# fiveable 🎢 AP PHYSICS C: MECHANICS CRAM CHART // @thinkfiveable // http://fiveable.me

## Kinematics
### Unit 1 ↓

- 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)
  - $t = \frac{v_i sin\theta}{g}$ to reach max height
  - $H = \frac{v_i^2 sin^2\theta}{2g}$ max height
  - $R = \frac{v_i^2 sin2\theta}{g}$ range

## Newton's Laws of Motion
### Unit 2 ↓

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

## Work, Energy, and Power
### Unit 3 ↓

- $W = F\Delta r\, cos\theta$ and $W = \int_{x_i}^{x_f} F_x\, dx$
- 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)
  - $F_s = -kx$
- Conservation of energy
  - $E_{mech} = \Delta K + \Delta U$
- Conservation of energy (including work and heat)
  - $\Delta K + \Delta U = W + Q$
- Average power $P = \frac{W}{\Delta t}$

## Systems of Particles and Linear Momentum
### Unit 4 ↓

- Center of mass
- Conservation of linear momentum
  - Conserved when $F_{net} = 0$
- Momentum is a vector
  - $\Sigma F = \frac{dp}{dt}$
- Impulse $I = \int_{t_i}^{t_f} \Sigma F\, dt$
- **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
  - $v_{1f} = (\frac{m_1 - m_2}{m_1 + m_2})v_{1i} + (\frac{2m_2}{m_1 + m_2})v_{2i}$
  - $v_{2f} = (\frac{2m_1}{m_1 + m_2})v_{2i} + (\frac{m_2 - m_1}{m_1 + m_2})v_{2i}$

## Rotation
### Unit 5 ↓

- Same kinematic equations as Unit 1 but with $\theta$, $\alpha$, $\omega$
- 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 = $\frac{1}{2}I\omega^2$
- Angular momentum $L = rmvsin\theta$
  - And $L = I\omega$
  - Conserved when $\tau_{net} = 0$
- Parallel-axis theorem
  - $I_o = I_{CM} + MD^2$

## Oscillations
### Unit 6 ↓

- Hooke's Law
  - $F_s$ = restoring force
  - Negative when $F_s$ and x in opposite directions
- Simple Harmonic Motion (sin/cos functions)
  - $x(t) = Acos(\omega t + \theta_i)$
  - $v(t) = -\omega Asin(\omega t + \theta_i)$
  - $a(t) = -\omega^2 Acos(\omega t + \theta_i)$
- $v_{max} = \omega A$ and $a_{max} = \omega^2 A$
  - A is max displacement from equilibrium
- Energy conservation
  - $\frac{1}{2}kA^2 = \frac{1}{2}mv^2 + \frac{1}{2}kx^2$

## Gravitation
### Unit 7 ↓

- Orbital speed $v = \sqrt{\frac{GM}{R}}$
  - M is mass of thing being orbited
- Gravity $g = \frac{GM}{R^2}$
  - Add h to R if there is an altitude
- Minimum escape velocity $v = \sqrt{\frac{2GM}{R}}$
- 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. $F_{net}$ = 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.)