Unit 1: Modeling and Measuring Movement

Euler's Forward Method

$x(t+\Delta t) = x_0 + v_0 \Delta t$

$v(t+\Delta t) = v_0 + a_0 \Delta t$

Drag (F_D)

Inertial: $\frac{1}{2} C_D \rho A v^2$ (big and/or fast, $A = \pi a^2$)

Viscous: $-6\pi\eta a v$ (small and/or slow)

Orbits

$r^2 = (x_1 - x_2)^2 + (y_1 - y_2)^2$

$|F| = \frac{G m_1 m_2}{r^2}$

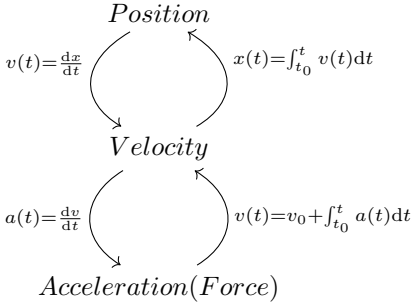
$F_r = -\frac{\mathrm{d}u}{\mathrm{d}r}$, $u(r) = \int \frac{G m_1 m_2}{r^2} = \frac{-G m_1 m_2}{r}$

Unit 2: Dynamics and Conservation Laws

$\vec{F}_{net} = \frac{\mathrm{d}\vec{p}}{\mathrm{d}t}$

$\vec{J} = \int_{t_0}^{t} \vec{F}(t)\,\mathrm{d}t = \vec{F}_{avg} \Delta t$

$F_{spring} = -k\Delta x$, $E_{spring} = \frac{1}{2} k x^2$



Weighted Averages

$\vec{F}_{avg} = \frac{\sum_n F_n(t_n)\delta t}{\Delta t} = \frac{1}{\Delta t}\int F(t)\,\mathrm{d}t$

Above δt is the partial weight, and Δt is the sum of the weights.

Collisions and Orbits

$\vec{F}_{net} = \frac{\mathrm{d}\vec{p}_{sys}}{\mathrm{d}t} = 0 \Longrightarrow \vec{p}(t) = \text{constant}$

$K = \frac{1}{2} m v^2$

$W = F_{\parallel} d$ (this is a "dot product", $A \cdot B = AB\cos\theta$)

Unit 3: Thermodynamics

$PV = N k_B T = nRT$

$\mathrm{d}U = T\,\mathrm{d}S - P\,\mathrm{d}V$

$\mathrm{d}E_{int} = \mathrm{d}Q - \mathrm{d}W = \mathrm{d}Q$

$Q = m C_s \Delta T$

$\mathrm{d}Q = C_p\,\mathrm{d}T$ or $C_v\,\mathrm{d}T$

$W = \int_{L_A}^{L_B} F\,\mathrm{d}L = \int_{V_A}^{V_B} P\,\mathrm{d}V$

$C_V = \frac{\Delta E_{int}}{\Delta T}$

$C_P = C_V + R$

$\gamma = \frac{C_P}{C_V}$

Classification	Mol	Part
monatomic (3 DOF)	$\frac{3}{2}R$	$\frac{1}{2}k_B T$
diatomic (5 DOF)	$\frac{5}{2}R$	$\frac{1}{2}k_B T$
complex (6 DOF)	$3R$	$\frac{1}{2}k_B T$

Equipartition Theorem

$\frac{3}{2}k_B T = \frac{1}{2} m \overline{v_x^2}$

Each DOF has $\frac{1}{2}k_B T$ of energy.

Adiabatic (No heat transfer) $P_i V_i^{\gamma} = P_f V_f^{\gamma}$

Heat Transfer

$\frac{\mathrm{d}Q_{rad}}{\mathrm{d}t} = -A\epsilon\sigma(T^4 - T_{amb}^4)$

$\frac{\mathrm{d}Q_{conv}}{\mathrm{d}t} = k_C A(T - T_{amb})$

Unit 4: Rotational Motion

Quantity	Angular	Linear	Units
Position	θ	x	rad
Speed	ω	v	rad/s
Acceleration	α	a	rad/s^2

Arclength $S = \theta\vec{r}$

$v_{tangential} = r\vec{\omega}$, $a_{tangential} = r\vec{\alpha}$

Rigid Objects

Conditions: All particles rotate with axis of rotation, and with same $\vec{\omega}$.

$K_{rot} = \sum_n \frac{1}{2} m_n v_n^2 = \frac{1}{2} I \vec{\omega}^2$

$I = \sum_n m_n r_n^2$ for every particle

$I = \square m r^2$ for an object

Unit 5: Special Relativity

$t' = \frac{t}{\sqrt{1 - \frac{v^2}{c^2}}}$ $\quad L = L_0\sqrt{1 - \frac{v^2}{c^2}}$

t' is the perspective ourside of the clock

L_0 is the fast moving perspective