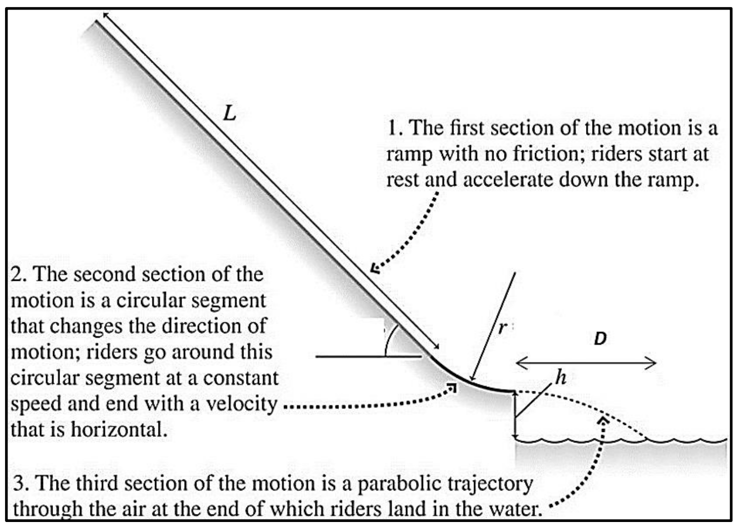
AP Physics 1: How to Derive Expressions on the AP Physics Exam

College Board will often ask you to drive expressions on the free response section of the exam. From College Board: "Derive is more specific and indicates that the students need to begin their solutions with one or more fundamental equations, such as those given on the AP Physics Exam equation sheet. The final answer, usually algebraic, is then obtained through the appropriate use of mathematics." You will be asked to derive expressions on every exam you take in this course to prepare you for the AP Exam. This is your guide to derivations and my three-step plan to successfully derive an expression to earn maximum credit.

Step 1: Translate the physics to identify exactly what is being asked in the derivation and come up with a general plan. Do not worry about specific numbers; most variables will be given to you in relative terms. For example, if a planet has a mass of *M* and you are told a second planet is four times more massive, than planet two would be expressed as *4M*. Another problem may state that an object starts at rest and moves to position *D* at time t_D. So, you would substitute *D* for the position (x) in the UAM equations and t_D for time in the UAM equations (see step 3 for details).

Step 2: Start with equations and formulas from the AP Physics equations sheet and any other fundamental constants. For example, you might start with $V_{fy} = V_{0y} + a\Delta t$ for a projectile, where "a" would be replaced with the fundamental constant, "g", for the acceleration due to gravity.

Step 3: Replace variables in the equation with the relative terms you derived in step 1 and simplify algebraically. Referring to the UAM equation in step 2, if you were told the time was reduced by half and the initial launch velocity tripled, than you could write: $V_{fy} = 3V_{0y} + g\,\frac{t}{2}$. Now look back at step 1. You might use the equation $x = v_0t + 1/2at^2$ and substitute the relative terms from step 1, so the equation becomes: $D = V_0t_D + 1/2at_D^2$. Because the object described in step 1 started at rest, the equation simplifies to $D = 1/2at_D^2$. Clearly show all steps of your derivation to receive maximum credit. Let's practice deriving expressions:



Unit 1.1: A slide of length *L* makes an angle θ above the horizontal. The end of the slide with a radius (*r*, not used in this unit) launches Sophia from a height (*h*) into the water with a horizontal velocity of V_x. Sophia flies through the air and gently lands a distance, *D*, from the end of the frictionless slide.

(a). Derive an expression for Sophia's horizontal launch velocity (V_x) in terms of *L*, θ, and any other fundamental constants.

(b). Mr. Pedersen wants to design a new slide that will double the horizontal distance, *D*, Sophia will launch before gently splashing into the water. He must leave the length of the slide and the angle of the slide the same, but he can change the height above the water. Derive a new expression in terms of *L*, *h*, θ, and any other fundamental constants that will result in a new horizontal range, *2D*.