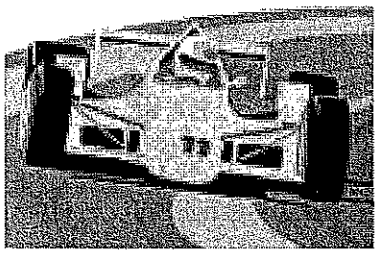
Activity 1

Race Car Design Basics Fact Sheet

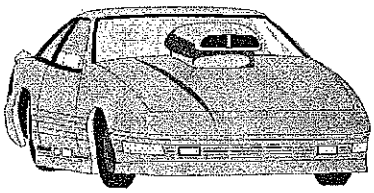
You may have heard engineers, designers, race drivers, or crew chiefs use the term R & D. What does it mean? R & D is short for "research and development" or "research and design:" how race cars and ther vehicles are designed, engineered, developed, and tested. From NASCAR stock cars, open-wheel formula and "Indy" cars, to sports cars and dragsters, these race cars represent the pinnacle of automotive technology.



Participating competitively in any type of motorsports requires dedicated teamwork, incorporating the latest in technology, engineering, and of course, lots of R & D. Much of what is learned by racing teams is transferred directly to passenger car production. Drag racing, which actually started on the streets, was born in California in the early 1950's. **Dragsters** are specially-built, high-horsepower race cars that race two at a time, side-by-side on a straight, 1/4-mile flat track.

There are many classes of dragsters depending on the body style, engine type, fuel, weight, and so on. Currently, "Top Fuel" and "Funny Car" dragsters are the fastest classes in professional drag racing.

They are powered by custom-built, largedisplacement, mega-horsepower, V-8 engines running on alcohol, nitromethane, or high-octane racing gasoline. The model dragster that you design and build in this module is patterned after the Top Fuel class (also known as a "rail," "fueler," or "slingshot" dragster). Professional Top Fuel dragsters accelerate at an extreme **velocity** (distance traveled divided by elapsed time). These machines travel from a standing start to over 300 miles per hour in an elapsed time (e.t.) of less than 5 seconds. For dragsters to achieve this kind of speed and time, they require thousands of horsepower, light weight, efficient aerodynamic design, and the proper lubricants to reduce friction.



Engines are usually rated in horsepower and torque. **Horsepower** is a unit of power in the U. S. Customary measuring system that equals 746 watts or 33,000 foot-pounds per minute. **Torque** is a twisting or turning force measured in foot-pounds. Your model dragster is powered by a carbon dioxide (CO_2) gas cartridge. When the tip of the cartridge is punctured by the race track starting gate, the CO_2 gas escapes through the hole causing thrust similar to a jet engine. This thrust causes the car to move forward until the gas is totally expelled.

Activity 1

Aerodynamics refers to the interaction of a vehicle or aircraft moving through the atmosphere; or how the wind flows over, under, and around the vehicle (see **Figure 1-A**).

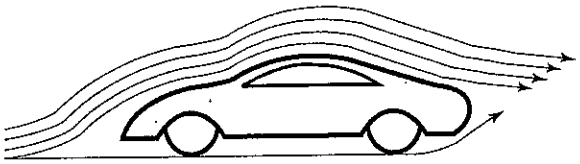


Figure 1-A. Aerodynamics

This is usually expressed as a "coefficient of drag" number; the lower the number the more aerodynamic the vehicle. An automobile, especially a race car, requires efficient aerodynamic design to "cut" cleanly through the air, reducing wind drag. Race cars have to be designed in a wind tunnel for optimum performance, running on a track by themselves and with other cars around them. By reducing drag, fuel mileage and performance are increased, while wind noise is decreased. This means that your model dragster should be designed and constructed with smooth, flowing surfaces. **Turbulence** is the disruption of smooth air flow around a vehicle. A sound aerodynamic design should strive to reduce turbulence. In addition, **base drag** is the turbulence caused by air passing around and behind a car. Engineers have found that if the rear corners of a boat or car are cut no more than about 15 degrees, that the air flowing around the rear of the vehicle can actually push the vehicle instead of causing drag. This concept is known as **boattailing.** (See **Figure 1-B**.)

