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A4_3 The Fastest Lap

N. Rowe-Gurney, M. Grant, A. Edgington, J. Sandhu

Department of Physics and Astronomy, University of Leicester, Leicester, LE1 7RH.

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Abstract

Both banked track and flat track roller derby are fast sports; this paper investigates on which type of track a skater can get their fastest lap time. By considering the frictional and gravitational forces acting on skater's wheels while going around the track types, the maximum velocity before a skater starts to slide outwards was found. The flat track lap time was 8.3 seconds compared with a faster 7.5 second lap on the banked track, even though the banked track skating path is 10m longer in circumference.

Introduction

There are two types of roller derby, flat tracked and banked tracked. Both versions of the sport are based on an oval track where players wear quad-wheeled skates. The banked track is almost exactly the same as the flat version but is slightly larger and is at an angle of around 9.6 degrees. As in many sports it is advantageous to be the fastest in many, if not all situations. The flat track and banked track types have many advantages and disadvantages but this paper will be looking solely at the maximum speed at which a player can do laps without slipping outwards. This will be found by looking at the static friction between the skaters' wheels and the surface and therefore resolving the forces related.

The most efficient way of measuring a particular players speed is by looking at their lap time. A typical flat track skater will be aiming for 25 laps in five minutes, which equates to 12 seconds per lap. The question is on which track can a player theoretically get their fastest lap time? Because the tracks are a different size, the time per unit length will also be calculated so that a comparison between the two can be made.

Theory

Static friction is the frictional force that acts when there is no sliding between the two surfaces in contact [1]. The maximum static friction is the maximum force at which the object stays unmoved. This can be seen in the static friction relation where the maximum static friction is defined as

$$f_{s,\max} = \mu_s F_n \ , \quad (1)$$

where μ_s is the coefficient of static friction and F_n is the force normal to the surface. μ_s is dependent only on the material properties of the track and of the skaters' wheels.

For this paper it is assumed that the materials are the same and at constant temperature for both track scenarios. A value of 0.5 is assumed because this is the value of polystyrene on polystyrene [2], which is a good comparison to polyurethane wheels on a vinyl sports track. The coefficient of rolling friction is assumed to be negligible and the skaters' weight to be evenly distributed over all eight wheels throughout.

Flat Track

Even though a roller derby track is oval in shape the preferred path of many skaters is roughly circular as the skater cuts in at the corners and sweeps out on the straights. If we take this into consideration, the average radius of a regulation flat track skating path is 8.6m [3].

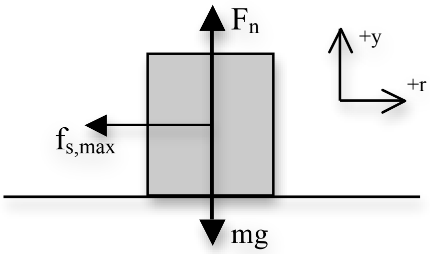

Figure 1: Free body force diagram for skaters wheel on a flat track.

Figure 1 shows a free body diagram of a wheel on the track. From this we can take the sum of the acting forces and equate it to the mass of the skater times the centripetal acceleration. The velocity in the equation is the maximum velocity the skater can go at before the skater slides outwards. Rearranging for this value,

$$v_{\max} = \sqrt{r\mu_s g} \quad , \quad (2)$$

where r is the track radius and g is the acceleration due to gravity. The value obtained is 6.5 ms^{-1}, which is the equivalent of 8.3 seconds per lap. The circumference of the flat track path is around 54m and therefore the time per unit length is 0.15 seconds per metre.

Banked Track

Figure 2 shows a free body diagram of the banked track situation.

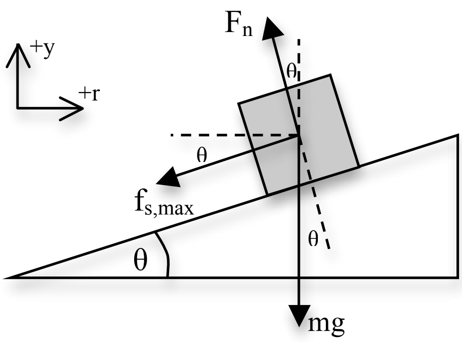

Figure 2: Free body force diagram for skaters wheel on a banked track.

Following the method used for the flat track, the radius of the skater's path is 10.2m [4]. The θ value is the bank elevation angle of 9.6° [5], and is assumed to be constant over the entire track length.

The resolved forces are rearranged for the maximum velocity and the equation found to be,

$$v_{\max} = \sqrt{\frac{rg(\sin\theta + \mu_s \cos\theta)}{\cos\theta - \mu_s \sin\theta}} \quad . \quad (3)$$

This is calculated as $8.6ms^{-1}$, and therefore 7.5 seconds per lap. Working out the banked track circumference to be 64m it is found that the time to skate per unit length is 0.12 seconds per metre.

Conclusions

A skater has been found to get their fastest lap time on a banked, rather than a flat, roller derby track. This is due to a component of the force of gravity aiding the frictional force in keeping the skater on their circular path.

If we take the times to skate per unit length for both tracks and calculate the time to skate over 100m a better comparison can be seen. For the flat track, 100m would take 15 seconds and for the banked track it would take 12s. This shows that over a significant distance the seemingly small time difference adds up and banked track becomes considerably faster. The lap times show that even though the banked track path has a longer lap distance the skater can easily overcome this and perform better than they could on flat track. The number of laps that can be completed on the flat track is 36. This is a reasonable number for a fast skater, showing the results of this investigation are not unrealistic.

References

[1] P.A. Tipler, G. Mosca, *Physics For Scientists and Engineers – Sixth Edition* (W.H.Freeman and Company, 2008), p.129.

[2] http://www.school-for-champions.com /science/friction_coefficient.htm (20/10/11)

[3] WFTDA, *WFTDA Standardized Flat Track Roller Derby Rules* (2010), Appendix B: WFTDA Track Design.

[4] http://www.kittentraxx.com /goingbanked.htm (20/10/11)

[5] https://share.ehs.uen.org/node/8607 (20/10/11)