Journal of Interdisciplinary Science Topics

The Winter Olympics on Enceladus

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24/03/2014

Abstract
The viability of Enceladus as a future location for The Winter Olympic Games is considered, using the large hill ski jumping event of the Sochi 2014 slope as a case study. Different conditions are found to significantly increase descent and air time, while the lack of a significant atmosphere could lead to interesting developments in the sport.

Introduction

Despite the successes of the Winter Olympic Games over the last century, increasing costs and political tensions highlight the need for neutral ground if the event is to continue into the future. Looking out into the solar system, Saturn's icy moon Enceladus is an obvious choice. Blankets of snow up to 100 metres thick are estimated in some regions [1], made of the finest particles, making it ideal for winter Olympic events. To assess the viability of such a proposal, the ski jumping large hill event is investigated as an example of how Olympic athletes would need to adapt to compete on this distant moon.

Skiing on Enceladus

Aside from the need to wear space suits, differences in gravity and atmospheric density are likely to be the key factors affecting skiing events. The surface gravity of Enceladus is 0.113 ms^{-2}, approximately 1.15% that of Earth [2], while the atmospheric density is currently approximated to be around 2.99×10^{-12} $kg\ m^{-3}$, based on Cassini data and computational simulations [3]. For simplicity, an assumption is made here of an atmosphere composed entirely of water vapour (the measured value is 91% [3]). As this value is approximately a trillion times smaller than the atmospheric density on Earth, air resistance is deemed negligible. To give a good indication of the differences on Enceladus compared to on Earth, the dimensions of the Olympic hill of the recent large hill ski jumping event in the 2014 Sochi Olympics are used [4].

Assuming the skier starts at the maximum in-run length (the top of the slope), upon release the skier will begin to accelerate due to gravity, slowed by friction between the skis and the snow (*figure 1*). The total force (F_{Total}) will hence be

$$F_{total} = F_{parallel} - F_{friction}.$$

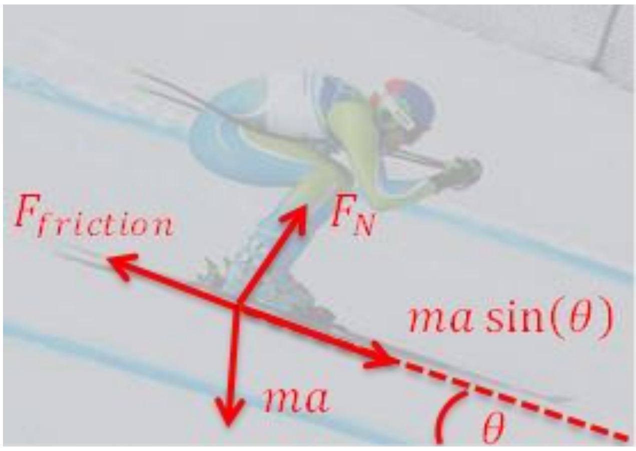

Figure 1: The forces acting on the skier when descending the slope. Image credit: Wikipedia (modified).

If the mass of the skier is taken to be 70kg and the slope angle is taken to be 35° [4], the force parallel to the slope will be

$$F_{parallel} = ma\sin(\theta)$$
$$F_{parallel} = 70kg \times 0.113ms^{-2} \times \sin(35°)$$
$$F_{parallel} = 4.537N.$$

The friction force is given by

$$F_{friction} = F_N \mu_k,$$

where μ_k is the coefficient of kinetic friction, which for waxed skis on snow is 0.05 [5] (an approximation is made here as this is the value at 273K with Earth's gravity, while Enceladus is roughly 72K [2], hence this is likely a lower limit).

$$F_{friction} = ma\cos(\theta) \times 0.05$$
$$F_{friction} = 70kg \times 0.113ms^{-2} \times \cos(35°) \times 0.05$$
$$F_{friction} = 0.324N,$$

giving a net force of

$$F_{total} = 4.213N.$$

The acceleration of the skier is then

$$a = \frac{F_{total}}{m}$$
$$a = \frac{4.213N}{70kg} = 0.060ms^{-2}.$$

The velocity at the bottom of the slope can be found using

$$v_f^2 = v_i^2 + 2as,$$

where s is the length of the slope, v_i is the initial velocity and v_f is the final velocity. Using 99.3m as the length of the slope [4], and substituting this and the value for acceleration gives

$$v_f^2 = 0 + 2(0.060ms^{-2} \times 99.3m)$$
$$v_f = 3.452\ ms^{-1}.$$

The skier takes off at an angle of 11° and a height of 3.14m [4], after which the only force acting on them is gravity. Change in height over time can be calculated using

$$y = v_0^y t + \frac{at^2}{2}, + y_0$$

where y_0 is the initial height, and v_0^y is the initial vertical velocity, given by

$$v_0^y = 3.452ms^{-1} \times \sin(11°) = 0.659ms^{-1}.$$

Plotting values of the skier's height against time gives the graph shown in *figure 2*, where the skier lands after approximately 9 seconds. The horizontal displacement will be the horizontal velocity multiplied by time, resulting in a horizontal displacement of

$$x = 3.452ms^{-1} \times \cos(11°) \times 9s$$
$$x = 30.5m.$$

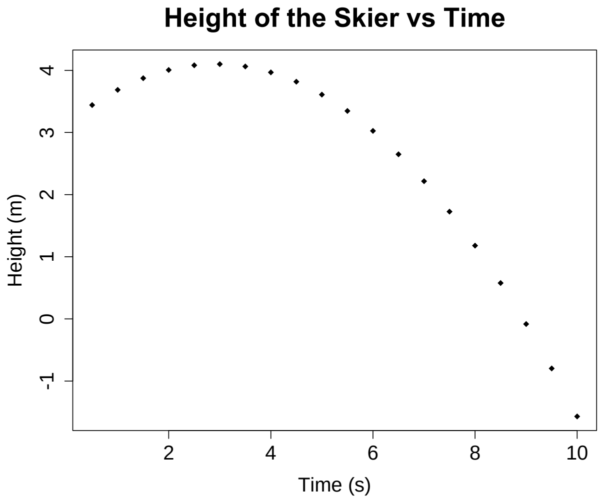

Figure 2: The height of the skier over time once in the air.

Discussion and Conclusion

In comparing the calculated results to the 2014 Sochi Olympics [6, 7], an average distance reached would only be a fifth of that seen on Earth. Furthermore, dividing the take off velocity by the acceleration shows around 30 seconds would be needed to reach the bottom of the slope, compared to around 5 seconds as seen at Sochi [6], while the time spent in the air nearly doubles on Enceladus. Such changes would likely result in a much calmer, safer sport. Interestingly, the lack of a significant atmosphere would make friction the only component dependent on the athlete, which would depend on the athlete's mass. This would likely shift the attention away from a focus on reducing drag to that of reducing friction, perhaps encompassing techniques used in curling in some way, giving just one example of how The Winter Olympic Games can have a bright future on the brightest moon in the solar system.

References

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