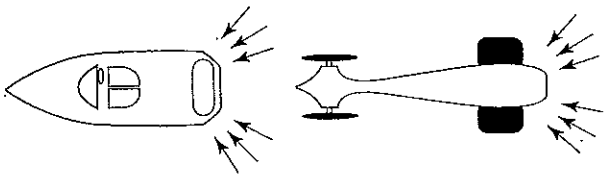
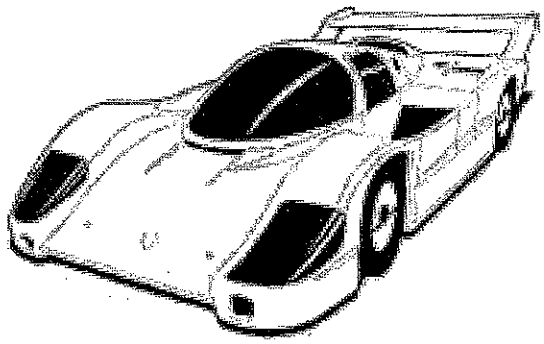


Figure 1-B. Boattailing

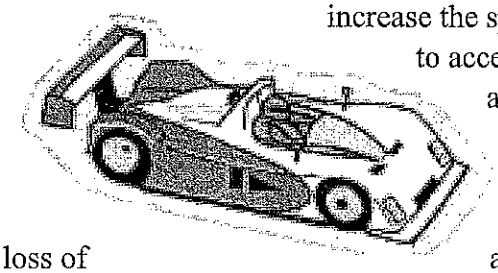
Because of their high speeds, race cars also have to generate and manage **downforce**. Downforce uses airflow to keep the car on the ground, preventing it from becoming airborne. Race cars also use downforce to increase tire traction especially while cornering at high speeds. Dragsters, which do not have to worry about high cornering speeds, need downforce to press down on the rear tires, creating traction when they launch off the starting line. Wings, spoilers, and air dams seen on both street cars and race cars are used to manage the airflow over and under the vehicle.

Frontal area is a term used to describe the size and arrangement of an automobile's front end. The larger the frontal area and the higher the car is off the ground, the more aerodynamics and handling suffer. To reduce frontal area, race cars are designed flat, narrow, and low to the ground.



Activity 1

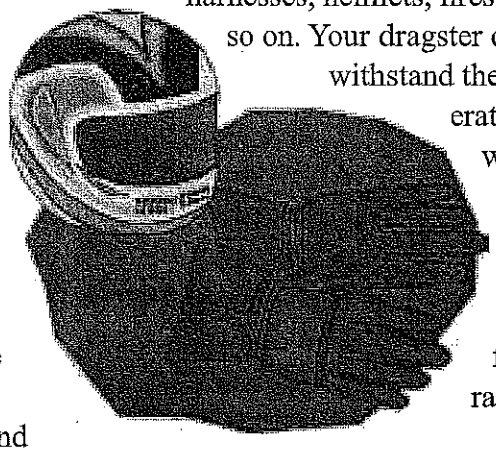
Friction, simply stated, is the rubbing of one object or surface against another; a force that resists the relative motion of two bodies in contact. Tire friction is created between a car's tires and the road surface. In addition, friction between engine and transmission components can cause a loss of horsepower and speed in automobiles. **Lubricants** such as oil, grease, and graphite are used in automotive powertrains to reduce friction between moving parts. This makes the parts smooth and slippery, which helps them operate easily without heat buildup. There are both petroleum-based, synthetic, and blended lubricants available on the market.



The **mass** of an object relates to the volume or bulk that the object contains. The mass of a vehicle is not dependent on gravity; therefore, it is different from, but proportional to its weight. Race cars, as well as passenger cars, benefit from lightweight construction. The use of aluminum, magnesium, titanium, plastics, carbon fiber, and other lightweight materials lower the weight of the vehicle, increasing acceleration and saving fuel. **Force** is pushing or pulling on an object. If all the forces on an object are equal and opposite, the object will not accelerate. If the forces are not equal and opposite, the object will accelerate in the direction of the greatest force. The physicist Isaac Newton developed an equation to describe the relationship of a car's weight to the force required to accelerate it: F=M x A (Force = Mass x Acceleration). Since the force of your dragster (CO_2 cartridge) cannot be changed, you can only reduce the mass (weight) to increase the speed. For your model dragster to accelerate quickly, you need to think about lightweight design and construction.

Finally, **strength** and **safety** are two very important factors to consider when designing a race car. Composite materials such as carbon fiber are being used in the manufacture of seating, chassis components, bodywork, and so on because of their superior strength and light weight.

Have you ever wondered why it is common for a driver to walk away from a 200 miles-per-hour crash? The safety of the driver is the primary reason race cars include roll cages and safety cells, fuel cells, crumple zones, safety harnesses, helmets, firesuits, restraints, and so on. Your dragster design must withstand the forces of acceleration and stopping without falling apart. A lightweight, aerodynamic car that is weak and is destroyed on its first run cannot be raced anymore.

