FORCON INTERNATIONAL

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AMUSEMENT PARK RIDE ACCIDENTS

Amusement park rides were in the news a lot this past summer. There were a number of unfortunate accidents where park patrons were killed while riding different types of thrill rides at large amusement parks. FORCON was called upon to investigate one of these accidents.

According to information from the U.S. Consumer Products Safety Commission, amusement park rides claimed 43 lives in 23 states between 1987 and June 30, 1999. They also report that thousands of others were injured. When you consider the number of amusement parks, the number of rides within those parks, and the number of riders, these are not staggering numbers. Amusement ride manufacturers work very hard to make sure their rides are safe. Operators of large amusement parks are also very diligent about the proper maintenance and operation of the rides in their parks. Many states require regular inspections of amusement park rides by certified inspectors.

In spite of all these precautions, accidents happen. FORCON is in the business of investigating accidents on behalf of insurers and self-insured businesses. As such, we have put together a team of specially qualified experts to assist our clients who insure or operate amusement parks. The team is comprised of Dave Peters, Ph.D., P.E., and Walt Laird, P.E.

Dave specializes in dynamics, the motion of bodies and the forces which act on those bodies as a result of that motion. Walt has worked on the engineering staffs at several large amusement parks and is in the final stages of becoming a certified amusement ride inspector in Virginia. Each of them has prepared an article for this newsletter focusing on their individual perspective and knowledge of amusement park ride accidents. We hope that you find them interesting even if you aren't involved with claims associated with these types of accidents.

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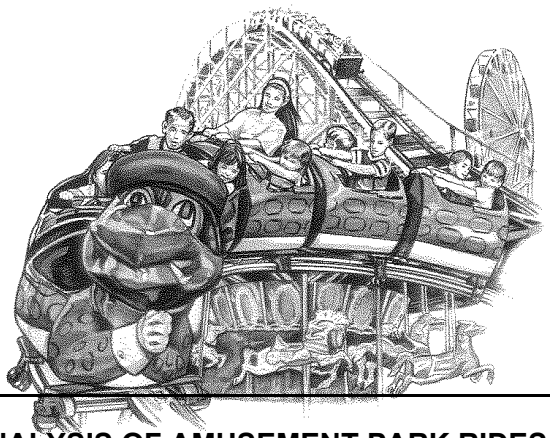

ANALYSIS OF AMUSEMENT PARK RIDES

By David A. Peters, P.E., Ph.D.

Whenever people are passengers in a moving vehicle, they can be tossed and moved within that vehicle due to its motions. For example, when you step on the gas in your car, you feel thrown backward against the seat. When you step on the brake, you feel thrown forward against the shoulder harness and seat belt. These are referred to as longitudinal (fore-and-aft) motions. The perceived motion is in the opposite direction of the change in velocity (slowed down implies thrown forward), Similarly, when one goes into a right-hand turn, one can feel thrown to the left: and when one goes into a left-hand turn, one can feel thrown to the right. These are referred to as lateral motions; and, once again, the perceived motion is opposite to the change in velocity (a change in velocity to the left causes a perceived motion to the right). In addition to longitudinal motions and lateral motions, there are vertical motions of the vehicle (caused by going over dips, hitting bumps, or hitting potholes) which cause opposing perceived body motions by passengers. It is these perceived body motions (whether in your car, an airplane, or an amusement park ride) that can move ones body around in the vehicle and cause discomfort or injury.

Of course, what is really happening in each of the above scenarios is that the vehicle is being slowed or turned out from under the passenger. It is really the vehicle that is changing motion, not the passenger. For example, when you step on the brake, the car is slowed; but your body wants to continue at the original faster velocity. The body then impacts with the slower moving vehicle (through shoulder harness) and that harness slows down the body until its speed matches that of the car. According to D'Alembert's Principle, the human body cannot really tell whether or not the car has slowed (pushing itself back into the passenger) or whether a

body force (like gravity) has actually pushed the body forward into the shoulder harness. Either way produces the same effect.

This means that one must be careful in analyzing the forces and motions of vehicles and passengers to distinguish between body forces (such as gravity) that act on every molecule of the body equally, and forces from the restraint system of the vehicle (including seats) that push only at the points of contact. Body forces due to apparent accelerations (like centrifugal force) are indistinguishable from body forces due to gravity. This is why a person revolving around the earth in a satellite feels no forces. The gravitational and centrifugal forces cancel, and he feels no forces at all. A person in orbit around Jupiter would, likewise, feel no net force, despite the fact that Jupiter's gravity is much larger than ours.

