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### Motorcycles

Donan Engineering's team of vehicle accident reconstruction experts understands the complex circumstances that are typically involved with motorcycle accidents. There are many variables that must be considered with respect to the reconstruction of a motorcycle accident.

Over 100 years ago, Gottlieb Daimler created a two-wheeled vehicle to test his gas-fueled internal combustion engine, beginning the evolution of the motorcycle. The Indian was the first commercially available motorcycle in this country, and Daimler began making sales in 1901. Since this first vehicle, the changes to the motorcycle have been few.

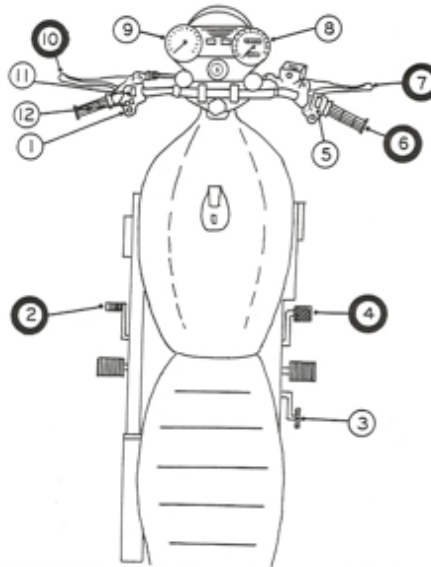
In 1969, there were 2.3 million motorcycles registered in the United States. In 1980, there were 5.5 million. With this increase in motorcycles came an increase in accidents. In 1969, there were 69,500 motorcycle accidents reported with 1,855 deaths. By 1986, the number of deaths rose to 4,566. Seventy-five percent of all motorcycle rider deaths involved males between the ages of 16 and 34 years of age. Forty-three percent did not have a valid motorcycle license at the time of the accident or were under license suspension.

Much can be learned from the proper examination of a motorcycle. Motorcycles can be categorized into three general groups: street motorcycles, dual-purpose bikes, and off-road bikes. The street bikes can be classified into the sub-groups of cruising, touring, sport, sport touring, standard, scooter, and moped. A smaller two-stroke engine is typically found on the smaller bikes and the off-road motorcycles. The most common engine is the four-stroke, which operates similarly to an automotive engine.

#### Braking

While many people have no problem using the engine to accelerate, it is stopping that causes fatalities. This is one of the crucial areas of difference between a motorcycle and a standard automobile; unlike the automobile, the motorcycle has two separate brake application points: a hand brake used to engage the front brake and a foot pedal used to engage the rear brake.

## MAJOR MOTORCYCLE CONTROLS



1. Horn
2. Gearshift Lever
3. Kick starter (if equipped)
4. Rear brake pedal
5. Engine Cut-off Switch
6. Throttle
7. Front brake lever
8. Speedometer and odometer
9. Tachometer
10. Clutch lever
11. High and low beam headlamp switch
12. Turn signal switch

Proper braking technique is required to achieve optimal braking performance. With a properly trained driver, a motorcycle can achieve better braking than an automobile. More often than not, the riders on the motorcycle are not able to achieve this type of braking efficiency, and ultimately have braking capabilities of approximately half that of an automobile. In order for a driver to get maximum braking, the simultaneous braking of the hand and the foot must be followed so that under an emergency braking situation, he or she overcomes the immediate reaction associated with driving an automobile: foot braking only. Some vehicles are now being equipped with an integrated braking system. This system gives some braking to the front wheel when the rear brake is applied. Anti-lock braking systems, which keep the wheels from locking so the vehicle maintains its steering capabilities, are also becoming popular.



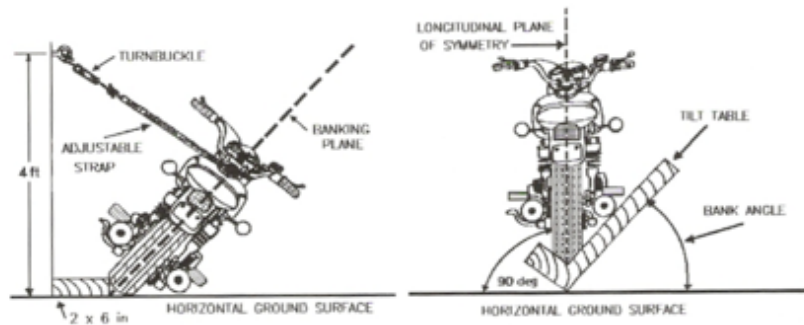
### Steering

Another major factor during an emergency event is the ability of the driver to overcome the natural (automotive) steering tendency to steer in the direction he or she wants to go. Unlike in an automobile, turning the wheel of a motorcycle has a reverse effect at higher speeds: the cycle actually turns the opposite direction of the steering input. This phenomenon is called "gyroscopic procession." Many times, after an accident a witness will claim the motorcycle operator "turned right into the car." This occurs when the operator reverts to a typical automotive steering reflex and literally turns toward the hazard due to gyroscopic procession instead of away from it. Steering to the right will cause the cycle to move to the left.

