

## 5.6: The acceleration due to gravity

If you have studied some physics before reading this textbook, you may have been surprised by our choice of dimension for  $g$  to be force per unit mass rather than acceleration. This is indeed an unconventional choice as  $g$  is usually presented as “the acceleration due to Earth’s gravity” instead of the “strength of Earth’s gravitational field”. Our choice comes from the potential difference between inertial mass,  $m_I$ , and gravitational mass,  $m_G$ , which we distinguish in this section.

Consider the simple model of a mass falling freely near the surface of the Earth in the absence of air-resistance. The only force exerted on the mass is its weight,  $m_G \vec{g}$ , which is given in terms of gravitational mass (the mass that determines how an object experiences gravity). Both the weight and the acceleration of the object point downwards. The free-body diagram for the mass is shown in Figure 5.6.1, where the  $y$  axis was chosen to be vertically upwards (co-linear with the acceleration).

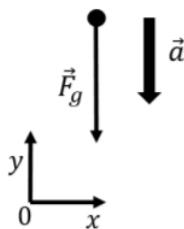


Figure 5.6.1: Free-body diagram for a mass that is free-falling in the absence of air resistance (drag).

Writing out the  $y$  component of Newton’s Second Law, being careful to distinguish between inertial and gravitational mass, and noting that both the weight and the acceleration are in the negative  $y$  direction:

$$\begin{aligned}\sum F_y &= -F_g = -m_I a \\ \therefore m_G g &= m_I a\end{aligned}$$

This makes it clear that  $g$  is not necessarily the acceleration due to gravity. It is only the acceleration due to gravity in the limit that the inertial and gravitational masses are the same. If  $m_G = m_I$ , then we have:

$$a = g$$

and indeed, the acceleration of objects near the surface of the Earth has a magnitude of  $g$ . It is also clear that the dimensions of  $g$  can also be written as an acceleration, and in most cases, one writes that, near the surface of the Earth,  $g = 9.8\text{m/s}^2$ . You should however remember that this is only true when inertial and gravitational masses are the same, and that  $g$  really should be thought of as the strength of the gravitational field, not as an acceleration.

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