Chapter 1

The Physics of Traffic Crash Reconstruction

The purpose of chapter 1 is to summarize the physical principles of mechanics required to perform automobile crash reconstruction, including an introduction to rotational motion. Mechanics, the field of applied physics that is utilized in vehicular crash reconstruction, is roughly divided into two broad categories: Kinematics and Kinetics. <u>Kinematics</u> is the study of motion without regard for the force required. An example of kinematics would be the position and motion of a vehicle as a function of time, where the solution is found assuming constant acceleration throughout the motion. <u>Kinetics</u> is the study of the motion of an object when subjected to a force or, for a given motion, the force required to produce that motion. Before delving into the specificities of mechanics, certain fundamentals are pre-requisite.

Quantities can be grouped into scalars or vectors, both of which are useful in the study of traffic crash reconstruction. A scalar is a quantity that has only magnitude. A vector is a quantity that has both magnitude and direction. An example of a scalar would be the speed of an automobile expressed as 60 miles per hour (mph). An example of a vector would be the velocity of that same automobile traveling at a rate of 60 mph, **due east**.

The coordinate system used follows the system used in the development of CRASH 3 and SMAC and followed in the PC versions of EDCRASH™ and EDSMAC™, as shown in Figure 1-1.

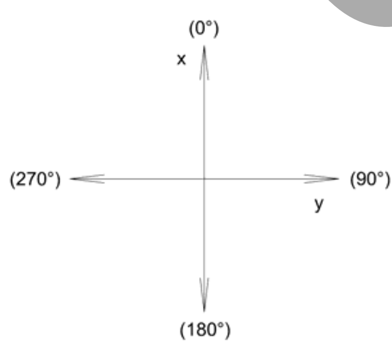

Figure 1-1

Note: The angle corresponds with directions on a compass; the x-axis corresponds with due north.

Kinematics

Kinematics may be roughly divided into linear and rotational motions. Most automobile crashes are primarily linear in nature. However, some automobile crashes may have an additional rotational motion component. For linear motion, most automobile reconstruction formulae assume constant acceleration; that is, the acceleration is assumed to be constant throughout the motion. Even when the acceleration is not constant, the same approach may be used by assuming an average (and therefore constant) value of acceleration over the entire motion.

Linear Motion

The constant or average acceleration over a period of time (Δt) is given by the following:

$$a = \frac{V_2 - V_1}{\Delta t} \quad \text{(Equation 1-1)}$$

Other useful formulae, assuming constant acceleration, are given by the following:

$$V_2 = V_1 + at \quad \text{(Equation 1-2)}$$

$$V_2 = \sqrt{V_1^2 + 2as} \quad \text{(Equation 1-3)}$$

$$s = V_1 t + \frac{1}{2}at^2 \quad \text{(Equation 1-4)}$$

$$s = \frac{V_2^2 - V_1^2}{2a} \quad \text{(Equation 1-5)}$$

$$V_2 = \sqrt{2as} \quad \text{(Equation 1-6)}$$

Where:

s = distance along the path of the center of gravity (ft)

V = linear velocity at the center of gravity (ft/s)

t = time (s)

Δt = change in time (s)

a = linear acceleration of the center of gravity (ft/s^2)

g = acceleration of gravity (32.2 ft/s^2)

Included are the following subscripts:

1 = initial value (subscript)

2 = final value (subscript)

The deceleration factor (or drag factor, f_{lin}) is commonly used in traffic crash reconstruction to describe acceleration (or deceleration in the case of braking). Deceleration is a negative acceleration, that is, the acceleration is in the opposite direction to the vehicle's velocity. By definition, the deceleration (drag) factor is the absolute value of the ratio of the acceleration (or deceleration) to the acceleration of gravity.

Mathematically,

$$f_{lin} = \frac{a}{g} \quad \text{(Equation 1-7)}$$

Where:

f_{lin} = the linear deceleration (drag) factor

a = linear acceleration or deceleration (ft/s)

g = acceleration of gravity (32.2 ft/s)

Note: f_{lin} is dimensionless and is the acceleration (or deceleration) as a multiple of the acceleration of gravity, referred to as "*g*'s".

Combining Equations 1-6 and 1-7 results in the following:

$$V = \sqrt{2gf_{lin}s} \quad \text{(Equation 1-8)}$$

Where:

f_{lin} = the linear deceleration coefficient

g = acceleration of gravity (32.2 ft/s)

s = distance along the path of the center of gravity (ft)

V = linear velocity at the center of gravity (ft/s)