Therefore, when one is considering the loads experienced by a passenger in some type of vehicle, one is really not so much worried about the body loads and accelerations on the body. One is more concerned with loads that are applied to the body through the restraint system (like seat backs and belts). A simple way to do this is to consider the accelerations (changes in velocity) of the vehicle and consider them as body loads on the body. Ultimately, these will have to be countered by the restraint system, so they give a good indication of the extent of loading.

How Much is enough?

In order to quantify the nature of the loads, we need to quantify the amount of change in velocity. Usually this is done by relating acceleration (change in velocity per unit time) to the acceleration experienced by a falling object under the body force of gravity, 9.8 m/sec/sec (32.1 ft/sec/sec). The ratio of rate of change of velocity of the vehicle to that of gravity is called the number of g's. Typically, acceptable levels for amusement park rides are plus or minus 1.0 g's longitudinal (front to back), plus or minus 1.5 g's lateral (sideways), and 0 to 3.0 g's vertical (up and down), including gravity as one-g vertical. Often, one also likes to limit the change in g's per unit time (jerk). Typical values of jerk are 2.5 g's/sec longitudinally, 3.75 g's/sec laterally, and 7.5 g's/sec vertically. These values must be sustained over at least a tenth of a second in order to be considered serious. It should be emphasized that these are accelerations and jerk of the vehicle. The head and neck can experience values two or three times these values depending on restraint systems.

Measuring techniques need to be able to measure in this range. In order to measure accelerations and jerk to this accuracy, one needs piezo-electric accelerometers with a frequency band-width in the kilo-herz range (one thousand samples per second). The accelerometer must be mounted to a hard point on the ride with passengers (or simulated passenger weights) in the vehicles. There must be some signal conditioning and some computerized signal analysis. The old-fashioned "strip-chart" recorders with static accelerometers are not adequate. With these types of measurements, one can find out where on the ride problems might occur and either adjust the ride accordingly or limit the age and health of riders.

AMUSEMENT RIDES AND DEVICES: PATRON RESPONSIBILITIES

By Walter S. Laird, P.E.

In designing an amusement park ride, it is the physics and biomechanics that determine the roughness and "thrill" experienced by the rider. The goal of the ride manufacturer is to provide the maximum thrill while maintaining an acceptable level of comfort and safety. Dr. Dave Peters addressed safety issues in his article "Analysis of Amusement Park Rides". He discussed the limits of forces that are considered acceptable during a typical thrill ride. Exceeding these forces may lead to discomfort and possible injury. The manufacturer calculates these forces and plays with them through changes in speed and direction of the seat in which one rides. The rest of the ride is there solely for the purpose of moving that seat. The faster these changes are made, the more exciting the ride becomes up to the limits described by Dr. Peters. The anticipation of these changes in speed and direction can also heighten the ride experience. For example, during the long climb of the roller coaster, passengers often think about the great distance to the earth with the sudden stop (change in speed) if they were to meet the ground. They also see the impending loops and curves ahead. This gives the impression of danger and builds excitement.

Just like seat belts in your car, the lapbars and shoulder harnesses on amusement rides are called restraints. It is these restraints that keep the riders in their seats during changes in speed and direction so that they may safely experience the thrill of the ride. These restraint systems are designed using accepted engineering practice which conforms to accepted principles, tests, and standards of recognized technical authorities. Again, just like the seatbelts in your car, one of the design considerations is that the ride restraints will be properly used by the passengers of the ride.

To ensure proper use of the ride restraints, the manufacturer is required to provide operating instructions to the owner of the ride. The owner of the ride is required to train the ride operators in the proper operation of the ride. Passengers see signs that are required to be prominently posted, bold in design, with wording short, simple, and to the point regarding instructions about the ride. Verbal directions are usually given, too. When the passengers are loaded and the restraint system is in place, each rider usually does a subconscious "tug" (test) of the harness. Finally, the ride

operators should physically check each passenger's restraint to make sure it is properly locked in position.

Now, let's talk about the role of the rider in relation to ensuring his own safety and the proper operation the restraint system. I recently investigated an incident where a passenger was thrown to his death from a standup roller coaster. Prior to this incident, almost 13 million people had ridden this coaster without incident. Immediately, the reliability and design of the restraint system on this coaster was questioned. The investigation concluded that there

was nothing wrong with the restraints on this ride. Then how did this terrible accident occur?

