From: http://www.reference.com/browse/wiki/Apparent_weight

Apparent weight

An object's weight, henceforth called "actual weight", is the downward force exerted upon it by the earth's gravity. By contrast, an object's **apparent weight** is the upward force (the *normal force*, or *reaction force*), typically transmitted through the ground, that opposes gravity and prevents a supported object from falling.

It is apparent weight, rather than actual weight, that a spring weighing scale measures. Apparent weight is also responsible for our sensation of the weight of our own bodies. A greater apparent weight results in a heavy or greater sensation of our weight, and vice-versa. An object's apparent weight is equal to its actual weight, except if:

- The object has an acceleration with a vertical component (relative to the earth), as in a lift, a rocket or a rollercoaster.
- Some force other than the earth's gravity and the normal force is acting on the object. This may be buoyancy, magnetic force, centrifugal force, or the gravitational force of another body.

Objects at rest

Suppose that Alice has a mass of 65 kilograms and is standing stationary on the floor. Gravity is pulling her downward with a force of:

$$\begin{aligned} F_{\text{gravity}} &= mg \\ &= 65\ \text{kg} \times 9.81\ \text{m/s}^2 \\ &= 637.65\ \text{N (newtons)} \end{aligned}$$

where m is mass and g is the acceleration due to gravity. By definition, F_{gravity}, the downward force of gravity, is Alice's actual weight. (Note that the force of gravity varies slightly over the surface of the earth, and 9.81 m/s² is only an approximate value. See Gee, Physical geodesy, Gravity anomaly and Gravity for further information.)

However, since Alice is at rest, the *net* force acting on her must be zero (otherwise Alice would be accelerating, according to Newton's second law). Since the net force is zero, the upward force exerted by the floor must exactly balance the downward force of gravity, meaning that Alice's actual weight and apparent weight are the same. (Here we are ignoring some minor effects such as buoyancy and centrifugal force, discussed later.)

It is the reaction force transmitted through the floor, not gravity pulling on her, that makes Alice feel heavy. The crucial difference is that gravity is a long-range force that acts uniformly throughout an object, while reaction forces are short-range forces that act only on the surfaces of an object. Reaction forces are transferred throughout the body, causing it to deform slightly and allowing stresses to build up. Gravity, because it acts uniformly, does not cause such stresses.

Objects accelerating vertically

If an object is accelerating upwards or downwards then its apparent weight respectively increases or decreases. Consider Alice again, but now in a lift accelerating downwards at 3 m/s^2 (metres per second per second). Let $F_{gravity}$ be the downwards force on Alice due to gravity, F_{normal} be the normal (upwards) force exerted by the floor of the lift, and F_{net} be the net force on Alice.

It is essential to be clear about the signs of these forces and accelerations. Let us take downward forces and accelerations to be positive and upward forces and accelerations to be negative. This means that $F_{gravity}$ is positive, F_{normal} is negative, and Alice's acceleration is positive.

We know that Alice is accelerating at +3 m/s^2, and we know that her mass is 65 kg. Applying Newton's second law, we have that

$$\begin{aligned} F_{net} &= ma \\ &= 65\text{ kg} \times 3\text{ m/s}^2 \\ &= 195\text{ N} \end{aligned}$$

However, this net force is the sum of the force due to gravity and the normal force. Thus,

$$\begin{aligned} F_{gravity} + F_{normal} &= F_{net} \\ &= 195\text{ N} \end{aligned}$$

We already know from the earlier example that Fgravity = 637 N. Therefore

$$637\text{ N} + F_{normal} = 195\text{ N}$$

so

$$F_{normal} = -442\text{ N}$$

Thus the normal force is 442 N (upwards), so Alice's apparent weight is 442 N, and it feels to Alice as if her weight has decreased by about 30% — even though her *actual* weight (the force exerted on her by gravity) remains unchanged. If Alice were standing on a weighing scale then the weight registered would also be 442 N. This is because a scale does not measure an object's actual weight, but rather measures the force that it exerts on the scale.

The workings above consolidate into the neat formula

$F_{normal} = m(a - g)$

We can now more easily examine what happens when a takes a range of different values. The formula shows that when $a = 0$ we have $F_{normal} = -mg$, which is, as expected, just the formula for Alice's actual weight (with the negative sign reflecting the fact that the normal force is upwards).

For increasingly positive a (increasing downward acceleration), the absolute magnitude of F_{normal} (the magnitude ignoring the sign) steadily decreases, meaning that Alice's apparent weight steadily decreases. Conversely, for increasingly negative a (increasing upward acceleration), Alice's apparent weight steadily *increases*.

It is important to understand that it is *acceleration*, not velocity, that causes changes in apparent weight. In a lift travelling upwards or downards at any *constant* speed – however great – Alice's apparent weight will be the same as if the lift were at rest.

Free-fall

Apparent weight decreases with increasing downward acceleration until eventually a reaches g (the acceleration due to gravity, 9.81 m/s^2), when the formula shows that Alice's apparent weight is *zero*. At this point the floor of the lift no longer provides any supporting force at all, the only force acting on her is gravity, and Alice is in free-fall. During free-fall Alice experiences weightlessness.

Free-fall also occurs, of course, if Alice is falling freely through the air (in the absence of any containing lift). Ignoring air resistance there is again no supporting force, and no sensation of weight. Objects in orbit are also in free-fall; the mechanics are explained at Orbit.

"Beyond" free-fall

If a increases beyond g then the formula shows that F_{normal} becomes *positive*, meaning that the normal force acts *downwards* and Alice experiences a "negative apparent weight". In fact, what happens is that Alice "falls" to the ceiling of the lift, which she now experiences as a floor, and which now provides a "supporting" force.

Objects accelerating in arbitrary direction

In general, an object's apparent weight is its mass multiplied by the vector difference between the gravitational acceleration and the acceleration of the object. This definition means that apparent weight is a vector that can act in any direction, not just vertically. For example, in a racing car accelerating horizontally at 1 *g*, apparent weight acts at an angle of 45 degrees downwards.

Buoyancy

Apparent weight is lessened by buoyancy, which occurs when an object is immersed in a fluid (a liquid or a gas). For example, an object immersed in water weighs less, according to a spring balance, than the same object in air. The apparent weight of a floating object is zero.

This effect is quite different from the accelerating lift examples. A floating or immersed object is not accelerating upwards or downwards, so there can be no net force. In fact, buoyancy provides a supporting force exactly as the ground does. Because this force is diffuse and dispersed over the surface of the body, a feeling of "pseudo-weightlessness" arises when one is floating.

Objects also experience some buoyancy in air, so even in air the normal force (apparent weight) is slightly less than the true force of gravity. Most objects are much denser than air and so the difference is usually small. However, for objects of very low density the relative effect can be large. In fact, an object that is lighter than air, such as a helium balloon, has a *negative* apparent weight (as does an object lighter than water when it is forcibly pulled below the surface).

Other factors

In general, any force (other than the normal force) that opposes or augments the downwards force of gravity will have an effect on apparent weight. Some examples are:

- Centrifugal force. Because the earth is rotating, objects on the earth's surface experience a small centrifugal force, which increases at lower latitudes (nearer to the equator). This offsets the force of gravity, resulting in a small decrease in the net downward force, and a corresponding small decrease in the balancing normal force.
- The gravitational effect of other astronomical bodies. Other astronomical bodies, particularly the sun and the moon, exert a very small gravitational force on objects at the earth's surface, depending on their relative positions. This causes the net gravitational force to vary by a small amount, and the normal force required to balance it to vary correspondingly.
- Magnetism. Strong magnetic fields have even been used to levitate frogs!