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## **A Tilting Trike with Rider Tuneable Stability and Handling for Improved Safety**

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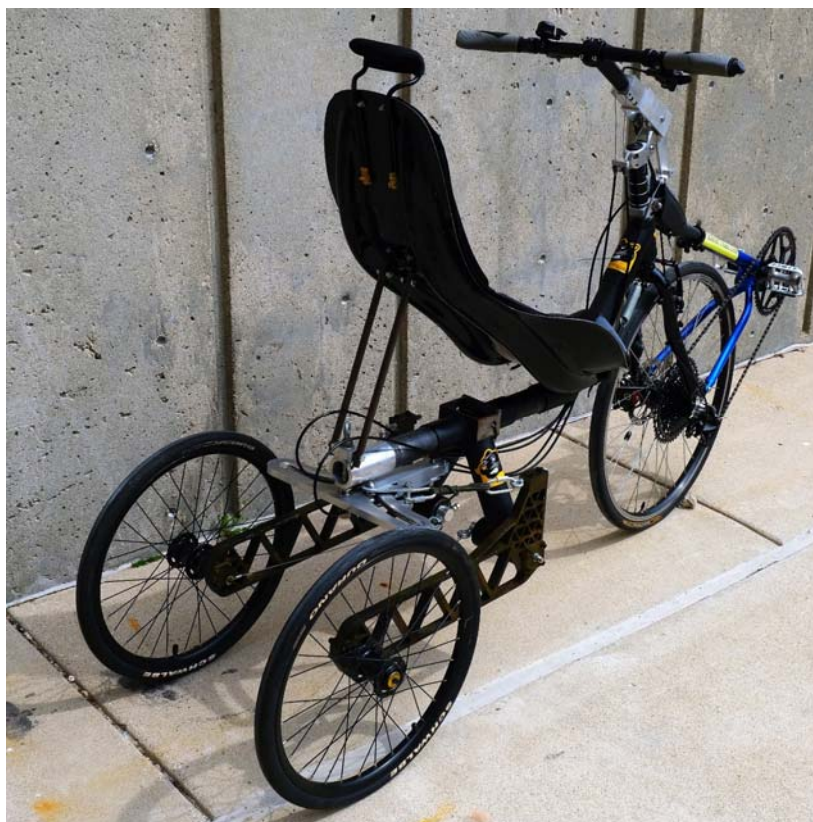
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### **1 INTRODUCTION**

The potential advantages of tilting trikes have been tantalizing for years: they can lean like a bike so that they do not have to be low, wide, or slow in turns; and they can keep the rider upright like a trike when stopped or going slow.

Implementing this functionality, however, has been somewhat problematic. Many tilting trikes have been built in which the extra wheel only offers some redundant traction, in the case of inconsistent friction with the road surface. Some have been built with a so-called “tilt-lock”, in which the third wheel can also act as a kickstand to hold the trike rigid when stopped.[1] A few tilting trikes have been built with sophisticated sensors, actuators, and control algorithms to assume the proper tilt angle in every situation,[2][3] and the motorcycle press breathlessly announces the latest patent filings in this area from major motorcycle manufacturers.



*Figure 1: The working prototype in “rigid” mode keeping itself upright.*

## 2 GENERAL DESCRIPTION

We demonstrate a tilting trike design in which the third wheel serves those first two purposes, plus it allows the rider to tune the vehicle roll acceleration without the expense, complexity, and weight of sensors, actuators, power sources, or dampers. Decreasing the roll acceleration makes the handling more docile and manageable, which can be especially helpful when traveling slowly and the weave instability, a relatively slow (0–4 Hz) oscillation between leaning left and steering right, and vice versa, is at its most unstable,[1] and this change in roll acceleration is accomplished only by varying the geometry of the tilting linkage, which can be actuated by hand.



*Figure 2: The working prototype in “tilting” mode leaning against a wall.*

## 3 CONFIGURATION

The initial working prototype features a delta wheel configuration, moving-bottom-bracket front-wheel-drive, to simplify the drive train, and aggressive recumbent seating, to minimize aerodynamic drag. New riders found it very difficult to master in purely free-tilting mode, when it acts exactly as the equivalent bicycle would. When halfway between free-tilting and rigid-trike, however, the roll acceleration is decreased, and riders found it much easier to ride.

The tilting mechanism is not tied, however, to the delta wheel-layout configuration, front-wheel-drive, or recumbent seating. A tadpole, rear-wheel-drive, cargo trike with upright seating is just as feasible.

## 4 IMPLEMENTATION

A linkage enables the rider to vary the tilting mechanism geometry, and as that geometry varies, the trajectory that the seat takes as the trike tilts varies, as shown in figure 3. At one extreme, the seat follows nearly the same trajectory it would if there was only one rear wheel, as with a bicycle. At the other extreme, the seat rises as the trike tilts, and gravity tends to pull it back to straight upright, as with a rigid tricycle.

In between these two extremes is a smooth and continuous variation of behaviour, and the rider can choose how quickly or slowly the trike tilts to suit the current riding conditions.[4]

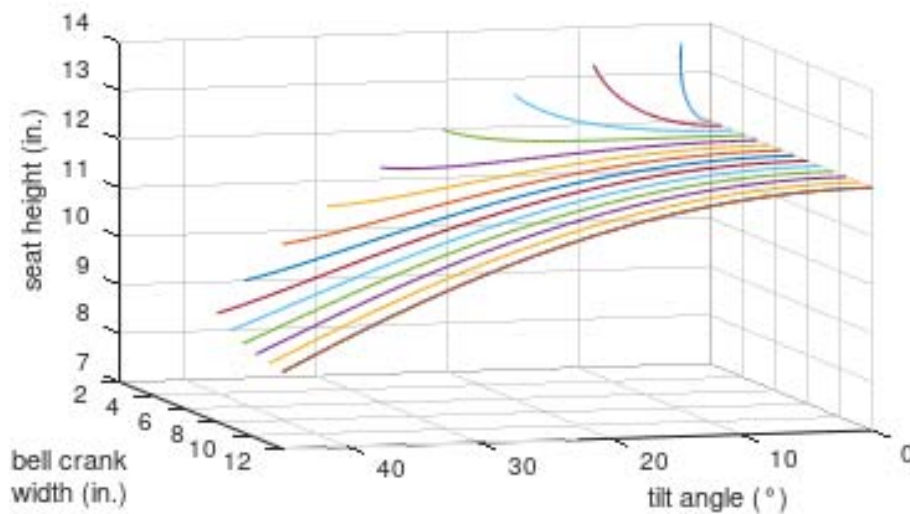


Figure 3: How the seat trajectory changes with tilting linkage geometry.

## 5 EXPECTED RESULTS

We will present the next iteration of this tricycle design that is more suited to consumer city biking and demonstrate the low-speed stability compared to a similar bicycle. The moving bottom-bracket and recumbent seating worked well for a proof-of-concept but would have limited appeal and utility in the general population. Instead, a version more similar to the standard European city bike will be easier for existing riders to adopt when they want or need a little help with balance.

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