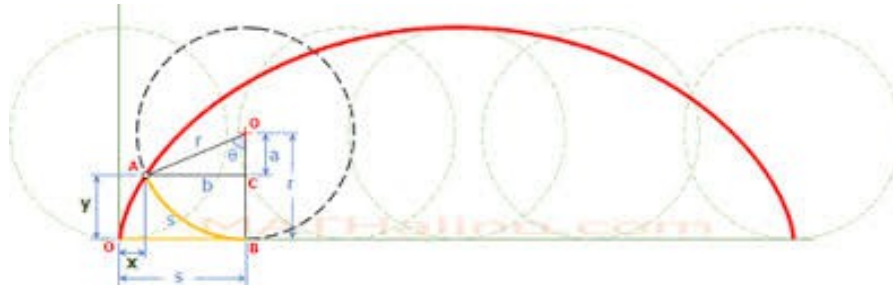# THE CYCLOID
## and the Kinematic Circumference



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Those of you who have read my papers on π=4 will know I have explained that problem using many visualizations and arguments, but after several years I have decided the best way to teach the new physics is by starting with the cycloid. Whenever I have to explain my physics to young people, this is now how I start.

If you roll a wheel on the ground one full rotation, it will mark off a path on the ground that is 2πr in length, as most people know. That length has been assigned to the circumference of the circle or wheel, which assignment is correct as far as it goes. My papers have not questioned that. However, if you do the same thing but follow the motion of a given point on the wheel (point A in the diagram above, for instance), it draws the red curve. That is called the cycloid. Obviously, the red curve is not the same length as the line on the ground. It is considerably longer, being 8r in length. Meaning, the current circumference is **21% shorter**.

So it is a bit strange that doing the same thing—rolling the wheel one rotation—gives us two very different path lengths. Both of them are physical and real. Neither seems to be abstract or mystical in any way. But for some reason the cycloid has been pretty much ignored in the history of physics. It is used in the problem of the rolling wheel and nowhere else. It isn't used for anything important, being completely overshadowed by the circumference and by π.

My feeling is that this is due to the problem most people have with visualizing math—or anything else for that matter. I have found by long experience that most people aren't very visual. If you are very visual, you tend to go into art or design, not into science. In fact, scientists and mathematicians are generally the *least* visual people I know. That is a strange circumstance, and I don't think it is a necessary outcome of history or science, but currently that is the way it is. It has a lot to do with the politics of science and physics in the 20th century, and with the specific people that were involved in it. We won't get into that here, but just be advised.

Anyway, the cycloid is a bit harder to visualize than the straight line on the ground, isn't it?  Especially if you watch the cycloid being drawn in an animation.  If you haven't previously seen it, I suggest you do a quick search online and watch it.  I have to admit it is a bit mind-boggling at first.  I am very visual myself, but even for me it was a bit mind-boggling.  It is hypnotizing, and if you watch it over and over in a loop you have to keep telling your brain to concentrate.  You are watching it to try to figure it out, but—especially if it is moving too fast—your brain just can't keep up.  Your brain empties and you find yourself just staring stupidly.

For that reason, I think a lot of people prefer to look away.  They are like bushmen looking up at an airplane, trying to figure it out.  It is beyond them, so it quickly becomes painful and they look away.  This is the only explanation I can come up with for why the cycloid hasn't been tied to the problem of orbits before I did it.  After I did it, it seemed obvious, and you will probably ask yourself the same question I asked once you understand it all: "how did no one see this before?"  They didn't see it because they were looking away.

What I am going to show you is that *both* the red line drawn by the cycloid and the line on the ground rolled by the wheel are circumferences, of a sort.  They both tell us something very important about the distance around the circle.  But, as it turns out, the red line drawn by the cycloid *is even more important* than what we have so far called the circumference.

What we will discover is that there are actually two correct circumferences.  There is a geometric circumference and a kinematic circumference.  The first is the familiar circumference you know about, and is just the perimeter of a given circle.  But it implies no motion and allows for no motion.  I call it geometric because it comes from geometry, which is static.  No motion is involved.  No motion is involved in geometry because no time is involved.  It is lengths only, with no time or velocity.  But if motion is involved, you must use a kinematic circumference.  "Kinematic" just means having to do with motion.  It is a cousin of the word "dynamic".  Kinematics and dynamics are classical subfields of physics, and they go beyond geometry by including time and motion.  What we are about to see is that the cycloid tells us the **kinematic circumference**.

So let's go way back in time, and pretend we are ancient Greeks first looking at this problem.  We see the two paths created by the same rolling wheel, and we ask ourselves, "OK, but which of those is the circumference of the circle?"  Is it the big red loop or the line on the ground?  The straight line on the ground is a lot more comprehensible, isn't it?  So we choose that one.

But what if we ask a slightly different question.  What if we say, "OK, but what if we lay our wheel over on the ground and make it very big?  We then have a great big circle on the ground.  What if we have to walk or run that circle, which path do we choose for that?  The big red loop or the line on the ground?"  We aren't creating a straight line on the ground in any way, so it is not clear we would want to choose the $2\pi r$ length.  No, logically, it seems we are acting more like the point on the wheel moving around as it turns, creating the cycloid.

Against this, one of my fellow Greeks might say, "No, you don't want to choose the cycloid for that, because the cycloid math is including the forward motion of the wheel as well as the circular motion.  If you are walking around a circle, you don't have that."

In fact, that was the historical argument against it, and is the current argument against it (when it comes up, which is almost never).  But it is not really true, is it?  If you are walking around a circle, *you are walking forward*.   You have a forward motion through time just like the point that creates the cycloid.

You aren't just sitting there while the circle spins, are you?  No, you are actually moving all the way around it.

