🚗 Unit 1
Kinematics

- Scalar vs. vector
- 1-D motion
  - Four kinematic equations
  - Free-fall motion (gravity is only force)
- Cross product and vector addition
- x(t), v(t), a(t) graphs
  - Derivatives and integrals
- 2-D motion
  - x and y components (like 2 1-D motions)
- Special projectile motion formulas (symmetric)
  - $t = (v_x \sin\theta)/g$ to reach max height
  - $H = (v^2_x \sin^2\theta)/2g$ to reach max height
  - $R = (v^2_x \sin 2\theta)/g$ range

🍎Unit 2
Newton's Laws of Motion

- Newton's 1st law: inertia
- Newton's 2nd law: Fnet = ma
- Newton's 3rd law: Action and reaction force pair
  - Equal in magnitude, opposite in direction
- Free-body diagrams
- Equilibrium (Fnet = 0) when at rest OR constant velocity
- Friction is fun! f = μN
  - Static > kinetic friction
- Centripetal = points to center
  - $Fc = (mv^2)/r$
  - $ac = v^2/r$
- Uniform circular motion means speed is constant but direction changes
  - $a = \sqrt{ar^2 + at^2}$ where ar is towards center and at is tangential

🎢 Unit 3
Work, Energy, & Power

- $W = F\Delta r \cos\theta$ and $W = \int_{xi}^{xf} Fx\,dx$
- Conservative vs. nonconservative forces
- Stable vs. unstable equilibrium
- $W_{conservative} = -\Delta U$
  - Gravity = conservative
- PE includes both gravitational and elastic
- Work-Kinetic Energy Theorem
  - $\Sigma W = \Delta KE$
- Hooke's Law (force law for springs)
  - $Fs = -kx$
- Conservation of energy
  - $E_{mech} = \Delta K + \Delta U$
- Conservation of energy (including work and heat)
  - $\Delta K + \Delta U = W + Q$
- Average power $P = w/\Delta t$

🎳 Unit 4
Systems of Particles & Linear Momentum

- Center of mass
- Conservation of linear momentum
  - Conserved when Fnet = 0
- Momentum is a vector
  - $\Sigma F = dt/dp$
- Impulse $I = \int_{ti}^{tf} \Sigma F dt$
- Elastic collisions → KE and momentum conserved
  - Objects bounce off each other
- Inelastic collisions → KE is NOT conserved, momentum conserved
  - Perfectly inelastic = stick together
- Special elastic collision formulas

🚲 Unit 5
Rotation

- Same kinematic equations as Unit 1 but with θ, α, ω
- Angular and translational
  - $v = r\omega$ tangential speed
  - $a = r\alpha$ tangential acceleration
- Torque $\tau = rF\sin\theta$ is a vector
- Net torque $\Sigma\tau = I\alpha$
  - Clockwise -
  - Counterclockwise +
- Moment of inertia
  - Single particle $I = mr^2$
  - Hoop, cylinder, rod, sphere
- KE includes both translational and rotational
  - Rotational $KE = (½)I\omega^2$
- Angular momentum $L = rmv\sin\theta$
  - And $L = I\omega$
  - Conserved when τ net = 0
- Parallel-axis theorem
  - $I_o = I_{cm} + MD^2$

🌊 Unit 6
Oscillations

- Hooke's Law
  - Fs = restoring force
  - Negative when Fs and x in opposite directions
- Simple Harmonic Motion (sin/cos functions)
  - $x(t) = A\cos(\omega t + \theta i)$
  - $v(t) = -\omega A\sin(\omega t + \theta i)$
  - $a(t) = -\omega^2 A\cos(\omega t + \theta i)$
- $v_{max} = \omega A$ and $a_{max} = \omega^2 A$
  - A is max displacement from equilibrium
- Energy conservation
  - $(½)kA^2 = (½)mv^2 = (½)kx^2$

🪐 Unit 7
Gravitation

- Orbital speed $v = \sqrt{(GM)/R}$
  - M is mass of thing being orbited
- Gravity $g = GM/R^2$
  - Add h to R if there is an altitude
- Minimum escape velocity $v = \sqrt{2GM/R}$
- Orbital period $T^2 = \frac{4\pi^2}{GM} r^3$
  - Kepler's 3rd law
  - Time it takes for a revolution around something
- Circular vs. elliptical orbits

💯 FRQ Tips

- Always list your givens at the start of the problem (m, v, a, F, etc.)
- If you are given a graph, use it!
- Make sure you know how to integrate and differentiate (i.e. u-sub)
- Relationships between variables (i.e. Fnet = ma, and a = dv/dt)
- Find keywords (constant speed means a=0, terminal speed means t=infinity)
- Visualize, draw a picture or FBD!
- Use conservation of energy, especially when heights and movement are involved
- Fundamental concepts in units reappear in other units! (FBDs, kinematic equations, etc.)