Journal of Physics Special Topics

An undergraduate physics journal

P2 6 Welcome to the Space Jam

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December 6, 2023

Abstract

This paper investigates at what radius away from Earth the game winning dunk from Space Jam would be possible. It was found that a gravitational acceleration of 1.21 ms^{-2} would be required, leading to a distance of 1.63×10^{8} m away from the surface of the Earth. The body with the most similar gravitational force to this was found to be one of Jupiter's moons, Europa.

Introduction

In the 1996 movie Space Jam, NBA star Michael Jordan is transported into the world of the Looney Tunes, and must win a basketball game in space (the titular Space Jam) in order to escape [1]. The game winning dunk by Jordan involves an initial jump from the half-court line, using a player from the opposing team as a step up (Figure 1). This paper investigates at what radius from Earth the gravitational acceleration would be low enough for the dunk to be possible. We ignore the cartoon physics of Jordan's stretching arm, the initial step up off of an opposing player, and the opposing team hanging onto Jordan.

Figure 1: The game winning dunk. [1]

Results

We began by calculating the gravitational potential energy of Jordan's maximum vertical jump height on Earth, and equating it to the equation for kinetic energy. Jordan's maximum vertical jump height in 1996 was 1.22 m [2]; taking his mass to be 88 kg [3] and gravitational acceleration to be 9.81 ms^{-2}, we obtained a value of 1.06 kJ. As all of this energy is transferred from the initial kinetic energy of the jump, we determined Jordan left the ground at 4.89 ms^{-1} through the kinetic energy equation:

$$v = \sqrt{\frac{2E}{m}} \tag{1}$$

During the game winning dunk, Jordan is in the air for 6 seconds [1], jumping from the half-court line towards the basket 14 m away [4]; the maximum height of the jump having his body aligned with the top of the backboard, 3.96 m off of the ground [5]. This means the energy of the jump would need to be acting at an angle. In order to find this angle, we can use projectile motion equations, specifically:

$$v_x = v_0 cos(\theta), \quad (2)$$

$$v_y = v_0 sin(\theta), \quad (3)$$

where v_x and v_y are the horizontal and vertical components of velocity respectively, v_0 is the initial velocity (the aforementioned 4.89 ms^{-1}), and θ is the angle. As the horizontal component of velocity is simply distance travelled divided by time taken, we calculated a value of 2.33 ms^{-1}. Equating this to Equation 2 we find a θ value of 61.5° from the horizontal plane, leading to a calculated vertical component of velocity of 4.30 ms^{-1} from Equation 2. As we now obtained a value for the vertical component of velocity, we were able to calculate the downward acceleration using the constant acceleration equation,

$$\Delta x = v_y t + \frac{1}{2} a t^2, \quad (4)$$

where Δx is the vertical distance, t is time, and a is the acceleration. Using the values introduced earlier, and rearranging for acceleration, a value of 1.21 ms^{-2} to 3 significant figures in the downward direction was calculated.

Furthermore, the radial distance from Earth required to achieve this gravitational acceleration can be found using Newton's universal law of gravitation,

$$F = \frac{GMm}{r^2}, \quad (5)$$

where F is the gravitational acceleration, G is the gravitational constant, M is the mass of the Earth, m is the mass of Jordan, and r is the distance between the centre of the two masses. Using a gravitational constant of 6.67×10^{-11} $\mathrm{m^3 kg^{-1} s^{-2}}$, the mass of the Earth as 5.97×10^{24} kg, and rearranging for r, the radial distance was calculated to be 1.70×10^8 m to 3 significant figures. Using a value of 6.38×10^6 m for the radius of the Earth, we found the altitude of Jordan to be 1.63×10^8 m.

Conclusion

The calculated distance between Jordan and the Earth is very large. The Karman line (the altitude at which space begins) is around 1000 times smaller than the altitude of Jordan [6], and therefore we can definitely say that the Space Jam is in space. Furthermore, Jordan would be situated at just over 40% of the distance between the Earth and the Moon. While it's perfectly reasonable for Jordan to be at this distance from Earth (assuming there is a basketball court there), he would be much more comfortable on the Jupiter moon Europa, which has a gravitational acceleration of 1.32 ms^{-2} [7]. While this gravitational acceleration is slightly greater than our requirements, Jordan might still be able to achieve the dunk if the step up off of the opponent was factored into the calculations.

References

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