Flipping Physics Lecture Notes:

AP Physics C: Equations to Memorize (Mechanics)
https://www.flippingphysics.com/apc-equations-to-memorize.html

While I am not a fan of memorization and do my best to avoid having my students memorize, there are a few items which are not on the equation sheet which I do suggest you memorize.

- $\Delta x = \frac{1}{2}\left(v_f + v_i\right)\Delta t$ (The fourth Uniformly Accelerated Motion equation)
- The Force of Gravity or Weight of an object: $F_g = mg$
- $F_{g_\perp} = mg\cos\theta$ & $F_{g_\parallel} = mg\sin\theta$ (The components of the force of gravity parallel and perpendicular on an incline where θ is the incline angle)
- General range for coefficients of friction: 0 – 2
- $\Delta E_{system} = \sum T$ (General equation relating the change in energy of the system to the net energy transferred into or out of the system.)
- $\sum W = \Delta KE$ (always true)
- $W_{friction} = \Delta ME$ (only true when there is no energy added to or removed from the system via a force.)
- $ME_i = ME_f$ (only true when there is no energy added to or removed from the system via a force and there is no work done by a nonconservative force.)
- $F_x = -\frac{dU}{dx}$ (The equation which relates a **conservative** force and the potential energy associated with that force.)
- That every derivative is an integral and every integral is a derivative. For Example:
  - $F_x = -\frac{dU}{dx} \Rightarrow F_x dx = -dU \Rightarrow \int_{x_i}^{x_f} F_x\, dx = -\int_{U_i}^{U_f} dU \Rightarrow W = -\Delta U$
- Book Example: $W_{F_g} = F_g \Delta r\cos\theta = \left(mg\right)\Delta h\cos\left(180°\right) = -mg\Delta h \Rightarrow W_{F_g} = -\Delta U_g$

- $\sum \vec{p}_i = \sum \vec{p}_f$ (Conservation of Momentum. It may seem obvious, however, you need to remember when it is valid.)
  - $\sum \vec{F}_{external} = \frac{d\vec{p}}{dt} = 0 \Rightarrow \sum \vec{p}_i = \sum \vec{p}_f$
- $\sum \vec{L}_i = \sum \vec{L}_f$ (Conservation of Angular Momentum. Again, it may seem obvious, however, you need to remember when it is valid.)
  - $\sum \vec{\tau}_{external} = \frac{d\vec{L}}{dt} = 0 \Rightarrow \sum \vec{L}_i = \sum \vec{L}_f$
- $r_{cm} = \frac{1}{m_{total}}\int r\, dm$ (The center of mass of a rigid object with shape)
- $\rho = \frac{m}{\forall}$ & $\lambda = \frac{m}{L}$ (Volumetric Mass Density and Linear Mass Density)

- $s = r\Delta\theta$ & $a_t = r\alpha$ (arc length and tangential acceleration)
  - Although $v_t = r\omega$ is on the equation sheet, so it is easy to get to the other two.
- $v_{cm} = R\omega$ & $a_{cm} = R\alpha$ (The velocity and acceleration of the center of mass of a rigid object which is rolling without slipping. Easy to remember from the previous equations.)
- $1\ revolution = 360^\circ = 2\pi\ radians$
- $\omega_f^2 = \omega_i^2 + 2\alpha\Delta\theta;\ \Delta\theta = \frac{1}{2}\left(\omega_i + \omega_f\right)\Delta t$ (Uniformly Angularly Accelerated Motion equations)
- $I = I_{cm} + mD^2$ (The parallel axis theorem)
- $\frac{d^2x}{dt^2} = -\omega^2 x$ (The condition for simple harmonic motion)
- $v_{\max} = A\omega$ (The maximum velocity during simple harmonic motion)
- $a_{\max} = A\omega^2$ (the maximum acceleration during simple harmonic motion)

There are equations which many of you will want to memorize, however, I strongly discourage.

- $\vec{F}_R = -b\vec{v}$ & $\vec{F}_R = \frac{1}{2}D\rho A v^2$ (Resistive force equations)
  - Neither of these equations are on the equation sheet. Don't memorize these equations.
    - The problem will specify to use $\vec{F}_R = \frac{1}{2}D\rho A v^2$ and give you that equation or tell you the drag force is "proportional to" the velocity, which means $\vec{F}_R = -b\vec{v}$.
- 746 watts = 1 hp (will be provided if you need it)
- Do not memorize: $G = 6.67 \times 10^{-11} \frac{N \cdot m^2}{kg^2}$
  - Instead, be familiar with the "Table of Information" and the page of general math formulas on the AP Physics equation sheet.
- Do not memorize the following equations; instead know how to derive them. This will be of much more use to you during the AP exam because they want you to understand where these equations come from and therefore will generally ask you a question that relates to their derivations. I did all of these derivations during the review.
  - $v_{cm} = \frac{\sum m_i v_i}{\sum m_i}$ & $a_{cm} = \frac{\sum m_i a_i}{\sum m_i}$ (velocity and acceleration of the center of mass of a system of particles. Simply take the derivative with respect to time once or twice of the position of the center of mass of a system of particles to get these equations.)
  - Terminal velocity: $v_{terminal} = \sqrt{\frac{2mg}{D\rho A}}$
  - Binding Energy: $W_{F_a} = \frac{Gm_o m_p}{R_p}$
  - Escape Velocity: $v_{escape} = \sqrt{\frac{2Gm_E}{R_E}}$

- Total Mechanical Energy of Orbital Object: $ME_{total} = -\frac{Gm_o m_p}{2r}$
- Kepler's Third Law: $T^2 = \left(\frac{4\pi^2}{Gm_p}\right) r^3$
- Velocity in simple harmonic motion: $v(t) = -A\omega \sin(\omega t + \phi)$
- Acceleration in simple harmonic motion: $a(t) = -A\omega^2 \cos(\omega t + \phi)$
- Moments of Inertia of …
  - Uniform Hoop or thin cylindrical shell about its cylindrical axis: $I_{cm} = mR^2$
  - Uniform rigid rod about its center of mass: $I_{cm} = \frac{1}{12} mL^2$
  - Uniform Solid cylinder or disk about its cylindrical axis: $I_{cm} = \frac{1}{2} mR^2$
    - Okay, I didn't do this one during the review.
  - Use the parallel axis theorem to find the moment of inertia of any of these about any other axis.
  - A quick note about moments of inertia and the AP Exam. If you need the equation for a Moment of Inertia to solve a problem, it will be provided. And, while you do not need to memorize the equations for moments of inertia of various objects, you do need to be able to determine relative relationships between various moments of inertia of objects and those are just based on the basic equation for moment of inertia: $I = \sum_i m_i r_i^2$