AP Physics

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Drawing Free-Body Diagrams and Applying Newton's Laws

Part 1: Drawing the Free-Body Diagram

Step 1: Draw a box and place an **m** inside to represent the object's mass. Be sure to preserve the physical orientation of the object when you draw the box. Think about the forces that act on the object. What types of forces are they and in what direction do they act on the object? If the case includes more than one mass, be sure to distinguish the masses using subscripts.

Step 2: Draw coordinate axes that are oriented along the direction of motion and indicate the positive direction with a + sign. The directions on these will serve to determine if a force will be positive or negative in Newton's 2nd Law equation.

Step3: Attach an arrow to the box; one for each force that acts on the object. Each arrow must show the correct direction of the force and must also have a symbol that indicates the type of force it is: $\mathbf{F_g}$ (Gravity/Weight), $\mathbf{F_n}$ (Normal), $\mathbf{F_a}$ (Applied), $\mathbf{F_f}$ (Friction). Be certain to use different subscripts for forces of the same type but which have different values.

Step 4. Apply trigonometry and/or Pythagorean Theorem to resolve any forces that are at an Angle. Label the force components appropriately with **x** and **y** subscripts.

Step 5: Next to the mass, but not attached to it, draw arrows with symbols (**a** and **v)** to show the direction of the object's velocity and acceleration along each axis.

Part 2: Appling Newton's 2nd Law

Step1: Begin by writing Newton's 2nd Law equation $\mathbf{F_{Net} = ma}$.

Step 2: Substitute terms from the force diagram for $\mathbf{F_{Net}}$. The sign (+ or -) of the term is determined by comparing the direction of that force to the direction that was chosen to be positive in the force diagram. If the directions are the same the term gets a positive sign (+) in the equation, if the directions are opposite the term gets a negative sign (-) in the equation.

Step 3: If the acceleration **a** is not given directly, a substitution using Galileo's Equations of Motion may be required; replacing **a** in Newton's 2nd Law equation with quantities of motion from Galileo's Equations.

Step 4: Any gravity/weight $\mathbf{F_g}$ may be expressed by **mg**, since the $\mathbf{F_g = mg}$.

Step 5: Complete by algebraically solving the equation for the required quantity. Box the answer and be certain to include its correct symbol and unit.