SHEET TWELVE - CHARGER FORCE

There are two types of force that will affect your design – positive forces and negative forces. Positive forces accelerate (or push) the dragster off the starting line. Negative forces decelerate (or pull) the dragster away from the finish line. The charger force is a positive force, while surface friction and drag are negative forces.

If you push your dragster forward, you are applying a positive force to the vehicle. Likewise, when charger force acts on a dragster, it causes it to move. The force causes the car to increase velocity or accelerate.

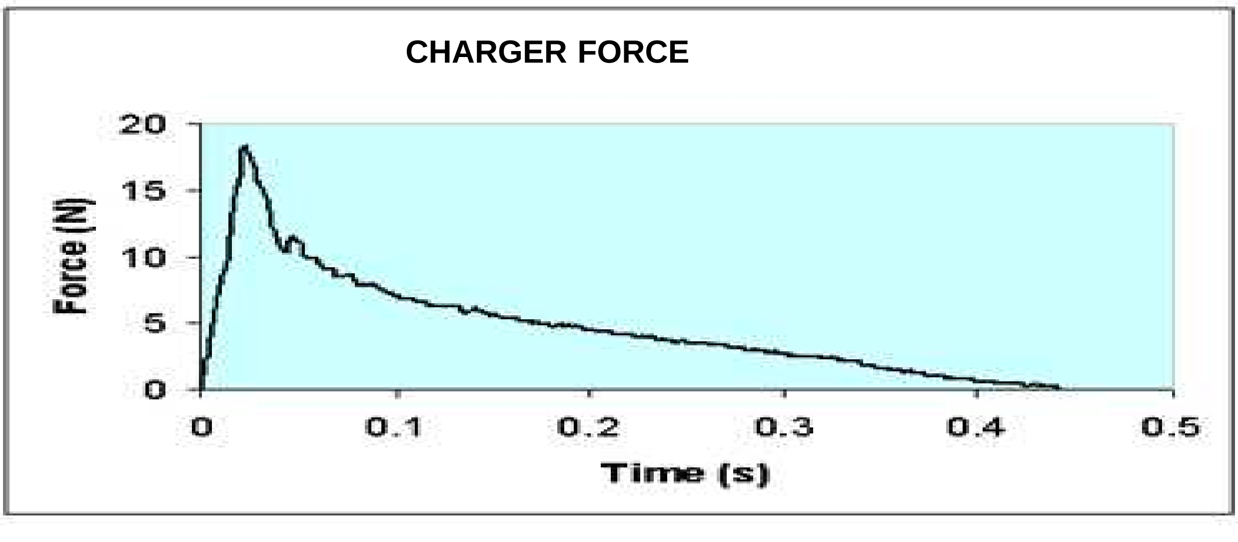
Remember Newton's law:

$$F = \frac{m}{a}$$

Math shows the relationship of variables. This equation tells us that there is a direct relationship between the variables force (F) and acceleration (a). Assuming mass does not change, if the force (*F*) applied to an object increases, then the object will accelerate (*a*). Conversely, if the applied force is negative, then the object will decelerate.

For all the dragsters in the challenge, a CO_2 charger provides the force to move the vehicle forward. The chargers contain a large volume of carbon dioxide gas under extreme pressure. The firing pin on the start gate makes a hole in the nozzle so the pressurized CO2 gas escapes producing thrust or force.

How much force does the CO_2 charger produce when fired? The Charger Force graph below shows the connected to a computer. Data was sampled every .001 seconds. As you can see from the graph, the



escaping gas produces the maximum force in less than 0.05 seconds. Force then ramps off gradually until the charger is empty in about 0.45 seconds. The maximum force is 18.3 N (Newtons), with an average of 4.67 N.

Dragsters will accelerate until force stops. So we can assume from the test that a typical dragster will accelerate for about 0.45 seconds. At this point, maximum velocity is reached. How fast would the dragster be going at this point? If we assume an average force of 4.67N, we can use Newton's law to calculate maximum speed. This can be done by replacing acceleration with velocity divided by time, a = v / t.

$$F = m\,a = m\left(\frac{v}{t}\right)$$

We can use rules of algebra to solving for velocity,

$$V = \frac{F\,t}{m}$$

The average mass of a CO_2 dragster is about 50 grams, but we also need to include the mass of the charger - about 25 grams empty. So our total mass is 75 grams, or 0.075 kilograms. If force (F) equals 4.67 Newtons and time (t) equals 0.45 seconds, then the maximum velocity in meters per second is calculated as follows.

$$V_{\max} = \frac{4.47 \times 0.45}{0.075} = 28.02 \text{ m/s}$$

If we convert 28 metres per second to kilometres per hour, the top speed is 100.8 kph. This equates to an average acceleration of 139 mi/hr/s!

Unfortunately, dragsters do not cross the finish line at 100 kph. There are resistive forces working to slow the vehicle.

SEE SHEET THIRTEEN – RESISTIVE FORCE