Duality of Free Fall: Is Force Application Possible?

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Abstract

This paper discusses a hypothetical scenario where a person and a massive rock are in free fall. It explores how the person might attempt to decrease the rate of falling and assesses whether such an attempt would be successful. The paper examines the dynamics of force application in free fall and the limitations imposed by weightlessness.

Main Question: Can You Jump While Standing on a More Massive Object while falling?

Let's address the question directly:

Can you jump upward to decrease the rate of fall while standing on an object (such as a table) that has a greater mass than you, assuming air resistance is neglected?

Condition

Now, consider a scenario where you are standing at a height ‘x’ meters and are about to jump. However, this time, you are standing on a large rock (let’s call it a boulder) that has a significantly greater mass than you do. Specifically, the mass of the boulder M is much greater than your mass m (i.e., M>m).

Analysis

To address the question, let’s delve into the physics involved. According to Newton’s Third Law of Motion, which states that "for every action, there is an equal and opposite reaction," when you jump while standing on the surface of the Earth, you exert a downward force on the ground. In response, the Earth exerts an equal and opposite force upward, which propels you into the air. However, because the mass of the Earth is vastly greater than the mass of a person, the Earth's movement in response to this force is negligible. The difference in mass is so immense that the effect of the Earth moving downward is virtually imperceptible, resulting in an instantaneous and effective jump for the person.

Relativity Perspective:

From the theory of relativity, we know that everything is about frames of reference and perspective. The same situation can be perceived differently by different observers. For instance, if you were in an elevator and it began to move upward, you might feel a stronger gravitational force, whereas if it moved downward, you might feel a weaker gravitational force. If the elevator's velocity exceeded $g=9.8\ m/s^2$, you might even float and experience weightlessness.

On the other hand, relativity teaches us that if you are in a situation where there is nothing around you except yourself, it is impossible to determine whether you are in motion or at rest. This concept is known as the principle of relativity.

Applying this to your scenario: if you are inside an isolated elevator with no external reference points and the elevator is moving with a constant velocity, you cannot tell whether the elevator is moving or stationary. From your perspective inside the elevator, you would feel as if you are at rest, even though the elevator might be moving relative to the outside world.

According to relativity, as long as the velocity of the elevator remains constant (i.e., it moves at a steady speed in a straight line), the laws of physics will appear the same to you as if you were at rest. This means that from your perspective, the elevator's motion does not affect the fundamental laws of physics you experience.

In summary, even if you are in motion from an external perspective, inside the elevator, you would experience the same physical laws as if you were at rest, provided the elevator’s velocity is constant.

Explanation

As we discussed regarding the principle of relativity and perspective in the previous explanation, let’s now consider the situation of standing on a boulder. This scenario can be analyzed through two possibilities.

Possibility1:

Since you and the boulder are falling together, from your perspective, it feels like you are at rest relative to the boulder. In other words, you don't feel the boulder moving away from you; you feel as though you are stationary relative to it because both are falling with the same acceleration due to gravity. Despite being in free fall, you are still at rest with respect to the boulder. According to Newton's Third Law of Motion, if you push against the boulder, you will experience an equal and opposite force. This means you can reduce the rate of fall.

For this phenomenon to occur, the force applied by the person on boulder must be equal to or greater than the value of acceleration due to gravity.

$$F \geq mg$$

Here,

F is force applied by person, m is mass of person and g is acceleration due to gravity.

Hence, we can say that the person is only be able to jump when it applies force more that the value of g. This means you can pull back yourself and decrease the rate of falling.

Possibility2:

Looking at the overall scenario, we know that while an object is in free fall, it experiences weightlessness. In this case, a person standing on a boulder, with both falling toward the Earth, will experience the same phenomenon. Since both the person and the boulder are in free fall, the weight of the object becomes effectively zero, regardless of the size or mass of the boulder.

$$W = 0 \ = mg$$

Here, W is the weight. Since, $F = mg$, we can write,

$$F = W$$

This relation shows that while you are in free fall, there is no possibility of using an external force to counteract the fall and pull yourself back up.

Conclusion

In this research, we examined the situation of a person standing on a massive rock while both are in free fall. We found that although the person can apply force relative to the rock, their ability to change the rate of falling is limited. The uniform acceleration experienced in free fall means that significant changes to the fall trajectory are not possible.