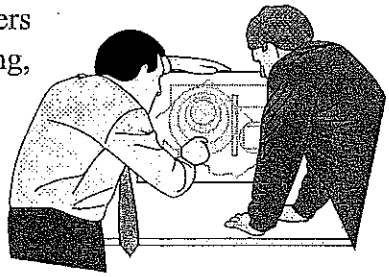


You should consider all these factors when designing your dragster. You must strike a balance between aesthetics (how the car looks), weight, aerodynamics, and strength.

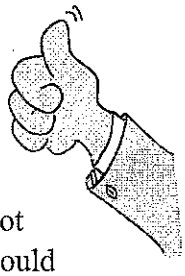
Activity 2

The Design Process Fact Sheet

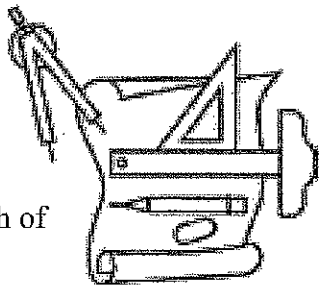
Design, the planned process of change, is another word for planning and creating a product or system such as an automobile. Many years of research, planning, testing, and development go into each new automobile design. Designers are responsible for choosing the proper information, materials, processes, and resources necessary for the creation of a product. There are several basic steps that most engineers use when planning, creating, and developing a design. Using these steps, the design can be examined and any changes made on paper (or computer) before going to the expense of manufacturing. This is called the **design process**, which can sometimes cost more than producing the actual product. Creating solutions to problems involves the design process. The five basic design processes for designing your model wood dragster are described below.



- **Thumbnail Sketches** – "Thumbnails" are small drawings that help you develop your design ideas on paper. These sketches do not have very much detail, and should show the basic shape of your car from different views.



- **Rough Sketch** – A rough sketch is a freehand drawing that is a larger and more detailed sketch of one of your thumbnail sketches. The rough sketch shows how your dragster will look from the top and side.



- **Technical Drawing** – A technical drawing is a detailed drawing of your rough sketch drawn to scale. This measured drawing will be the same size and shape as your finished dragster. You use the finished drawing as a pattern to transfer your design to the dragster wood body blank included in the kit you receive later.

- **Prototype** – Upon completion of the technical drawing, a scale model is usually constructed of foam or clay. A prototype is used to test and further develop a design. If problems are discovered with a prototype, the original design can be changed before production.

- **Production** – After the prototype is researched, tested, and developed, production of the product (dragster) begins. You are going to construct only one dragster. This custom dragster is also known as a "one-off" car; meaning only one car is produced. However, most cars are mass-produced on an assembly line.

Activity 2

Your main task is to design and construct a CO_2-powered, wood model dragster working from a Design Brief. You refer to this **Design Brief** as you complete this task. A Design Brief is a guide that leads an engineer or designer through a design project. There are several components of a design brief.

- **Problem** – helps the engineer or designer state the description of the project or identify the problem that must be solved
- **Specifications** – the specific requirements of the design; provides the guidelines of the project
- **Limitations** – rules that must be followed to let the designer know exactly what boundaries they must work within
- **Testing and evaluation** – specific procedures of how the completed design will be tested and evaluated

The better you know and understand the specifications and limitations, the better your dragster design will be. The basic dragster shape is somewhat limited by the general shape of the wood body blank and the location of the CO_2 cartridge hole. It requires a design with a small front end and a large rear end. Although there are thousands of dragster designs, there are three basic design shapes that can be identified: bullet, wedge, and skeleton. (see **Figure 2-A**).

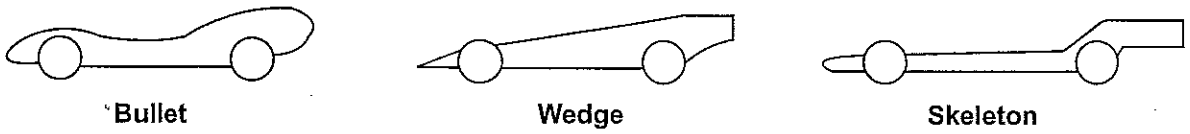


Figure 2-A. Basic Design Shapes

The bullet design is a very strong shape that causes little turbulence. It is easily boattailed. The main disadvantage of this design is its high weight. However, the weight can be reduced by hollowing out the body and placing the wheels inside the body, reducing weight and improving aerodynamics. The wedge design is also a very strong shape. It is an easily boattailed, medium weight design causing very little turbulence if properly designed. This shape can blend into a skeleton design. The skeleton design is a very light car, but can be weak in structure. This design with its exposed wheels produces a lot of turbulence and friction. The wood holding the CO_2 cartridge would need to have a bullet shape in front and boattailed in the back.

Each design has its own strengths and weaknesses. Probably the best shape is one which combines a bit of each major design. Finally, the design specifications concerning length, width, height, weight, and so on, must be observed.