A tool or method available to a reconstructionist which I haven't previously addressed in a newsletter is rotational mechanics. Although this newsletter doesn't have the space for me to give any of the documentation or derive the various formulas and methods, application of rotational mechanics can be very helpful in evaluating the impact speed of a motorcycle in a broadside impact with a car or light truck when the impact vector has a significantly offset alignment with a vector passing through the heavier vehicle's center of mass.

The concept of rotational mechanics begins with some basics of circular motion. In linear momentum, we use linear speeds and the orientations of the velocity vectors. In basic circular motion, we evaluate the angular velocity and acceleration in terms of the instantaneous linear velocity and the radius of curvature of the path. Angular momentum is analogous to linear momentum, but the terms may seem foreign: in linear momentum, we use a vehicle's mass and consider the location of the center of mass of the object as well as the linear velocity and the orientation of the pre-impact and separation velocity vectors, but in angular momentum we use angular velocity and a quantity called the moment of inertia. Just as a body's mass is a measure of its resistance to changes in linear motion, the moment of inertia is a measure of a body's resistance to changes in angular (rotational) motion. The circular analogy to center of mass is the radius of gyration, which is defined as the radius at which all the mass of a given body could be concentrated to produce an equivalent moment of inertia. These concepts are difficult to grasp—we can measure the mass of an object (or its proportional weight) directly and easily on a scale, and we can usually determine its center of mass relatively easily, if we need that bit of information. Properties like moment of inertia and radius of gyration do not lend themselves to ready observation or easy calculation like the mass of an object or the location of its center of mass. But they are just as real and just as useful in some situations.

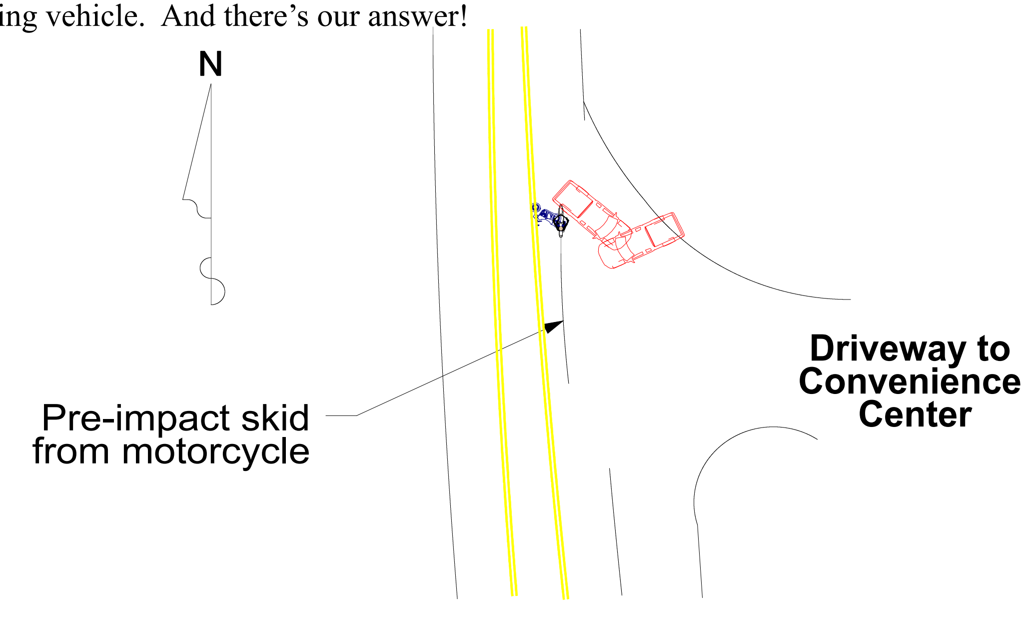
Torque is another concept related to circular motion. Many of you have heard of an engine's torque or of using a torque wrench to tighten a bolt to a certain level. Torque is simply defined as a twisting or turning (rotational) motion; in the United States, it is usually expressed in foot-pounds, although some sources use pound-feet. (Work is also defined in foot-pounds.) A linear force of 50 pounds perpendicularly applied to a two-foot-long lever arm will produce a torque of 100 foot-pounds. It is engine torque, not horsepower, that causes or allows a vehicle to accelerate; brake torque causes it to decelerate. Gasoline engines typically have low levels of torque delivery at low rotational speeds, increasing to some peak level of torque at some higher speed (3800 rpm or 4500 rpm or whatever, depending on many factors of engine design). Electric motors, however, deliver maximum torque as soon as current flows; that is why electric cars and hybrids with electric motors typically accelerate more quickly from a stop than similar vehicles propelled only by a gasoline engine.

