Flipping Physics Lecture Notes:

Apparent Weightlessness

In order for an object to have zero weight, the force of gravity acting on the object would need to be zero.

$$F_g = m_o g = m_o(0) = 0$$

In order for that to be true, the acceleration due to gravity would need to be zero.

$$F_g = m_o g = \frac{G m_o m_E}{r^2} \Rightarrow g = \frac{G m_E}{r^2}$$

In order for the acceleration due to gravity to be zero, the object would need to be infinitely far away from all other objects ($r \approx \infty$), which is impossible. Okay, so this is the simplest way to get something to be weightless, however, there are others. However, I am more concerned about the fact that Astronauts in space are often referred to as weightless, however, because none of those cases you just mentioned apply to Astronauts in space, astronauts in space are not weightless.

Solving for the acceleration due to gravity on the International Space Station.

Knowns: $Altitude_{ISS\ average} = 4.2\times10^5\ m;\ M_{Earth} = 5.97\times10^{24}\ kg;\ R_{Earth} = 6.371\times10^6\ m$ ♠

Note: The altitude of the International Space Station varies from 304 to 528 kilometers. We have taken an average of 420 km.♥

$$g_{ISS\ average} = \frac{G m_E}{\left(R_{Earth} + Altitude_{ISS}\right)^2} = \frac{\left(6.67\times10^{-11}\right)\left(5.97\times10^{24}\right)}{\left(6.371\times10^6 + 4.16\times10^5\right)^2} = 8.63441 \approx 8.6\frac{m}{s^2}$$

$$\frac{g_{ISS\ average}}{g_{Earth}}\times100 = \frac{8.63441}{9.81}\times100 = 88.0164 \approx 88\%$$

Objects in orbit are not weightless, however, they appear to be weightless because everything is falling at the same rate, hence, “apparent weightlessness”.

♠ https://nssdc.gsfc.nasa.gov/planetary/factsheet/earthfact.html

♥ https://www.nasa.gov/centers/kennedy/about/information/shuttle_faq.html#14