My fellow Greek will answer, "But the point on the circle that creates the cycloid is moving all the way around the circle *while at the same time* it is moving forward through space.  So its motion is the sum of those two motions.  That is why it is farther."

That's true, but it doesn't mean a person walking in a circle isn't summing motions in the same way.  My fellow Greek needs to demonstrate not only that a cycloid works that way, but that a person walking a circle *doesn't* work that way.   He has demonstrated that the cycloid works that way, and I have accepted it, but I haven't accepted that walking the circle doesn't work that way as well.

He will say, "There is no forward motion through space, as with the cycloid.  So how can the cycloid be the same as walking the circle?"

Because, in fact, there *is* forward motion through space when walking a circle, and the mainstream already admits that.  If, instead of asking about a circumference, you ask the mainstream about an orbit, they tell you that the circular orbit *is created by summing two separate motions*.   They still teach you what Newton taught centuries ago: the orbit is a combination of a tangential velocity and a centripetal acceleration.  What is the tangential velocity?  **It is a straightline motion through space.**

In planetary orbits, you have the Sun creating the centripetal motion.   But if you are just walking in a circle, you have to create it yourself.  For instance, you can lean toward the center of the circle and let gravity create some of it for you.  Or you can push more on your outer leg.  It doesn't really matter, except that you understand that circular motion *isn't* just like straightline motion, and that the mainstream knows that and admits it.   So walking $2\pi r$ in a straight line and walking $2\pi r$ in a circle is not the same: not physically, not mathematically, and not in any other way.

It gets a little more difficult from here on out.  If this were really easy, it wouldn't just now be discovered, so press yourself a bit.  Let us go back to the wheel rolling on the ground, that we started with.  Notice that when we draw the normal circumference on the ground with the wheel, we aren't following any one point.  No point on the wheel is moving along that line, and no point on the earth is, either.  We are told we are letting points on the circle match points on the ground, and most people accept that, since it seems to make sense.  But it cannot be demonstrated and never has been.  Yes, you can paint lines on the ground with wet paint, roll the wheel over them—getting the paint on the wheel —and then claim that the distance between lines on the ground and on the wheel is the same, but it doesn't prove anything of the sort.  All it proves is that curve and the line match up that way when rolled, but it doesn't prove the distances are the same.  Again, you can only compare straightline distances to other straightline distances.   You can't match curves to lines and say they are the same, because they aren't created the same way, they don't have the same math, and *they aren't traveled in the same way*.

What I am trying to get you to see is that it is this match-up that is actually slippery.  The mainstream has tried to claim it is my math or ideas that are slippery, but the reverse is true.  When you roll a wheel along the ground, and then monitor that line created, you aren't actually monitoring one point or one event. You are monitoring a series of events in a very offhand and imprecise manner.  The claim at the end that points have matched up or that distances are equal is just a claim, with nothing at all to support it.  Just as measuring curves with straight lines is extremely complex and difficult, measuring straight lines with curves is just as difficult and problematical, and cannot be glossed over so casually, as if it is

self-apparent.

My fellow Greek will no doubt say something like, "If this is all so difficult, why do surveyor's wheels work so well? You can measure any distance with that rolling wheel, and it will match a measurement with a yardstick."

I hope you can see the problem there. *Of course* the surveyor's wheel gets the right number: the circumference was matched to the distance on the ground after the fact, so there is no way it could be wrong. It couldn't be wrong any more than a yardstick could be wrong. The yardstick is right because it was *marked* as right. Same thing with the surveyor's wheel. Either one can be wrong only if they slide on the ground or something.

Notice another thing here. When we force the circumference of the wheel to match the line on the ground, we are "simplifying" the problem in a very important way: we are forcing everything into one dimension. A line is one-dimensional. You can express that line with just one variable, say the variable x. But with the cycloid, you have a curve, which requires two variables, say x and y. Since the cycloid is admitted to be moving forward, you also have a time variable t which gets expressed in the math. So with the cycloid, you have three variables you have to track. When you write out the math, all three are present and accounted for.

With the line on the ground, you can't really "track" anything, since no point is moving along that line. You just have a series of points that are said to match, but you have no mathematical way to track that. And, although the wheel is moving forward, since no real point is being tracked, you can't include time in the same way, either. So if you were asked to create an equation for that line in the same way you created one for the cycloid, you couldn't do it. Strictly, there is no equation for that line, since it is just a raw distance, determined by nothing but the size of your wheel. There is no way to logically assign a y or even a t variable, since there is nothing to assign it to. You can't assign a variable to a series of points.

So the creation of the line by this method doesn't really *simplify* the problem, it *hides* it. It doesn't make the analysis easy, it *prevents* analysis.

Another thing to notice is that you couldn't walk that circle the way the line on the ground is walking it. And again, the reason is because with the line on the ground, you have a *series* of match-ups. But when you monitor a body moving in a circle, you have no series of match-ups. You have no series of anythings. You have the motion of a point, or of a limited body which you treat as a moving point.

Therefore, the rolling wheel matching the line on the ground is actually the *avoidance* of the problem, or the *burying* of the problem. Circular motion is a kinematic problem **by definition**, and there is no way to solve a kinematic problem by *assuming* the matching of points in a series.

To solve a kinematic problem, you have to let some real object travel the path in question, and write an equation for it, with all variables represented, including time. That has never been done for π, and cannot be done. The reason it cannot be done is because circular motion requires three variables, just like the cycloid. Since the circle is planar (2D), it requires the variables x and y. And since circular motion includes motion, it also requires the variable t. And, although the variable assignments aren't exactly the same as with the cycloid, since you have three variables and the circle, you end up getting the same answer at the end: 8r instead of 2πr. If you want to know more about those three variables and their precise assignments, I send you back to my previous papers, certain sections of which you

will have to slog through if you really want to understand the full math and full solution.