how to solve Newton’s Second Law problems with one object

1. Make a **sketch** of the object and its surroundings.
2. Write down **what the question is asking for**. If possible, represent what is asked for with a symbol.
3. Show the object’s direction of motion by **adding the velocity vector to your sketch**.
4. Check that all given units are **SI units**.
5. For symbolic problems, write down **the “given” symbols**.
FREE-BODY DIAGRAM
6. Identify the **object** you will apply Newton’s Second Law to. This is usually the object whose mass is mentioned in the problem.
7. Start a **Free-Body Diagram** for the object from step 6 by drawing a vector for the object’s **weight**.
8. Complete the **Free-Body Diagram** by drawing a force vector exerted **by each thing that is *touching* the object**.[1] Include only the forces exerted *on*, not *by*, the object that you are focusing on. A surface may exert *both* a normal force *and* a frictional force.
FORCE TABLE
9. Start a **Force Table**. For each force from your Free Body Diagram, write down a number, symbol, or expression to represent **the magnitude of the overall vector**. If you are given a value for the overall magnitude of a force, use that value. Otherwise, if a force has a “special formula”, use that special formula to calculate or represent the magnitude. The forces with special formulas are weight, kinetic friction, and *maximum* static friction: $w = mg$, $f_k = \mu_k n$, $\max f_s = \mu_s n$ There are no special formulas for normal force or tension, or for static friction when the static friction is not assumed to be at its maximum. If a magnitude has no special formula and no given value, just represent the magnitude with a symbol.
10. *Before* you break the forces into components, you must **choose your axes**. Usually, you should choose an axis that points in the object’s direction of movement.
11. Complete the **Force Table** by breaking each force into **components**. Use the overall magnitude from step 9 to calculate or represent the components. Always include a “+” or “-” sign on each nonzero component.
NEWTON’S SECOND LAW EQUATIONS
12. Write the **Newton’s Second Law equations** at the top of two adjacent columns: $\sum F_x = ma_x$ $\sum F_y = ma_y$ Keep your later versions of the *x*- and *y*-equations organized in these two columns.
13. On the left side of the Newton’s Second Law equations, **add all the individual force components,** including any negative signs, using the components from the Force Table. On the right side of the Newton’s Second Law equations, when possible, substitute specific values or symbols for the object’s **mass** and for **a_x and a_y**. If an object is motionless in a component, or if an object moves with constant velocity in a component, then that component of its acceleration is 0.
14. **Use algebra to solve** the Newton’s Second Law equations for the unknowns.
15. **Check** that you answered the right question, and that you answered all parts of the question. **Check** whether your results make sense. For numerical answers, **check** that you included units. For symbolic answers, **check** that your answer includes only the “given” symbols.

1 This method works for most *first-semester* problems in a typical introductory physics course.

HOW TO SOLVE DIFFERENT TYPES OF PROBLEMS INVOLVING FRICTION

Problems involving an object that you know is sliding

1. Use the Newton's Second Law framework.
2. Apply *kinetic* friction
3. Use the special formula for f_k in the first row of your Force Table: $f_k = \mu_k n$

Maximum or *minimum* problems involving whether an object will slide

1. Use the Newton's Second Law framework. Assume that the object is just on the *borderline* between sliding and not sliding. Assume that at this borderline value, the object does *not* slide. Apply *static* friction, and assume that static friction is at its *maximum*.
2. Use the special formula for max f_s in the first row of your Force Table: max $f_s = \mu_s n$
3. To determine a_x and a_y, assume that the object does *not* slide.

Problems that ask you to determine whether the object will slide

1. Assume that the object does *not* slide, and use the Newton's Second Law framework to determine the f_s that would be required to prevent sliding. We apply *static* friction. In this step, we do not assume that f_s is at its maximum. Therefore, in this step, we do not use a special formula for f_s. Instead, in the first row of your Force Table, just represent the magnitude of the static friction by the symbol "f_s". To determine a_x and a_y, assume that the object does *not* slide.
2. Use the special formula to determine max f_s.: max $f_s = \mu_s n$ To find the n you need for the special formula, use the Newton's Second Law framework from step 1.
3. To determine whether static friction will be able to rise high enough to prevent the object from sliding, compare the required f_s from step 1 with the max f_s from step 2. If required f_s < max f_s, then the object will not slide. If required f_s > max f_s, then the object will slide.