4. Forces (1)

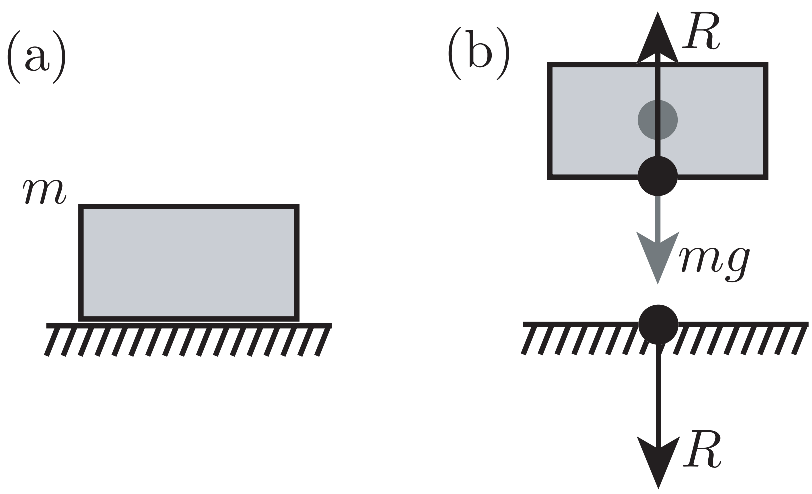
Weight:

The weight of a body, of mass m, is defined to be the force, $\underline{W}$, with which it is attracted to the Earth.

Its magnitude, W, is given by the Law of Gravitation with $r \approx R$ (radius of the Earth) as $W = \dfrac{mGM}{R^2}$, where M is the mass of the Earth. Weight is also given by Newton's Second Law. For a body falling under gravity with constant acceleration g 'close to the Earth's surface' $\underline{W} = m\underline{g}$ and so $g = \dfrac{GM}{R^2}$; $g \approx 9.81\ \mathrm{m\,s^{-2}}$.

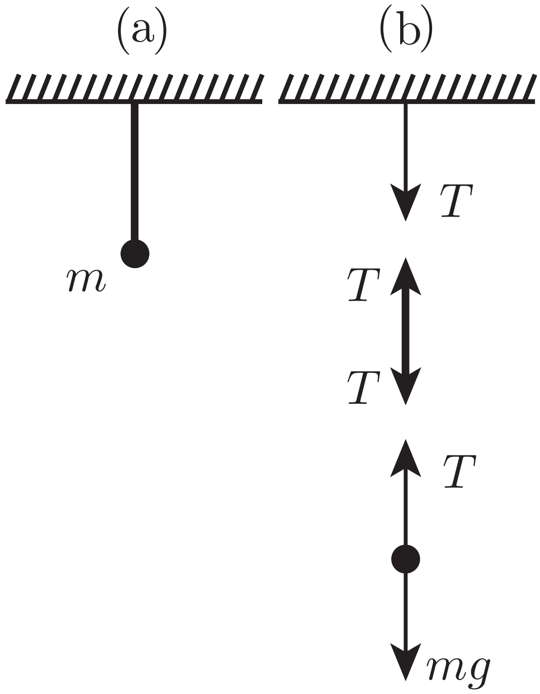
Reaction:

A block, of mass m, rests on a horizontal surface, as shown in diagram (a). The block and the surface interact, exerting on each other equal and opposite normal reactions of magnitude R. A *separated body diagram* for the block is shown in diagram (b). Since the block is at rest $R = mg$ from Newton's 2nd Law.



Tension: (i) Light, inextensible strings.

A mass m hangs in equilibrium on the end of an inextensible string attached to a ceiling, diagram (a). The **tension** at any point of the string equals the force exerted at that point. The string is said to be 'light' if its weight is negligible compared to the weight mg, and the tension, T, is then constant along its length. A separated body diagram (b) shows the forces acting on the mass and the string, and shows the tension exerted on the ceiling. From Newton's 2nd Law $T = mg$.



Tension: (ii) Elastic strings or springs (Hooke's Law).

Hooke showed that, provided the extension is not too great, the tension, T, in an elastic string or spring is directly proportional to the extension, x, and inversely proportional to its natural length, L:

$T = \dfrac{\lambda x}{L}$ where λ is Young's modulus of elasticity, or $T = kx$ where $k = \dfrac{\lambda}{L}$ is called the 'spring stiffness'.