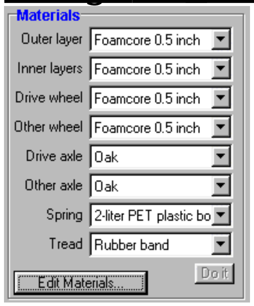
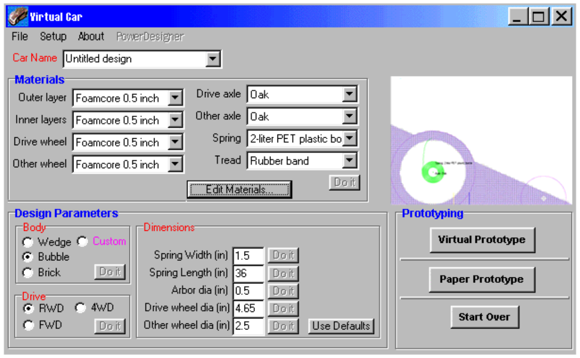
The Virtual Car

Virtual Car adopts the spirit of *virtual prototyping* (designing and testing prototypes in software) and *rapid prototyping* (printing prototypes in 3-D), without the need for advanced training or special equipment. The Virtual Car's body and wind-up spring engine are designed and modeled interactively as a virtual prototype, after which a working model can be generated in rapid prototyping fashion.

Design

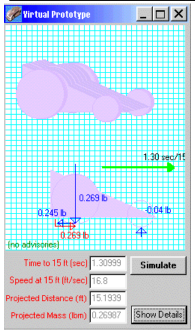


To begin designing a Virtual Car, designers first consider possible construction materials. Foamcore, corrugated cardboard, or similar material may be used for the car body. The wind-up spring that powers the car may be made with plastic material from a soda bottle. Other materials may be defined by measuring their physical properties, such as density and thickness, and entering them into the software.



Designers are then free to generate virtual designs by specifying variations of key design parameters, such as body shape, materials, wheel size, spring dimensions, and type of drive (front, rear, or all-wheel). Virtual Car internally computes resultant quantities such as total mass and center of mass, which would otherwise be difficult to predict.

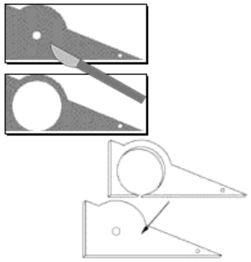
Virtual Prototyping



Each variation of design parameters represents a design alternative that is instantly modeled as a virtual prototype. Designers can immediately see the effect of their choices on key performance metrics such as traction, propulsion, speed, and distance, as predicted by Virtual Car.

Rapid Prototyping

After identifying a virtual design that promises good performance, the designer may print it to an ordinary printer to produce a "paper prototype", a set of parts-cutting templates for layer-by-layer construction of a working model from sheets of the chosen materials. This method ensures that the physical prototype is as faithful as possible to the virtual one.

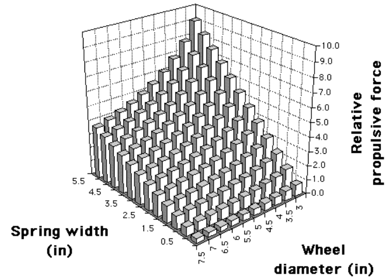


Testing

As construction nears completion, design teams transform into pit crews as they begin troubleshooting the many unanticipated problems that invariably occur when the newly-built car hits the track. Team members cooperatively problem-solve as they brainstorm among themselves to identify the source of the problem (friction, slippage, misassembly) and implement solutions on the fly.

Redesign

After problems of implementation are isolated from problems of design, attention focuses on improving the design. The relatively small number of design parameters allows an instructor to illustrate how the solution space may be explored systematically. For example, a spreadsheet may be used to generate charts such as the one below which expresses the relative propulsive force for various values of wheel diameter and spring width (which determines the available torque). Naturally, practical constraints and tradeoffs prevent one from simply selecting the extremes.



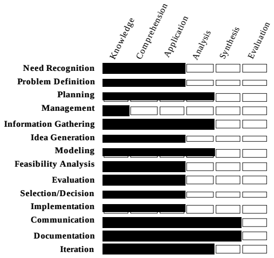
Virtual Car provides features designed to aid the redesign process, such as Power Designer mode, which systematically varies selected design parameters, and Virtual Race mode, in which alternative designs compete in simulated races.

