- "Torque-ing" about Wheels Gears and mechanical advantages
- Measuring Robot power

Building a Pneumatic Test Stand

- Pneumatic Safety
- Basic Pneumatic Components and Circuits
- Levers, Wheels and Axles
- Force and Torque
- Work and Power
- Piston Force, Pressure and Flow
- Pressure and Boyle's Law
- Air Storage Capacity and Flow

Configure a Control System

- Radio's Tx/Rx
- Wiring Fundamentals
- Electronic Speed Controllers
- Fixed Magnet Motor Control
- Pulse Width Modulation
- PWM and programs Sensors,

Fabrication Tips and Safety

- Shop Safety
- Tools and techniques for building Robots.
- Best practices for assembling kit parts, mechanisms, wheels, and various fabrication strategies is discussed.
- Mechanical Fasteners, threading and taping.

Design and Animation: Building The Virtual Machine System

- Animation software, powerful tools for the imagination
- Virtual machines and seeing with the minds eye.

The Competition Begins
Referees are trained, the game is prepared and the double elimination tournament ladder is developed.

Napkins, Notebookseb and Web Pages

- The complete story of the machine creation must be told

Grading and assessment

Putting Away the Toys

- Kits are inventoried, organized, cleaned and stored.

Enjoying the Process and Solidifying the Lessons

- If it's important enough to do, then it's important enough to review
- The videos of the matches are reviewed and a "debriefing" session is scheduled.