**Newton's Laws and Balloon Race Cars Explained**

**Newton’s First Law of Motion**

"Objects at rest will stay at rest and objects in motion will stay in motion in a straight line unless acted upon by an unbalanced force." In other words, the forces pushing a rocket up must be stronger than the force of gravity pulling it down.

**Newton's Second Law of Motion**

Newton’s second law of motion states that the net force on an object is equal to the product of its acceleration and its mass (F=ma). Net force is the overall force on an object after all the forces are added together, acceleration is the rate at which velocity changes and mass is the amount of matter in an object. A greater mass is equivalent to less acceleration and vice versa. Also, a greater acceleration is equivalent to a greater force and vice versa. Therefore, a car with a less mass is more likely to have a greater acceleration when the balloon is released which causes the balloon to give the car more force as it continues forward. Disregarding all other causes of the movement and impediments of the car and solely based off of this fact, it may be said that a car with less mass is more likely to travel further than a car with greater mass.

**Newton's Third Law of Motion**

For every action, there is an equal but opposite reaction. This means that, for every force pushing on an object, there is an equal but opposite force pushing back. The balloon pushes the air in one direction, and the air pushes back on the balloon to make it go in the other direction. A rocket works by pushing gases out one end very quickly, which results in a large force that pushes the rocket in the other direction. If the gases are pushed out faster, this will produce more force to push the rocket.

The rocket racer is an excellent demonstration of Newton’s third law of motion. Air is compressed inside a balloon that is expanded. When the nozzle is released, the balloon returns to its original deflated size by propelling the air out its nozzle. The straw mounted to the balloon extends the nozzle beyond the rear end of the car. The action force of the expelling air produces a reaction force that pushes the racer in the opposite direction. The racer’s wheels reduce friction with the floor, and the racer takes off down the race course.

***Mass***

A lighter mass will speed up more quickly than a heavier mass if the same force is applied. A lighter rocket will speed up more quickly and will also be easier to launch because it will have less gravity acting on it. A good example of the effect of mass is to think of a light person and a heavy person sitting on two swings. If each person is given the same size push, the lighter person will speed up more quickly. A light balloon car will speed up more quickly.

***Force***

A larger force will cause an object to speed up more. For a balloon car, it is good to use a fresh balloon each time and blow it up well. To maximize the forward force, friction from the wheels (and perhaps from air resistance) also needs to be minimized.

***Momentum***

Once the car is moving, it will keep moving because of its momentum, even though the balloon is deflated. Momentum is equal to mass multiplied by velocity (p=mv). Newton’s first law states that an object at rest will tend to remain at rest and that an object that is moving will tend to keep moving at a constant speed in a straight line until an external force acts on it.

***Friction***

The car will slow down and stop due to the opposing force of friction. There are two kinds of friction: air resistance and the friction as the surfaces of the axle, body of the car, wheels and ground move past each other. Ideas of streamlining and designing good axles and wheels are intended to reduce friction. In this challenge, minimizing friction caused by surfaces rubbing together is more important than streamlining.

Although the rocket racer seems simple, there are many challenging complexities in its operation. In principle (Newton’s second law of motion), the less mass the car has, the greater its acceleration will be. Generally, heavy rocket racers do less well than lighter racers. However, very small racers are limited by other factors. Vehicles with short wheel bases tend to circle or partially lift off the floor. Balance becomes a problem. The mass of the balloon may cause the car to tilt nose down to the floor, causing a poor start.

The engineering design of the racer is very important. Many designs are possible, including wide, narrow, and I-beam shaped bodies and three, four, or even six wheels. Students have to review the trade-offs of their design. For example, an extra-long body may provide a straighter path, but the car might travel a shorter distance as a result.

**What do you think?**

***Would it be a good idea for automobiles to be powered by rocket engines?*** If there was only one rocket powered automobile on the road, it would work fine. However, imagine rush hour traffic loaded with rocket cars. Each would blow exhaust gas at the vehicles to the rear.

***How are the wheels on a rocket racer similar to and different from wheels on a regular automobile?*** Rocket racer wheels reduce friction with the ground. They turn when the air coming from the balloon exerts a thrust. Wheels for an automobile also permit the car to roll across the ground, but the thrust of an automobile depends upon friction. The engine turns the wheels, and friction with the rubber and the pavement transmits the action force so that the car rolls forward.