Power is the time rate of doing work. Electric power is often expressed in watts or kilowatts; engine power is often expressed in terms of horsepower. One horsepower is defined as 550 foot-pounds per second. One horsepower is equal to 746 watts, or 0.746 kilowatt.

Angular momentum is conserved, just like linear momentum. Perhaps all of you have seen a figure skater go from spinning very rapidly to spinning much more slowly, or vice versa. They do that by changing their moment of inertia—they bring mass close to the center, causing them to spin faster, or they move mass away from the center, causing them to spin slower. The angular momentum stays the same; as the moment of inertia changes, the angular velocity must change to maintain the same level of angular momentum..

Another concept that must be applied to rotational mechanics to evaluate an eccentric impact (i.e., one in which the velocity vector is not aligned through or near the center of mass of the struck vehicle) is the parallel axis theorem. When an eccentric collision occurs, the struck vehicle usually rotates about a point which is (roughly) on or near the axle farthest from the impact point on the vehicle. The parallel axis theorem allows us to determine the effective moment of inertia about some point other than that value as applied to the entire body in rotation about its center of mass, which is how inertial properties for cars and light trucks are generally specified or defined.

When we have crash data, we can calculate the torque necessary to cause the sliding axle to rotate around the other axle as the product of the vehicle's wheelbase times the load on the sliding axle times the drag factor, similar to relating work done during skidding to the skid distance and drag factor. Once we have calculated the torque, we can calculate the induced initial angular velocity of the struck vehicle by considering the applied torque, the angle of rotation of the struck vehicle, and the shift in the effective moment of inertia with respect to the other axle (using the parallel axis theorem). Once we have calculated that value, we can determine the linear speed of the striking vehicle (or the component perpendicular to the longitudinal axis of the struck vehicle) by again considering the effective moment of inertia of the struck vehicle, its initial angular velocity acquired as a result of the collision, the distance from the axis of rotation to the point of impact on the side of the struck vehicle (measured parallel to its longitudinal axis), and the mass of the striking vehicle. And there's our answer!



The diagram on the previous page is from an active case in which I applied rotational mechanics to calculate the impact speed (and, ultimately, the pre-skid speed) of the motorcycle. In this case, the involved vehicles were long gone, the skid mark was no longer visible but had been measured by investigating police officers who had taken numerous photographs of final positions and other site details before vehicles were moved from their final positions, and the details of the driveway on which the pickup truck came to rest had not changed between the date of the collision and the date of my examination of the scene. Because it is an active case, I will not provide any more particulars in this newsletter; I am including this diagram to show the fundamental elements one needs to begin a speed analysis by applying principles of rotational mechanics. I hope this text was not confusing; I have tried to explain these concepts as simply as I can. Angular momentum and rotational mechanics are foreign concepts to many people, but they can be very useful to a reconstructionist.

Bosch has released version 5.0 of the Crash Data Retrieval (CDR) software. This version also has two new cables to accompany the software release: one for Honda, one for Ford. Version 5.0 includes the first coverage for any Honda vehicles; covered are the 2012 Honda CR-V and the 2012 Acura RDX. There is a virtual certainty that more vehicles of Honda manufacture will be included in future releases. Also newly included in version 5.0 are a collection of 2013 Ford vehicles and virtually every 2013 product of General Motors. It is my understanding that Bosch is currently in talks with Mazda regarding incorporation of their product line into the expanding group of vehicles whose event data recorders can be accessed and imaged with the Bosch CDR Toolkit. Model year 2013 is the demarcation point at which Federal regulations require that all manufacturers of cars and light trucks whose airbag control modules record any crash data record a specified minimum set of data and that the data be accessible with software and hardware available to consumers; the manufacturers actually have up to six months after release of the model year to be in compliance. The next twelve months should see some interesting developments in the world of crash data retrieval.

I was recently asked to reconstruct a collision which involved a sideswipe between the front fenders and front wheels of two vehicles. There had been no pre-impact skidding. There was no post-impact skidding, although there was a post-impact yaw mark made by the right front tire of one of the vehicles. There was no documentation concerning the final position or orientation of either vehicle. No on-site photographs had been taken. Because of the location of contact between the vehicles and because of the lack of any data concerning trajectories or final positions, there were no data elements to support either an energy-based or momentum-based reconstruction. However, one of the vehicles had an airbag control module (ACM) which recorded five seconds of pre-crash data; extraction and analysis of that data provided the client with enough information to make decisions regarding the handling of the matter. The majority of vehicles now on the road do not have data recording capabilities in their ACMs, but, with passing time, that will change. Please call if you need CDR or any of the other services I offer.

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