SHEET ELEVEN – NEWTON AND ACCELERATION

What makes a CO_2 dragster go fast? If you want to design the best dragster, you need to know what design factors make CO_2 cars perform. Knowing how these factors or system components improve or hinder performance leads to good design decisions.

Given a design problem, there are some things that can be changed and some things that cannot be changed. The things that can be changed are called ***variables***. Those factors that cannot be change are called ***constants***. Mathematical equations define the relationship between variables and constants. Understanding these relationships, and recognizing when they apply to real world design problems, is the key to good design decisions.

Get Moving Fast!

The goal is to move your dragster down the track as quickly as possible.

Sir Isaac Newton (the dude on the right) defines the problem. His second law of motion states:

The acceleration of an object of constant mass is proportional to the force acting upon it.

In mathematical form, the relationship of force, mass and acceleration is defined as:

$$\text{Force } (F) = \text{mass } (m) \times \text{acceleration } (a)$$

To go fast, acceleration is the key. The faster the car accelerates the greater the speed. What does Newton's law tell us about acceleration? We can use algebra to change the force equation to solve for acceleration.

Given

$$F = m\,a$$

To solve for acceleration (a) divide both sides by mass (m)

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

Therefore

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

This equation shows how to increase acceleration. An increase in force (F) will increase acceleration. Acceleration will also increase by decreasing mass (m).

To better understand Newton's law and how it applies to improving your design, you need to understand the variables—acceleration, mass and force.

Acceleration

Acceleration is related to velocity, but they are not the same. First, let's takes a look at velocity.

Velocity is equal to distance travelled over time.

$$\text{velocity}\,(v) = \frac{\text{distance}\,(d)}{\text{time}\,(t)}$$

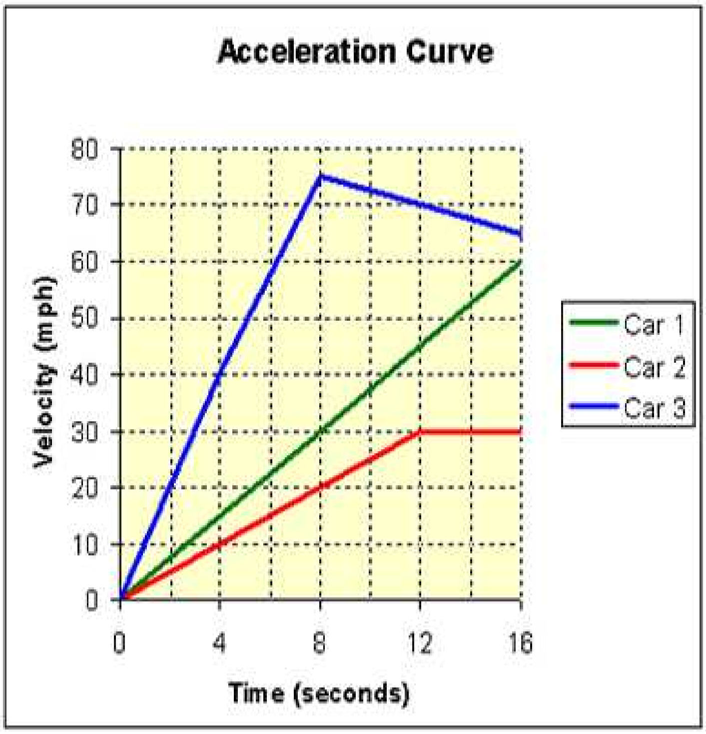
Miles per hour (mph) is a common measure of velocity. It is the distance travelled (miles) over time (hours). If you were driving at a constant velocity of 60 miles per hour (mph), in one hour you would have travelled 60 miles.

Acceleration is a change in velocity (*v*) over time (*t*).

$$a = \frac{(v_2 - v_1)}{(t_2 - t_1)}$$

A typical sedan can accelerate from 0 to 60 mph in 16 seconds. Therefore

$$a = \frac{(60 - 0)}{(16 - 0)} = 3.75\ mi/hr/s$$



An acceleration curve is a graph of velocity versus time. In the graph on the left, we see that "Car 1" represents our typical sedan. Since acceleration is the change in velocity over the change in time, the slope of the line represents acceleration. In the case of our typical sedan, we have a straight line from t = 0 seconds to t = 16 seconds, so we can pick any two data points from the graph and find that acceleration is 3.75 mph every second. For "Car 2" we can see that there is constant acceleration between t = 0 seconds and t = 12 seconds. At 12 seconds, acceleration is 0 mph per second.

Can you see why?

Use this graph above to answer the questions that follow...

1) Which of the three cars in the graph above accelerates most rapidly between 0 and 8 seconds?

(A) Car 1

(B) Car 2

(C) Car 3

(D) Car 1 and 2

2) Which of the following statements best describes Car 3's motion between t=8 seconds and t=16 seconds?

(A) The car is accelerating

(B) The car’s acceleration is zero

(C) The car is slowing down

(D) The car is stopped

3) If car 1 continues to accelerate at 3.75 mph/s, how fast would it be going at t=20s?

(A) 60 mph

(B) 15 mph

(C) 70 mph

(D) 75 mph