GRAVITATION

WEIGHTLESSNESS

Weightlessness is a term used to describe the sensation of a complete or near-complete absence of weight. Astronauts orbiting the Earth often experience the sensation of weightlessness. These sensations experienced by the orbiting astronauts are the same sensations experienced by anyone who has been temporarily suspended above the seat on an amusement park ride. The causes of the sensation of weightlessness in both these cases are the same.

We Feel Weightless

Weightlessness is a sensation experienced by an individual where there are no external objects touching one's body. In other words, the sensation of weightlessness exists when all contact forces are removed. These sensations are common to the state of free fall.

During free fall, the only force acting on the body is the force of gravity. As gravity is a non-contact force, it cannot be felt without any opposing force. This is the reason why you feel weightless when in a state of free fall.

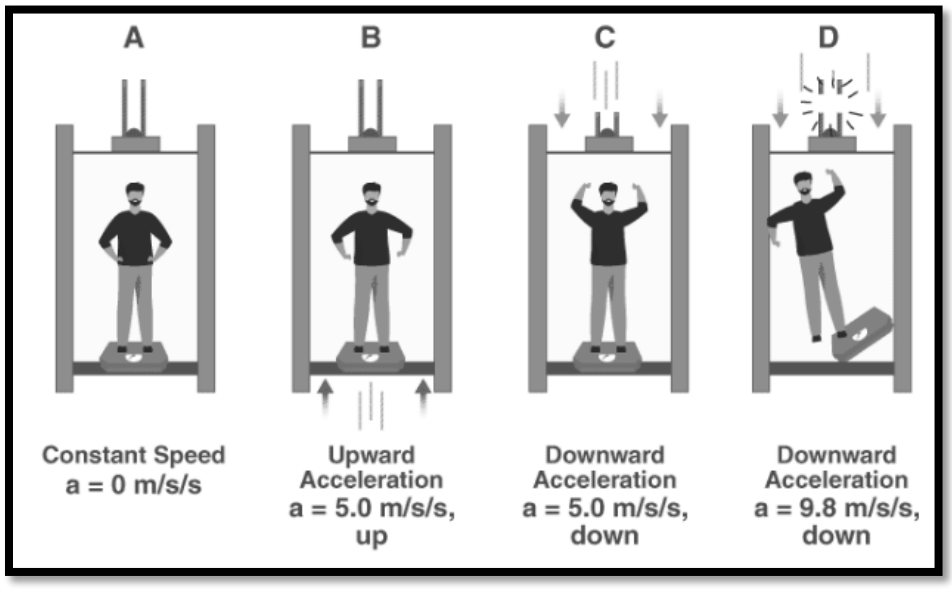
It is important to remember that weightlessness is only a sensation and not a reality corresponding to an individual who has lost weight. Weightlessness has a little to do with weight and a lot to do with the presence and absence of contact forces.

Otis L. Evaderz's Elevator Experiment

Did you know that the weighing scale doesn't measure one's weight? Rather the scale reading is the measure of the upward force applied by the scale to balance the downward force of gravity acting upon the person standing on the scale. When the body is in equilibrium, the two forces are balanced. The upward force exerted upon the person equals the downward pull of gravity. In such instances, the scale reading equals the weight of the person. However,

if the person standing on a weighing scale bounces up and down, the scale reading undergoes a rapid change. While bouncing, the body is accelerating. As a result, the upward force of the scale is changing. Does this mean that the weight is also changing? Of course not! You weigh the same. Only the scale reading changes because it doesn't measure your weight but is a measure of the contact force that is being applied to the body.

Otis L. Evaderz conducted his famous elevator experiment riding the elevator up and down while standing on a bathroom scale. He noticed that the scale reading was different while he was accelerating up and down and while he was at rest or travelling at a constant speed. We know that the scale reading is a measure of the upward normal force, therefore its value can be predicted during various stages of motion. The value of Normal force acting on Otis's 80-kg body could be predicted if the acceleration is known. This prediction is made by applying Newton's second law of motion.



In the diagram, Otis's 80-kg is traveling with constant speed (A), accelerating upward (B), accelerating downward (C), and free-falling (D) after the elevator cable snaps. The normal force is greater than the force of gravity when the elevator accelerates upwards (B). And it is lesser than the force of gravity where there is a downward acceleration (C and D) and is equal to the force of gravity when there is no acceleration.

Since the normal is responsible for the sensation of weight, the elevator rider would feel his normal weight in case A, slightly heavier in case B, and less than his normal weight in case C. In the case of D, the rider would feel weightless, without an external force acting on him, he would feel no sensation of weight. Concluding we can say that the rider weighs the same in all four cases, yet the sensation of weight felt by him is different. The sensation of weight felt by the rider fluctuates throughout the ride.

Astronauts Feel Weightless in Space

Astronauts orbiting in space feel a sense of weightlessness because there is no external contact force in space pushing or pulling upon their bodies. Gravity is the only force acting upon their body. Gravity being an action-at-a-distance force cannot be felt and therefore would not provide any sensation of weight.

Do Astronauts Experience Weightlessness Because There Is No Force of Gravity in Space

Many students are under the assumption that astronauts feel weightlessness because there is no force of gravity in space. This is not true. If it were true then it would violate the circular motion principles. If a person believes that the absence of gravity in space is the reason for weightlessness then they would have to come up with a reason for how astronauts are orbiting in space?

The Gravity in Space Lesser than the Gravity on the Earth

The force of gravity acting on the astronaut in space is certainly lesser than the gravity on Earth's surface. But it is not small enough to account for a drastic reduction in weight. Let us consider the space station to orbit at an altitude of approximately 400 km above the Earth's surface, then the value of g at that location will be reduced from 9.8 m/s^2 to approximately 8.7 m/s^2. While it certainly reduces weight, it does not account for the absolutely weightless sensations that astronauts experience. Their absolutely weightless sensations are because of the absence of a surface to support them as they are free-falling towards the Earth.