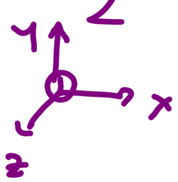
$\bar{F}, \bar{a}, \bar{v}$ ← time average

e.g. a single particle moving with velocity that is changing with time. The average velocity would be the total displacement over a finite time interval.

$\langle K \rangle$ $\langle v \rangle$ ← ensemble average

The average (arithmetic mean) of MANY particles at one specific time.

$$K = \frac{1}{2}mv^2 = \frac{1}{2}m\left(v_x^2 + v_y^2 + v_z^2\right) = \underbrace{\boxed{\frac{1}{2}mv_x^2}}_{\text{x-direction}} + \underbrace{\boxed{\frac{1}{2}mv_y^2}}_{\text{y-direction}} + \underbrace{\boxed{\frac{1}{2}mv_z^2}}_{\text{z dir}}$$



Each degree of freedom has energy $\langle K \rangle = \frac{1}{2}Nk_BT$

Ideal gas, non-atomic $\langle K \rangle = \frac{3}{2}NkT$

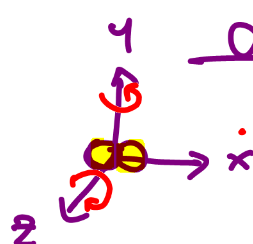
$$\langle K \rangle = \frac{1}{2}mv_{rms}^2$$

$$\underbrace{v_x^2 = v_y^2 = v_z^2}_{\text{random motion (no preferred dir)}}$$

Because motion is random, and does not prefer x or y or z or vice versa, therefore kinetic energy must be split over motion in all 3 translational directions

EQUAL PARTITION THEOREM

diatomic gases



$$K = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$$

↑ translation ↖ rotation

Kinetic energy is split between 5 degrees of freedom (3 translation and 2 rotation) →

$$K = \underbrace{\frac{1}{2}mv_x^2} + \underbrace{\frac{1}{2}mv_y^2} + \underbrace{\frac{1}{2}mv_z^2} + \underbrace{\frac{1}{2}I\omega_y^2} + \underbrace{\frac{1}{2}I\omega_z^2}$$

diatomic gas $\langle K \rangle = \frac{5}{2}NkT$