

This is the Maxwell-Boltzmann velocity distribution. Technically, it's a joint probability density function of v_x , v_y , and v_z .

$$f(v_x, v_y, v_z) = \left(\frac{m}{2\pi kT} \right)^{3/2} \exp \left(-\frac{m(v_x^2 + v_y^2 + v_z^2)}{2kT} \right)$$

In spherical coordinates with $v = \sqrt{v_x^2 + v_y^2 + v_z^2}$ we have

$$f(v, \theta, \phi) = \left(\frac{m}{2\pi kT} \right)^{3/2} \exp \left(-\frac{mv^2}{2kT} \right)$$

By integrating over

$$d\Omega = v^2 \sin \theta \, d\theta \, d\phi$$

we obtain Maxwell's speed distribution, also a probability density function.

$$f(v) = 4\pi \left(\frac{m}{2\pi kT} \right)^{3/2} v^2 \exp \left(-\frac{mv^2}{2kT} \right)$$

Noting that

$$\int_0^\pi \sin \theta \, d\theta = \cos(0) - \cos(\pi) = 2$$

the integral can be done by inspection.

$$f(v) = \int_0^{2\pi} \int_0^\pi f(v, \theta, \phi) v^2 \sin \theta \, d\theta \, d\phi = 4\pi v^2 f(v, \theta, \phi)$$

Historically, the speed distribution came first. Maxwell derived it in 1867. Boltzmann extended Maxwell's work a year later in 1868.

<https://mathshistory.st-andrews.ac.uk/Projects/Johnson/chapter-6/>