Materials

The following materials and equipment are all that is needed to design and build a Virtual Car:

Material	Application
Foamcore, cardboard	Car body and wheels
Plastic soda bottles	Spring engine
Wooden dowels	Axles
Rubber bands	Wheel treads
Paper glue	Body assembly
Plastic tape	Spring assembly
Paper clips	Spring installation
Equipment	
Hobby knives, scissors, pins Laboratory or postal scale (optional) And, of course, a PC and printer	

Instructional Setting



A Virtual Car project can be tailored to many different levels of learning objectives [1]. For example, when it comes time to select materials, students may simply be provided materials and their physical properties, or be asked to come up with their own choices, procure them, and measure their properties independently. In more advanced settings, the task could be enriched by asking the students to list the functional requirements of each material to help justify their choices.

Many opportunities arise to investigate certain issues in more detail, or to jump off into related topics of design and science. For example, the plastic spring provides a context to discuss the manufacture of soda bottles, the thermosetting properties of PET plastic (useful for heat-treating the spring!) and the functional requirements of soda containers. Here are a few more Virtual Car topics:

Physical Concepts

Weight distribution and center of mass
Summation of moments
Finite methods and effect of element size
Integration

Physical Relationships

F = ma
Traction = Normal force • static friction coeff.
Propulsive force = Torque / wheel radius
Distance = revolutions • wheel circumference

Engineering Design

Design parameters and functional requirements
Objectives and constraints
Information gathering, Experimentation
Idea generation, Modeling
Prototyping and testing
Planning and Management

How to get it

Virtual Car was developed by Mike Safoutin, instructor of Engineering 100 (Introduction to Engineering Design) at the University of Washington. Freshmen in that class use the software as part of a four-week design project, culminating in a final competition. For more information on the Virtual Car project and the quarterly competition, you may visit the class web site at:

http://students.washington.edu/safoutin/engr100/

or email the instructor at:

ms@u.washington.edu

Instructors and others are encouraged to try Virtual Car in other settings and provide the author with feedback. The latest version may be downloaded from the course web page. Car assembly instructions and teaching materials may also be found there. Virtual Car runs on any PC running a 32-bit Windows operating system (95/98/2000/NT or later). A minimum screen resolution of 800 x 600 is recommended.

Please be aware that the construction phase involves the use of sharp knives, so this activity should be supervised and may not be suitable for young children.

Research opportunity

Virtual Car is also part of a design research project. In the future there may be opportunities for groups or individuals to use Virtual Car as subjects in this research. Please contact the author if you wish to participate or can provide an experimental setting.

Reference:

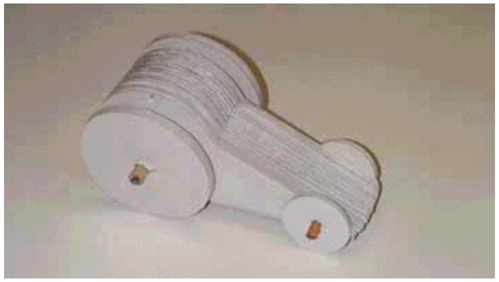
[1] Safoutin, M. J., Atman, C. J., et. al., "A Design Attribute Framework for Course Planning and Learning Assessment", IEEE Transactions on Education, May 2000.

VIRTUAL CAR

Virtual Prototyping and Rapid Prototyping in the Classroom

Virtual Car is a free, easy-to-use instructional software package for learning and teaching engineering design. Developed for education and research at the University of Washington, it allows students at almost any level to design and build spring-powered toy cars that follow physical laws modeled by the software.

Virtual Car provides a fun and engaging hands-on activity that stimulates team problem solving, provides a physical context for related lessons in physics and mathematics, and highlights key concepts of modern engineering design.



A Virtual Car can be designed and constructed in one or two hours using inexpensive, readily available materials. This means that Virtual Car can provide the basis for anything from a one-day activity to a multi-week project involving multiple prototypes and competitions.

Virtual Car is currently used in a four-week freshman design project in ENGR 100 (Introduction to Engineering Design) at the University of Washington.