How does a motorcycle steer through a curve? It's not steering that turns the bike; it's leaning. Gyroscopic procession causes the steering force input to the front wheel to create a force that

deflects the wheel from vertical, making the motorcycle lean instead of steer. As the motorcycle leans, physics defines the movement of the bike. For every speed and lean angle, a path is generated for the bike. This translates into the simple equation of the higher the speed, the larger the turning radius. Also, the higher the lean angle, the lower the turning radius. The critical speed of a curve with a motorcycle is defined by the maximum capabilities of the bike within these two parameters. The centrifugal forces or the inertial force involved resulting from rotation attempt to make the motorcycle continue in a straight path. The lean angle and the available side friction work opposite the centrifugal force, keeping the motorcycle on path. If the centrifugal force is greater than the available lateral friction forces, the motorcycle cannot maintain the curve. If the lateral forces are greater than the centrifugal forces, the motorcycle can safely navigate the curve. This critical point of equilibrium is the critical speed of the curve for a given motorcycle.

What are the factors that go into the lean angle of a motorcycle? The tires play a role. Tires should be rounded and capable of achieving a large lean angle from vertical. The more the tire is leaned, the greater the forces pushing on the tire. Any change in available friction will cause a sudden loss of control of the cycle. It is not uncommon to see a motorcycle lose control in a hard lean on the painted white or yellow line in a roadway. The available friction of these surfaces is less than that of a paved roadway. The attachments to the motorcycle are also contributing factors to possible lean angles of a motorcycle. Foot pegs sticking out of the side will dig into the ground, as will mufflers and crash bars. The farther these objects stick out from the body of the vehicle, the less the motorcycle can lean. The less a motorcycle can lean, the lower the speed must be in order to navigate a turn. Sport bikes are made without appendages to allow for maximum leans, which is why they can take a given curve at higher speeds than a touring bike.



### Loss of Control

There are different definitions for a loss of control by a motorcycle. Each term represents a specific set of parameters that help determine exactly what happened to cause an accident.

**Flutter** – A low-speed front wheel movement induced by factors such as road bumps, ruts, pavement seams, low tire pressure, or the motorcycle itself. This occurs at a rate of 1 to 3 cycles per second, or 1 to 3 Hertz (Hz), and can be caused by something as simple as altering the bike's basic design (e.g., adding aftermarket parts). This typically occurs at speeds of 45 mph or less while the bike is under deceleration.

**Weave** – A high-speed wander that begins with a rear-end oscillation. The whole bike weaves in a snake-like manner. This phenomenon typically occurs with speeds in excess of 60 mph and has a rate of between 2 and 3 Hertz. This problem could arise from things such as improper loading, tire wear, tire inflation, mismatched tires, rider weight, load distribution, roadway surface conditions, worn or loose parts, or motorcycle design.

**High Speed Wobble** – This occurs from an uncorrected weave when the rear-end oscillation is transferred through the frame to the front forks. It is also referred to as a "tank-slapper" because the handlebars rotate back and forth violently, slapping the tank at each movement. The wobble occurs at a rate of 6 to 10 Hertz.

### Putting it all together

So what does this all mean? By knowing what you are looking for and how to read the details, a correct analysis of the motorcycle traffic accident can be made. Each minor detail, correctly

identified, can dramatically reduce error. Pre-collision skid marks should be examined to determine if both wheels were braking or if only the rear tire was braking. Typically, a very long skid mark will be made by only the rear tire being locked up.

Examination of the motorcycle itself can answer many questions. Does the driver have a history of using only the front brake? When front brakes are applied regularly, it indicates that the driver is comfortable with and used to making this type of brake application, increasing the odds that he or she would be able to utilize front braking in an emergency situation. Damage to the forks reveals much about braking applications at the moment of impact. The bending of the forks at impact can show whether or not the front of the motorcycle was loaded (front braking) or unloaded (no front braking).

Note the abrupt change in the forks:



Note the history of front end braking. This can be seen in the “rings” on the forks:



The history of braking:

