Wikipedia and Centrifugal Force

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Abstract. **Wikipedia is the on-line encyclopaedia that anybody can edit. The content changes on a continual basis. One of the rules is that editors must not insert original research. The contents must reflect what is stated in reliable sources.**

In the case of the *centrifugal force* article however, reliable sources don't always agree, and over the years, the inability of editors at that article to consider the totality of existing knowledge on the subject has led to never ending discussions and edit wars. An example of the confusion that surrounds this topic can be found at this web link, http://physics.stackexchange.com/questions/37968/centrifugal-force-and-polar-coordinates

The Inertial Forces

I. Most people agree that centrifugal force follows from the tendency of a body to continue at uniform speed in a straight line known as the inertial path. Centrifugal force is therefore a consequence of Newton's first law of motion. When the inertial path is described in polar coordinates relative to an inertial frame of reference, the centrifugal force shows up as an outward radial component while the Coriolis force shows up as a transverse component. See the appendix at section **VII**. These inertial components are used when analysing planetary orbits, and due to conservation of angular momentum, the centrifugal term can be reduced to an inverse cube law in radial distance **[1]**, **[2]**. This was first demonstrated in the seventeenth century by Leibniz **[3]**.

Constraints

II. When a physical constraint is introduced against the motion of a body that is undergoing its inertial path, an inertial force is transmitted to the constraint. The constraint in turn causes a reactive force to act on the original body as per Newton's third law of motion. Relative to a centre of rotation, the radially outward inertial force that is exerted on a constraint corresponds to Isaac Newton's understanding of centrifugal force. Newton, considering it to be a reaction to the centripetal force which the constraint exerts on the body, failed to realize that rather than being in conflict with Leibniz, this action-reaction phenomenon is actually a secondary consequence of the primary phenomenon as understood by Leibniz **[3]**. That primary phenomenon is due to Newton's first

law of motion, while the secondary phenomenon is more accurately an action rather than a reaction, considering that in many cases, such as in that of a stone being swung around on the end of a string, the inward centripetal force does not arise until after the outward centrifugal force has already pulled the string taut.

Controversy

III. Nothing in sections **I** and **II** above conflicts with what is in the literature, yet nevertheless, there is a great reluctance on the part of Wikipedia editors to present both of these perspectives. The tendency is to completely hide them out of view and instead to give dominance to the erroneous idea that the inertial forces are merely artefacts of making observations from a rotating frame of reference. Under the Wikipedia rules, this might at first appear to be justified since most of the modern literature on centrifugal force presents it in this manner. Even if a serious mathematical error should exist in the analysis, which it indeed does, (see section **VII**) the editors would argue that their job is not to right great wrongs, but rather to reflect what is written in reliable sources.

Rotating Frames of Reference

IV. It should be a matter of common sense that a rotating frame of reference cannot create an outward acting artefact, yet centrifugal force is an outward effect. Wikipedia editors explain this away by introducing a radial Coriolis force, but it is demonstrated in the appendix at section **VII** that this is impossible. The truth is that a rotating frame of reference merely serves to mask the actual rotation that gives rise to the centrifugal force in the first place.

The Totality of Reliable Sources and Common Sense

V. Under the existing Wikipedia rules, editors might be justified in promoting centrifugal force as being an artefact of making observations from a rotating frame of reference, even if they themselves realize that this must be wrong. The sources say so, and that's what they have to repeat.

But it's not as simple as that. Not all sources insist on the necessity of involving a rotating frame of reference in order to justify the existence of centrifugal force, and anybody who has ever analysed planetary orbital theory using polar coordinates knows that a rotating frame of reference is not needed **[1]**, **[2]**. Likewise neither is a rotating frame of reference needed when the inertial forces are used in gyroscopic analysis **[4]**. So what should a Wikipedia editor

do? They cannot legitimately point out the maths error that is repeated across so many modern textbooks, and they are obliged to give primacy to the manner in which most modern textbooks present the topic.

But must they go out of their way to hide the alternative perspectives? And they do hide them. At the time of writing, *although this may change at any moment*, the perspective that centrifugal force in the inertial path can be exposed in polar coordinates in an inertial frame is segregated into a separate article on polar coordinates. The claim is made, without any justification whatsoever, that these inertial terms which bear an identical mathematical form, hold no relationship whatsoever to the real thing. Also, *at the time of writing*, there is a special article for the secondary action-reaction phenomenon that arises when a constraint acts against the inertial path, and they have even given it a totally misleading name i.e. *reactive centrifugal force*, when in fact it's actually an active force. This very real secondary phenomenon has been totally divorced from its primary cause and dismissed as some kind of historical relic.

These two hidden perspectives both suggest that centrifugal force is a real force, and so to give these perspectives significant coverage in the article would create a major dilemma by conflicting with the notion that centrifugal force is merely an artefact. But that doesn't mean that the editors are under any obligation to take responsibility for this dilemma and to cover up for it. Common sense should be applied when deciding the relative weightings, and emphasis should be given to the commonality.

Conclusion

VI. All Wikipedia editors are subject to the *"no original research"* rule. Editors would not be permitted to draw attention on the article page to the mathematics error (see appendix at section **VII**) that exists in the derivation of the inertial forces when done in conjunction with a rotating frame of reference. They are obliged to copy this derivation into the article regardless of its merits, since it is found in what are considered to be reliable sources.

They would still however be allowed to have a section explaining that a rotating frame of reference is not necessary and that the inertial forces can be derived accurately using polar coordinates in an inertial frame of reference, and that the inertial forces are merely a product of Newton's first law of motion. Editors would still be allowed to write that centrifugal force is an effect of inertia that arises relative to a centre of rotation due to the tendency for a body, in the absence of applied forces, to continue in its uniform straight line path. They would still be allowed to explain that planetary orbits are mostly solved without the need to involve a rotating frame of reference. They would still be allowed to point out that the understanding of the centrifugal force that arises in many mechanical devices does not depend on the involvement of a rotating

frame of reference, and they would still be allowed to point out that when a physical constraint is applied to a body which is undergoing its inertial path, that a very real centrifugal force can be transmitted to the constraint.

Ignoring the totality of reliable sources and insisting on using only the modern sources which contain a major mathematics error will result in the centrifugal force article at Wikipedia remaining incomprehensible to lay readers. Lay readers will always be perplexed as to how a real outward effect, which they can observe in Newton's rotating bucket, can be said to be merely an artefact of making observations from a rotating frame of reference. The truth is that this is an absolute effect which can be observed from any frame of reference. Common sense would dictate that a rotating frame of reference cannot create an artefact that acts outwards from the centre, and that only absolute rotation can do this. A rotating frame of reference can only create transverse artefacts, and even these are not the same thing as the Coriolis force.

Appendix - Polar Coordinates in the Inertial Frame of Reference

VII. Consider a particle in motion in an inertial frame of reference. We write the position vector of this body relative to any arbitrarily chosen polar origin as,

$$\mathbf{r} = r\hat{\mathbf{r}} \qquad \textbf{(1)}$$

where the unit vector $\hat{\mathbf{r}}$ is in the radial direction and where r is the radial distance. Taking the time derivative and using the product rule, we obtain the velocity term,

$$\dot{\mathbf{r}} = \dot{r}\hat{\mathbf{r}} + r\dot{\theta}\hat{\boldsymbol{\theta}} \qquad \textbf{(2)}$$

where $\hat{\boldsymbol{\theta}}$ is the unit vector in the transverse direction and where $\dot{\theta}$ is the angular speed about the polar origin. Taking the time derivative for a second time, we obtain the expression for acceleration in the inertial frame,

$$\ddot{\mathbf{r}} = \ddot{r}\hat{\mathbf{r}} + \dot{r}\dot{\theta}\hat{\boldsymbol{\theta}} + \dot{r}\dot{\theta}\hat{\boldsymbol{\theta}} + r\ddot{\theta}\hat{\boldsymbol{\theta}} - r\dot{\theta}^2\hat{\mathbf{r}} \qquad \textbf{(3)}$$

which can be rearranged as,

$$\ddot{\mathbf{r}} = (\ddot{r} - r\dot{\theta}^2)\hat{\mathbf{r}} + (2\dot{r}\dot{\theta} + r\ddot{\theta})\hat{\boldsymbol{\theta}} \qquad \textbf{(4)}$$

The first and the third terms on the right hand side of equation **(4)** are the centrifugal and the Coriolis terms respectively. Note that no rotating frame of reference is needed, and that all that is necessary is to identify a centre of rotation. Contrary to popular belief, centrifugal force is a product of absolute rotation and not of making observations from a rotating frame of reference. In the case of uniform straight line motion, the total acceleration will be zero, and hence we can deduce that the centrifugal force takes on the same mathematical form as the second (centripetal term) term on the right hand side of equation **(4)**. It should also be

noted that while the centrifugal force is specifically a radial force, the Coriolis force is specifically a transverse force.

In the Wikipedia article on polar coordinates, *at the moment as I write this*, it says that the centrifugal and Coriolis terms above are lookalikes which are a mathematical consequence of differentiation, and hence they are not the real thing? Let's therefore take a look at the alternative derivation of the inertial forces which is prominent in the literature and which is eagerly supported by Wikipedia editors as being the only true way. This time the position vector **r** is tied up with a rotating frame of reference. The equation for a particle moving in the rotating frame is then written as,

$$(d\mathbf{r}/dt)_S = (\delta\mathbf{r}/\delta t)_R + \boldsymbol{\omega}\times\mathbf{r} \qquad \textbf{(5)}$$

where $(d\mathbf{r}/dt)_S$ is the velocity of the particle relative to the inertial frame, and **ω** is the angular velocity of the rotating frame. It is assumed that the velocity of the particle in the rotating frame, $(\delta\mathbf{r}/\delta t)_R$, can be in any direction, but if that is so, then **r** cannot be the same vector throughout the equation, since the origin of the latter is the fixed point in the rotating frame which has the transverse speed **ω**×**r**. It's a simple question of vector addition of velocities and so a serious error has been made. Equation **(5)** can only make sense if **r** is the same vector throughout the equation, but in that case it becomes equivalent in every respect to equation **(2)**, and therefore the meaning changes and the rotating frame of reference at the beginning of the derivation becomes irrelevant and misleading. The $(\delta\mathbf{r}/\delta t)_R$ term therefore cannot have any transverse component, and since the Coriolis force term takes on the vector cross product format, $2\boldsymbol{\omega}\times(\delta\mathbf{r}/\delta t)_R$, the Coriolis force must be strictly a transverse force. The consequence of this mathematics error is the absurd belief that the Coriolis force can act in any direction. This absurdity is then used to justify why a stationary particle as observed from a rotating frame, does not move outwards from the centre despite the claim that a centrifugal force artefact is being observed.

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