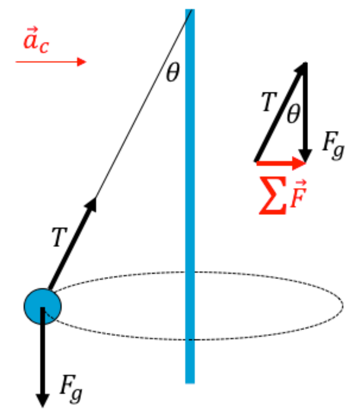
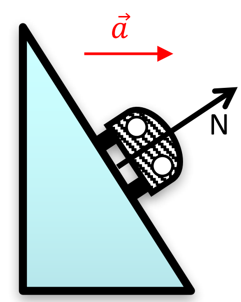
**7.2 Conical Pendulum:**




The conical pendulum is "the tetherball problem" and likely gets its name because the string attached to the ball traces out the shape of a cone as the ball makes a circular path on the horizontal plane as shown at right. Using a dynamics lens: centripetal acceleration inward is caused by two forces: $F_g$ and the tension in the string. The sum of these forces, must be in the same direction as the acceleration: $\vec{F}_{resultant} = \sum\vec{F} = m\vec{a}$. From the diagram at right, we see $T > F_g > \sum\vec{F}$. Thus, in the scenario above, if the ball is 1 kg and $F_g$ is 10 N, we might expect the tension to be about 12 N and the vector sum of the forces is about 6 N. Thus the centripetal acceleration is about 6 m/s$^2$.

Example 1:
For the above tether ball, draw the example that theta is much larger such that the string is close to horizontal. Show with a vector diagram how this would affect the tension in the string, the vector sum of the forces, and the acceleration. How would the speed of the ball compare to that in the diagram above? Be prepared to support your answer. Does your answer correlate with what you experience in the world?

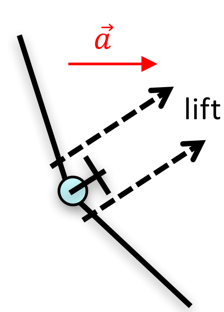
Example 2: For the above tether ball, consider the example that theta is much smaller such that the string is close to vertical. Show with a vector diagram how this would affect the tension in the string, the vector sum of the forces, and the acceleration. How would the speed of the ball compare to that in the diagram above? Be prepared to support your answer. Does your answer correlate with what you experience in the world?




The ball on the string is only one of the four examples of the conical pendulum that you see in the world. The other three are:

1) car on a frictionless, banked turn,
2) an airplane banking into a turn, and
3) a bicyclist leaning into a turn.

For all of the examples, there is a downward force of gravity and one other force that keeps the object in equilibrium in the y-direction while providing an inward force that accelerates the object into uniform circular motion.




Example 3: For a car and an airplane, the tension in the string is replaced by the normal force and lift, respectively. Please draw these scenarios and show how the vector diagrams follow from the free body diagrams. Be careful to make sure that you pick the right angle theta, and not its complement.

Example 4:

For the bicyclist, the tension in the string is replaced by the compressional force of the seat on the bicyclist's body pushing in the direction of the bicycle frame. You can think of this as a normal force. Draw out this scenario and identify how the acceleration changes if the bicyclist leans further into a turn.