how to solve Newton's Second Law problems involving circular motion

1. Make a **sketch** of the object and its circular path of motion.
2. Write down **what the question is asking for**. If possible, represent what is asked for with a symbol.
3. Check that all given units are **SI units**.
4. For a symbolic problem, write down **the "given" symbols**.
FREE-BODY DIAGRAM
5. Identify the **object** you will apply Newton's Second Law to. This is usually the object whose mass is mentioned in the problem. In your sketch, indicate the object's current **position** in the circle.
6. Start a **Free-Body Diagram** for the object from step 5 by drawing a vector for the object's **weight**.
7. 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. Typically, forces in the *tangential* component will not be important for the solution of the problem. A surface may exert both a normal force and a frictional force.
FORCE TABLE
8. 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. There are special formulas for weight, kinetic friction, and *maximum* static friction. If a force has no special formula and no given value, just represent the magnitude with a symbol.
9. Write down **axes** with **positive directions**. Choose a **radial axis** that points *towards* the center of the circle. Label which of your axes is radial.
10. Complete the **Force Table** by breaking each force into **components**. Use the overall magnitudes from step 8 to calculate or represent the components. Always include a "+" or "-" sign on each nonzero component.
NEWTON'S SECOND LAW EQUATIONS
11. Write down the **Newton's Second Law equations**. For a *horizontal* circle, you will typically need to write Newton's Second Law equations for the radial component, and for the component that is perpendicular to the plane of the circle. For a *vertical* circle, you will typically need to write a Newton's Second Law equation only for the radial component.
12. 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 equations, when possible, substitute specific values or symbols for the object's **mass** and for $\boldsymbol{a_x}$ **and** $\boldsymbol{a_y}$. Use the **formula** $a_{\text{radial}} = +\frac{v^2}{r}$. (a_{radial} will be positive only if you choose a radial axis that points *towards*, rather than away from, the center of the circle.) If an object is motionless in a component, then that component of its acceleration is 0.
13. **Use algebra to solve** the Newton's Second Law equations for the unknowns.
14. **Check** that you answered the right question, and that you answered all parts of the question. **Check** that your answer makes 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.