True and Apparent Weight

True Weight \((W_T)\): The weight of an object when the net force in the y-direction is 0.0N.

Apparent Weight \((W_A)\): The weight of an object when it is accelerating upwards or downwards.

Weightlessness: Weightlessness is experienced when the acceleration of a person in the downward direction matches the acceleration of gravity.

- When an object accelerates upwards, the apparent weight is going to be greater than the true weight.
- When an object accelerates downwards, the apparent weight is going to be less than the true weight.

The theory behind this (we’ll use an elevator to help explain):

First, we need to know that it is the normal force that a scale has to push back up on the person to support the person’s weight.

If the elevator is stationary, then \(F_{\text{net}} = F_g + F_N\). In this case, \(F_N = -F_g\). So basically, the scale will read the force of gravity of the person. This is the person’s true weight.

When the elevator accelerates upwards, the scale will read a different number. This number is referred to as the apparent weight. Since the elevator is going upwards, it means that the force upwards will be larger than the force downwards. The scale has to push up on the person:

a. enough to cancel the force of gravity (since the person isn’t falling downwards) and
b. an extra little bit to push the person upwards (net acceleration must be in the upwards direction)

When an elevator is accelerating upwards:

\[
\text{Apparent weight} = ma - mg
\]

If the elevator accelerates in a downwards direction, the scale will also show an apparent weight, not the true weight. However, this time the logic is different. Again, the person’s true weight is the force of gravity. However, since it is accelerating downwards, the force of gravity must now be larger than the normal force. Since the normal force is less than the force of gravity, the apparent weight of the person will be less.

When an elevator is accelerating downwards:

\[
\text{Apparent weight} = ma + mg
\]

Note: Both formulas are the same. Just make sure you put in values as negatives when they should be negative!
Example Questions

1. A man has a mass of 82kg. While standing in an elevator that is accelerating upwards at 1.3m/s², what is the true and apparent weight of the man?

True weight – always equal to the force of gravity (but must be a positive value)

\[ F_g = mg = (82\text{kg})(-9.81\text{m/s}^2) = 804.42\text{N} = 8.0\times10^2\text{N} \]

Apparent Weight is equal to \( mg + ma \) so:

\[ W_A = ma - mg = (82\text{kg})(1.3\text{m/s}^2) - (82\text{kg})(-9.81\text{m/s}^2) \]
\[ W_A = 911.02\text{N} = 9.1\times10^2\text{N} \]

2. The same man with a mass of 82kg takes the same elevator back down to the ground floor. The elevator accelerates downwards at \(-1.3\text{m/s}^2\). What is the apparent weight of the man?

\[ W_A = ma - mg = (82\text{kg})(-1.3\text{m/s}^2) - (82\text{kg})(-9.81\text{m/s}^2) = -804.42\text{N} + 106.6\text{N} \]
\[ W_A = 697.82\text{N} = 7.0\times10^2\text{N} \]

3. A man has a mass of 102kg. While riding in an elevator, he has an apparent weight of 725N. Is the elevator accelerating upwards or downwards? What is the acceleration of the elevator?

We can figure out if the elevator is going up or down by comparing it to the true weight.

\[ W_T = mg = (102\text{kg})(-9.81\text{m/s}^2) = -1000.62\text{N} \]

The true weight is \(1.00\times10^3\text{N}\)

Since the apparent weight is less than the true weight, the elevator must be accelerating downwards.

\[ \text{Apparent weight} = ma - mg \]
\[ 725\text{N} = (102\text{kg})a - (102\text{kg})(-9.81\text{m/s}^2) \]
\[ 725\text{N} = (102\text{kg})a + 1000.62\text{N} \]
\[ -275.62\text{N} = (102\text{kg})a \]
\[ -2.70\text{m/s}^2 = a \]