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P5_7 Artificial Gravity for Kicks

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Abstract

In the film *Inception*, Arthur uses explosive devices to create artificial gravity in a zero-g dream. We estimate that the mass of TNT required to simulate gravitational acceleration on a lift containing six people is 11.6 kg. Finding that this is an unreasonable mass considering the size of the explosive devices in the film, we propose an alternative method requiring only 0.70 kg of TNT.

Introduction

In *Inception*, Arthur must create a gravitational 'kick' in order to wake up five people. Kicks are usually achieved by dropping the sleeper, creating the sensation of falling. However when Arthur's own dream world is suspended in weightlessness, he has to create a kick without the aid of gravity. In the film, Arthur attaches explosives to one end of a lift with the floating sleepers inside. The resulting acceleration simulates the sensation of gravity. We estimate how much TNT this required and also suggest a more efficient method which creates artificial gravity via centripetal acceleration.

Arthur's Method

We estimate the mass of the empty lift to be 1200 kg [1] and the payload of six adults to be 6x70 kg, giving a combined dry mass M_d of 1620 kg. In the film, Arthur attached two hand-held explosive devices to the end of the free-floating lift. There is some controversy amongst fans over the timing of this scene in relation to the dream structure. In the film we think the resulting explosion appears to be non-instantaneous and rocket-like with a burn time, Δt, of 5 seconds [2]. For simplicity we will assume that the devices remain fixed to the lift and that they direct the exhaust linearly down the lift shaft in the plane of acceleration. This means we can model the lift as a rocket. As there is no clear indication in the film as to how much acceleration is required for a successful kick, we will assume the full effect of gravity is required, ie. gravitational acceleration on Earth, g, which is 9.81 m/s. Assuming the acceleration is constant, we calculated the required change in velocity, Δv, to be 49.05 m/s. We rearranged Tsiolkovsky's rocket equation [3] to find the mass of the fuel required, M_f, where v_e is the exhaust velocity.

$$M_f = M_d e^{\frac{\Delta v}{v_e}} - M_d, \tag{1}$$

For TNT, v_e is 6900 m/s [4], therefore using Eq. 1 the mass of TNT required is 11.6 kg, resulting in each explosive device having a mass of at least 5.8 kg.

Rotational Method

On a rotating spacecraft passengers experience artificial gravity due to a centripetal force [5]. The centripetal acceleration [6] needs to equal g, such that

$$g = \frac{v_t^2}{r}, \quad (2)$$

where v_t is the tangential velocity and r is the radius from the centre of rotation. We assume that three people are positioned on the floor and three on the ceiling so that the centre of mass is also the rotation point, A, shown in Fig.1 .

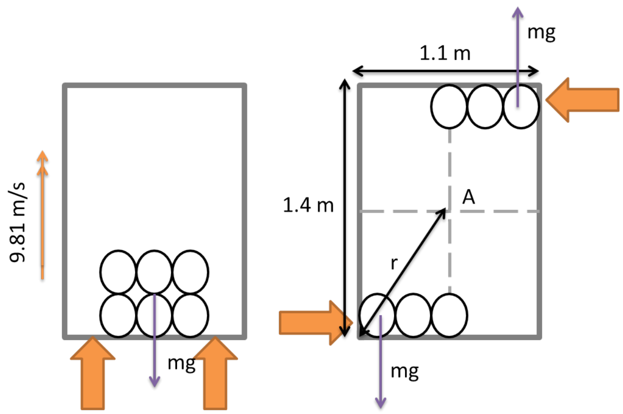

Figure 1: Arthur's linear acceleration method (left) and our rotational method (right). Points where explosives are attached are shown as orange arrows. Humans are modelled as circles. The dimensions of the lift were sourced from [7]. The 8 person lift was used as it had the most similar dimensions to the lift in the film.

Since the devices act on the corners, r was calculated by Pythagoras' theorem to be 0.89 m. From Eq. 2, we calculate the v_t required is 2.95 m/s, therefore each device has to contribute a Δv of 1.31 m/s. Substituting this as before into Eq. 1 gives a total requirement of 0.70 kg TNT, equivalent to 0.35 kg per device.

Discussion

The mass of TNT required for Arthur's method to be successful seems far greater than the mass of the hand-held devices as they appear in the film. For comparison, the density of TNT is 42 kg/m^2 [4], so the required volume of TNT per device for Arthur's method is equivalent to a cube of side length 52 cm, or 20 cm for our method. While our method still requires a slightly larger device than the ones shown in the film, it is a much more feasible approximation than Arthur's method. Our model assumes that there is room in the lift shaft to rotate the lift freely. We also neglect air resistance. While we assume this to be negligible for the rotational case due to the slow rotational speed, it is certainly not negligible in Arthur's high velocity method. The retarding force of air resistance would further increase the required mass of TNT, making his method even less viable. The main limitation in our model is that the centripetal force is not uniform along the sides of the lift due to the lift being a cuboid. People closer to the centre will be rotating more slowly so will not experience as much force as those in the corners. In order to ensure everyone experiences the kick, Arthur would need to acquire a cylindrical lift.

Conclusion

Our calculations suggest that the method used by Arthur to create artificial gravity is unlikely to be achievable considering the mass of hand-held devices required. We have proposed a centripetal model instead which has a much more reasonable fuel mass requirement, proving that Arthur can still create the kick provided he has the appropriate knowledge of rotational dynamics.

References

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