The American Society for Testing and Materials (ASTM) is a recognized authority that provides technical standards for industry worldwide. Committee F-24 on Amusement Rides and Devices provides accepted standards to the amusement industry covering everything from design, manufacture, testing, maintenance, and operations of these rides. In standard F 770 – 93, Standard Practices for Operation Procedures for Amusement Rides and Devices, ASTM states under Patron Responsibility:

" There are inherent risks in the participation in or on any amusement ride, device, or attraction. Patrons.....accept the risks in such participation of which an ordinary prudent person is or should be aware. Patrons have a duty to exercise good judgment and act in a responsible manner while using the amusement ride, device, or attraction and to obey all oral or written warnings, or both, prior to or during participation, or both."

Although the average person would know nothing about ASTM standards, much less the wording in Standard 770 – 93, it is an accepted industry standard to believe that reasonable judgment and care will be exercised by the passengers. In the case of the roller coaster accident mentioned above, in the middle of his ride, this passenger intentionally wiggled out of the shoulder restraints in order to heighten his thrill experience. Because he was acting in an irresponsible manner, he was no longer riding the ride as it was designed to be ridden. Consequently, he was thrown to his death.

National Association of Subrogation Professionals

The National Association of Subrogation Professionals (NASP) is a new, non-profit trade association of insurance company subrogation specialists, attorneys practicing in the field of insurance subrogation and vendors serving the subrogation needs of the insurance industry. The Inaugural Conference of this organization entitled "Re-Inventing Subrogation for the New Millennium" is scheduled for November 7 through 10, 1999 in Las Vegas. As of mid September, over 300 attendees had registered for the conference.

Bill Ver Eecke of FORCON International has been elected to the initial Board of Directors of NASP and he will be speaking at the Inaugural Conference on the subject of Subrogation and the Expert Witness.

For further information on NASP contact the Executive Director, Gloria Isackson at 612-928-4661 or e-mail www.subrogation.org.

FORCON SEMINARS ARE ON THE ROAD AGAIN

Steve Chewning, one of the foremost accident reconstructionists in the country will be presenting ***"Accident Reconstruction and the Importance of Physical Evidence"*** Seminars to the Insurance Claims and Defense Industries. This seminar has been presented in Tampa, Ft. Lauderdale, Orlando and Jacksonville, FL as well as Atlanta, GA, Raleigh, NC, Nashville, TN, Charlotte, NC, St. Louis, MO and Gaithersburg, MD. Those who have attended have been impressed with the visual format presented and all agree that the seminars were well worth the effort to attend. A summary outline of the topics discussed during the seminar is listed below.

1. Uses of Accident Reconstruction
2. What the Vehicle May Show about the Nature of the Acident
3. What the Vehicle May Show about the Extent of Personal Injury.
4. Obtaining Information from the Traffic Way
5. What the Traffic Can Show about the Nature of the Accident.
6. Accidents Involving Commercial Vehicles
7. Measurements and Mapping
8. Preliminary Speed Calculation Methods
9. Accident Scene Check List

For addition information about future seminars in your area or to set up a private seminar for your firm, please contact Bob Dwyre at 1-800-436-7266

FORCON will be an exhibitor at the annual meetings listed below.

- Annual Claims Exposition & Conference (ACE) November 4-5, 1999 at the Baltimore Convention Center - Booth # 613
- 38th Annual RIMS Annual Conference, April 30th - May 5th, 2000 being held in San Francisco, CA.

If you will be attending any of the above meetings, please stop by our booth and say hello.

FORCON International Offices

Ann Arbor, MI	(248) 760-0654	Atlanta, GA	(770) 390-0980
Avon, CT	(860) 674-8101	Raleigh, NC	(919) 834-5190
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PROPERTY / CASUALTY ASSIGNMENT HOTLINE 1-800-390-0980
ACCIDENT RECONSTRUCTION ASSIGNMENT HOTLINE 1-800-877-3260

E-Mail Us at
(Tampa) jjholland@forcon.com
(Atlanta) FICATL@aol.com
http\\www.forcon.com

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NATIONAL ASSOCIATION OF SUBROGATION PROFESSIONALS

FORCON INTERNATIONAL CORP.
1216 Oakfield Drive
Brandon, Florida 33511