| . Unit 1 <br> Kinematics | Unit 2 <br> Newton's Laws of Motion | Unit 3 <br> Work, Energy, \& Power |
| :---: | :---: | :---: |
| - Scalar vs. vector <br> - 1-D motion <br> - Four kinematic equations <br> - Free-fall motion (gravity is only force) <br> - Cross product and vector addition <br> - $\mathrm{x}(\mathrm{t}), \mathrm{v}(\mathrm{t}), \mathrm{a}(\mathrm{t})$ graphs <br> Derivatives and integrals <br> - 2-D motion <br> - $\quad x$ and $y$ components (like 2 1-D motions) <br> - Special projectile motion formulas (symmetric) <br> $t=\left(v_{x} \sin \theta\right) / g$ to reach max height | - Newton's 1st law: inertia <br> - Newton's 2nd law: Fnet = ma <br> - Newton's 3rd law: Action and reaction force pair <br> - Equal in magnitude, opposite in direction <br> - Free-body diagrams <br> - Equilibrium (Fnet $=0$ ) when at rest OR constant velocity <br> - Friction is fun! $f=\mu N$ <br> - Static > kinetic friction <br> - Centripetal = points to center $\begin{aligned} & \mathrm{Fc}=\mathrm{r} \\ & \mathrm{ac}=\mathrm{r} \end{aligned}$ <br> - Uniform circular motion means speed is constant but direction changes <br> - where ar $a=$ is $\sqrt{ }$ | - $W=F \Delta r \cos \theta$ and $W=\int d x$ <br> - Conservative vs. nonconservative forces <br> - Stable vs. unstable equilibrium <br> - Wconservative $=-\Delta U$ <br> - Gravity = conservative <br> - PE includes both gravitational and elastic <br> - Work-Kinetic Energy Theorem $\text { - } \quad \Sigma W=\triangle K E$ <br> - Hooke's Law (force law for springs) $\text { - } \quad F s=-k x$ <br> - Conservation of energy $\text { - Emech }=\Delta K+\Delta U$ <br> - Conservation of energy (including work <br> - and heat) $\Delta K+\Delta U=W+Q$ <br> - Average power $\mathrm{P}=\mathrm{w}$ |
|  <br> Rotation | Unit 6 <br> Oscillations | Unit 7 <br> Gravitation |
| - Same kinematic equations as Unit 1 but with $\theta, \alpha, \omega$ <br> - Angular and translational <br> $v=r \omega$ tangential speed <br> $a=r \alpha$ tangential acceleration <br> - Torque $\tau=r F \sin \theta$ is a vector <br> - Net torque $\Sigma \tau=1 \alpha$ <br> - Clockwise - <br> - Counterclockwise + <br> - Moment of inertia <br> - Single particle I = mr2 <br> - Hoop, cylinder, rod, sphere <br> - KE includes both translational and rotational <br> - Rotational KE = I $\omega 212$ <br> - Angular momentum $L=r m v s i n \theta$ <br> - And L = I $\omega$ <br> - Conserved when $\tau$ net $=0$ <br> - Parallel-axis theorem <br> - $\quad \mathrm{IO}=\mathrm{ICM}+\mathrm{MD} 2$ | - Hooke's Law Fs = restoring force <br> - Negative when Fs and x in opposite directions <br> - Simple Harmonic Motion (sin/cos functions) $\begin{array}{ll} \circ & x(t)=A \cos (\omega t+\theta) \\ \circ & v(t)=-\omega A \sin (\omega t+\theta) \\ \circ & a(t)=-\omega A \cos (\omega t) 2+\theta i \end{array}$ <br> - $\operatorname{vmax}=\omega \mathrm{A}$ and $\operatorname{amax}=\omega \mathrm{A} 2$ <br> - A is max displacement from equilibrium <br> - Energy conservation <br> - kA mv kx | - Orbital speed $v=\checkmark$ RGM <br> - $\quad M$ is mass of thing being orbited <br> - Gravity g = R2GM <br> - Add $h$ to $R$ if there is an altitude <br> - Minimum escape velocity $v=\sqrt{ }$ R2GM <br> - Orbital period Tr Kepler's 3rd law <br> - Time it takes for a revolution around something <br> - Circular vs. elliptical orbits |

## Unit 4

Systems of Particles \& Linear Momentum

- Center of mass
- Conservation of linear momentum
- Momentum is Conserved when Fnet $=0$
- Momentum is a vector
- Impulse I = F dt
- Elastic collisions $\rightarrow$ KE and momentum conserved
- Objects bounce off each other
- Inelastic collisions $\rightarrow$ KE is NOT conserved, momentum conserved
- Perfectly inelastic = stick together
- Special elastic collision formulas
- $\quad v) v) \vee 1 f=(m 1+m 2$
- 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 $\mathrm{a}=\mathrm{dv} / \mathrm{dt}$ )
- 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.)

