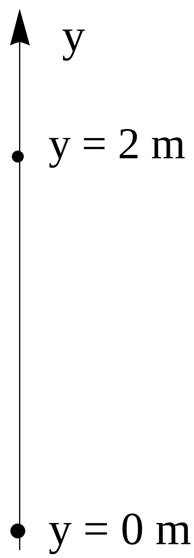
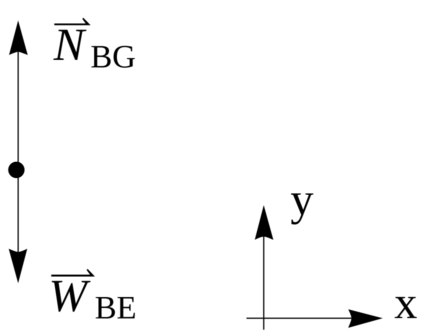
Example 1:



The ball is dropped from rest ($v_1 = 0$) at a height of $y_1 = 2\,m$. Its velocity just before hitting the ground $\vec{v}_2$ is given by

$v_2{}^2 - 0^2 = -2\,g\,(0 - 2) \Longrightarrow \vec{v}_2 = -\sqrt{2 \times 9.8 \times 2}\;\vec{j} = -6.3\,\vec{j}\,m/s.$

While the ball is colliding with the ground, two forces are acting on the ball, the weight $\overrightarrow{W}_{BE}$ and the normal by the ground $\overrightarrow{N}_{BG}$.



$\vec{F}_{\text{net}}$ is always along the y-direction and is $(N_{BG} - m\,g)\,\vec{j}$. If we apply the impulse momentum theorem between

$t_i = 10$ ms = instant just before the collision with the ground when

$\vec{v} = \vec{v}_i = -6.3\,\vec{j}$

and

$t_f = 20$ ms = instant just after the collision with the ground when $\vec{v} = \vec{v}_f$

we get

$m(\vec{v}_f - \vec{v}_i) = \int_{t_i}^{t_f} \vec{F}_{\text{net}}\,dt$

or since all of the vectors have only y-components

$m(v_f - v_i) = \int_{t_i}^{t_f} F_{\text{net}}\,dt = \int_{t_i}^{t_f} N_{BG} - m\,g\,dt = \int_{t_i}^{t_f} N_{BG}\,dt - m\,g\,(t_f - t_i)$

The integral $\int_{t_i}^{t_f} N_{BG}\,dt$ is the area under the $N_{BG}(t)$ curve and is equal to

$\frac{480\,(20-10)\,10^{-3}}{2} = 2.4\,N.s$

Also

$m\,g\,(t_f - t_i) = 0.2 \times 9.8\,(20 - 10)\,10^{-3} = 0.02\,N.s$

Notice that most of the impulse is due to the normal force.

The velocity just after the ball bounces off the ground is then

$v_f = v_i + \frac{\int_{t_i}^{t_f} N_{BG}\,dt - m\,g\,(t_f - t_i)}{m} = -6.3 + \frac{2.4 - 0.02}{0.2} = 5.6\,m/s$

The ball reaches a height h such that

$0^2 - v_f^2 = -2\,g\,h \Longrightarrow h = 1.6\,m$