B25 (Team, CK, SRJ)
The Inversion Speed
March 25, 2010

Critical Velocity. Be sure to read and understand the entire assignment before you begin.

When considering the velocity of a bike, there are three basic stability regions (with respect to velocity). When a bike is going very slow, it is unstable and will not balance without help from a human, a human who is turning the handlebars and shifting their body. As a bike accelerates and increases in velocity, it crosses a critical value, let's call it $v_{critical1}$, where the bike will now stay upright with or without a human controller. The bike continues to be stable as we increase its speed until a second critical value is reach, let's call it $v_{critical2}$, where the bike once again becomes unstable for faster speeds, and once again needs a human controller to stay upright.

An important note, that follows from this description of critical velocities, we have also defined what we mean by a **bike being stable**. The instability region for speeds less than $v_{critical1}$ is often called the region of **capsize** instability.

In this assignment we're going to figure out $v_{critical1}$ for our bicycles. Here is a list of possible ways. Be sure your speedometer is calibrated.

A) Push your bicycle with no rider and figure out what is the minimum speed at which it will stay upright and go kind of straight. To do this experiment we need to have some sort of instrument that helps us figure this out by measuring rotational acceleration of the frame and forward velocity.

B) Ride your bike in a sort of straight line, trying to keep your body in line with the bike (in the same vertical plane as bike frame) and figure out where the transition point (in the velocity) is between needing to steer to stay upright and not needing to steer to stay upright.

C) Ride your bike in a sort of straight line, trying not to steer, but using your body (shifting your weight around) to stay balanced. Figure out where the transition point (in the velocity) is between needing to shift your weight around to stay upright and not needing to.

In the next set of possible ways to find $v_{critical1}$, we actually are going to be finding something call the **inversion speed**. We will then need to justify why, and how, the inversion speed is related to $v_{critical1}$.

D) Mark out a circle and ride your bike around it at a constant speed (mark the circle on the ground with books, cones, sweat-shirts, etc.). Hold your body inline with the bike's frame (in the same plane). At slow speeds the rider will have to apply torque (to steer) in the direction opposite of the direction of turning. At fast speeds the rider will have to apply torque (to steer) in the same direction as the direction of turning. Thus there exists a speed between fast and slow such that no torque needs to be applied to ride around the circle (remember your holding your body in the plane of the bike). This speed is the inversion speed.

E) Mark out a circle and ride your bike around it at a constant speed. Lean your body so that no torque is needed to steer the bicycle. At slow speeds the rider will have to lean outward. At fast speeds the rider will have to lean inward. Thus there exists a speed between fast and slow such your body is in line with the bike when riding around the circle (remember your applying no steering torque). This speed is the inversion speed.

Perform and record your results for experiments B) through E) (with at least two members to each group being the rider in each experiment). Experiment A) will be performed later in the semester. During an experiment there should be one rider, one recorder (who takes down all information), one video logger.

Assignment should include write-up of results, 'lab report' speadsheet of findings, powerpoint presentation of findings.

Since you can prevent *capsize* instability with extremely small body movements, it is very important in these experiments to do your best to suppress such movements in experiments B) and D).

Be sure to trim your bike before each and every experiment (Add to spread sheet, turn in spreadsheet). Hint: Fill the wheels to the maximum air pressure will give better results. Bike helmets are encouraged. Be sure to record your experiments on video. There is a laptop available for your use for downloading your videos on the fly, if needed. Be sure you're recharging the camera's battery and erasing the disk for other's to use.