Basic Strategy for Dynamics Problems

1. Draw a picture of the problem, if you don't already have one.
   (Note: this is a good first step for *any* physics problem, not just for dynamics problems.)

2. Draw a **free-body diagram** for each object of interest, showing all forces that act on that object. You may need to define new variables for forces that are not known.

   - Only include forces that act *on* the object you're drawing the diagram for.
   - When drawing free-body diagrams for several different objects in the same problem, remember Newton's 3rd Law: the force object A exerts on object B (which appears in the free-body diagram for object B) must be equal and opposite to the force object B exerts on object A (which appears in the free-body diagram for object A). Make sure the arrows representing these forces point in opposite directions, and label their magnitudes with the *same* variable.
   - **Make sure that you have not forgotten any forces** by mentally running through a checklist of all the other objects in the problem that might push or pull on your object. Remember that for 8.01 purposes the only force that can act at a distance (without touching) is gravity.
   - **Make sure that you have not included any bogus forces** by mentally identifying the physical source of each force in your diagram (which other object exerts this force on your object?).

3. Determine what you know about the acceleration of each object. You may find it helpful to include the acceleration in your free-body diagram; just be careful not to confuse it with a force (one thing that works well is to use a dashed arrow that's not actually connected to the object). If you don't know the acceleration, define a new variable for it.

   - Remember that any object moving in a circular path must have an appropriate centripetal acceleration.
   - Often, you will know the *direction* of the acceleration but not its magnitude.

4. Choose a coordinate system in which to analyze each object. You may want to draw a small set of coordinate axes in your diagram to help you remain consistent about your choice.

5. Write Newton's 2nd Law for each object, filling in the forces and accelerations from your free-body diagram. Split the vector equation $\sum \vec{F} = m\vec{a}$ up into scalar component equations according to your chosen coordinate system:

$$\sum F_x = ma_x$$
$$\sum F_y = ma_y$$
$$\sum F_z = ma_z$$

   - Any force or acceleration vector whose direction is not aligned exactly with one of the axes of your coordinate system will need to be split up into components.

6. Write down additional **constraint equations** based on any other knowledge you have about the problem that hasn't yet been captured in an equation. For example:

   - If two objects moving horizontally along the ground are to remain in contact, then they must have the same horizontal acceleration.
   - An ideal rope or cord under tension will always maintain a constant length. This "conservation of rope" principle can be expressed mathematically as an equation relating the accelerations of the two objects tied to the ends of the rope (and the accelerations of any pulleys the rope passes over). The exact form of the constraint equation varies from problem to problem.

7. Solve the resulting system of n equations, n unknowns.