Turning a Motorcycle: the Curious Case of the Countersteer

by Rolly Meisel for the OAPT Newsletter

There you are, riding your motorcycle down the street in a straight line at a constant speed of 50 km/h while mouthing the lyrics of Born to Be Wild and imagining yourself as Peter Fonda in Easy Rider. As you approach the next corner, you want to initiate a sharp left turn.
How do you do it?

My current Iron Horse: 1982 Kawasaki KZ250LTD

a) steer the handlebars to the left
b) shift your weight to lean the motorcycle to the left
c) both a) and b) are required
d) either a) or b) will initiate the left turn
e) steer the handlebars to the right

Even seasoned veterans of the two-wheeled vehicle will more often than not pick the incorrect answer. The correct answer is e).

Just before you fire off an abusive email questioning where I might have purchased my undergraduate degree, let me hasten to add that I rode a number of different motorcycles for many years before this simple proposition was presented to me. How did I come to accept that it was true?

Consider the operation of a motorcycle. The front wheel acts like a gyroscope. The faster you go, the more stable it becomes. Below about 20 km/h, its angular momentum is low enough that you can steer the motorcycle to the left by turning the handlebars to the left. You might even be able to shift your weight enough to make that work, although you will be unlikely to make a really sharp turn unless you are riding a very light motorcycle.

Go faster, and at some point the unexpected happens. Shifting your weight has little effect on the direction of travel. Hard steering to the left results in a surprisingly violent lean to the right. The only way you can initiate a safe turn to the left is to momentarily countersteer, i.e., apply pressure to turn the handlebars to the right. The result? A lean to the left, making as sharp a turn as you desire.

Since this is a newsletter for physics teachers, I'll leave it to you to apply the right hand rule to determine the direction of precession of the gyroscopic front wheel of the motorcycle as you turn the handlebars left, and then, right, applying a torque to the axis of rotation through the front forks. Any elementary college or university text can help you, if it's been a while since you considered the physics of rotating bodies.

Of course, pencil, paper, and the right hand rule are not as satisfying as a real experiment. If you don't have access to a motorcycle, you can get almost the same effect from a bicycle. Being much lighter, you can turn a bicycle to some extent by weight shifting even at higher bicycling speeds. However, try riding along in a straight line, as fast as you can. Then, gently apply pressure to turn the handlebars to the right. The result may surprise you.