LECTURE T1 –What Doc Jobe Found by a Close Friend of Doc Jobe

We just ran across a patent, US 8,469,831 B2 "CYCLOID RAMP FOR GRAVITY DRIVEN RACE CARS". When we contacted the inventor, John "Doc" Jobe of PinewoodDerbyPhysics.com, Doc Jobe explained to us that he has run across something very interesting regarding various aluminum tracks which he has been testing in his lab. It has to do with a geometric shape called a cycloid, a curve first discovered by Johann Bernoulli in 1696. E.g. See:

https://en.wikipedia.org/wiki/Brachistochrone_curve

It turns out that the cycloid curve is the curve of fastest descent for rolling from point A to a lower point B in a gravitational field. Also, any point on a section of the cycloid has this same fastest descent property. Doc Jobe was able to solve equations that would give coordinates of the cycloid starting at a pinewood derby height to a lower point which is the coasting run start at floor level. The details of his solutions may be found in his patent. Another curious property of the cycloid is that if you race two identical cars down a section of the cycloid, they will hit the end of the ramp in a tie. It doesn't matter where they start, as long as they are released simultaneously. One could be started at 4 feet high, and another at 2 feet high, and they tie in elapsed time at the ramp bottom where the higher velocity car passes the slower car. Now get this — this elapsed time is the same for any car released anywhere on the cycloid.

But most importantly, the cycloid curve also puts the least possible force on a car on to pull out of its descent. This is only 20% of a "G" for the cycloid so the net force on the car wheels is only 1.2 G total at pull out. Since most of us test our cars on a level surface at 1G the 20% difference doesn't make much difference in their straight tracking under a slightly larger load. So, they don't deviate much from straight tracking down the cycloid ramp and along the horizontal run to the finish line.

One aluminum extrusion Doc Jobe tested had a curing procedure that caused a certain stiffness or bending moment. When testing this bending moment something very interesting happened when this inventor found a "sweet spot" on the ramp where a force pulling down on the ramp and directed towards where the front legs touch the floor can cause the whole downward ramp section to bend into a cycloid section shape. The whole idea here is to have the bend or curvature of the ramp be highest where the velocity is the lowest. Refer to his patent to see this sweet spot. The patent examiners at the USPTO thought this finding was unique enough and unobvious enough to qualify for a patent in gravity racing. In the G-Track we pull down with a force of 30 lbs per lane at a point identified as point 32 in the patent, being about 20 % lower vertically down track from start. More different design embodiments for making the ramp conform to a cycloid shape may be found in the patent.

Now consider what the other major aluminum track builder has to offer, namely a track where at the critical maximum speed spot close to the floor they have unfortunately placed their sharp pullout curve of r = 4 ft radius. The velocity here is $\sqrt{2Gh}$ where G = 32 ft/s^2 is the acceleration due to gravity and h = 4 ft. So v = $\sqrt{(2)(32)(4)}$ ft/s = $\sqrt{256}$ ft/s = 16 ft/s.

The extra G force introduced is easy to calculate, being simply v^2/r . The extra G force = (16ft/s)^2 /4ft = 64 ft/s^2 = 2G. If we now add the car weight of 1 G, we have the net downward force increasing from the acceleration at pullout = 3 G. So all the rolling tests we do at 1 G to get straight tracking are no longer valid because this friction increase at triple weight usually does not always go up equally for each rear wheel. This can cause the car to start bouncing side-to-side like when you pull the handle on a commercial lawnmower to increase one rear wheel rolling resistance to make the lightly loaded front swing in that direction. This front end swing is what starts the bouncing (See Slo Mo Vid) taken by a mini camera car 1 lane over). Hardly a "best" track behavior compared to the perfect cycloid shaped ramp that is described here.