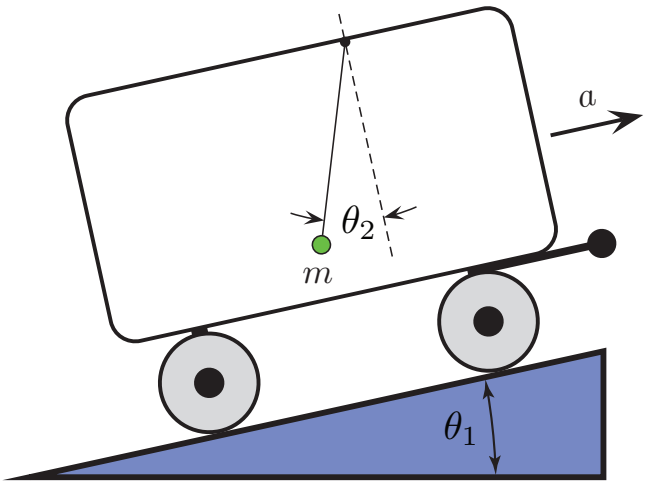

Figure 1: A boxcar is towed *without friction* up a track at an angle θ_1 with respect to the horizontal. The mass inside the boxcar hangs at an angle θ_2 with respect to the top of the boxcar.

Problem 1: Boxcar on a Hill

In the figure, a boxcar of mass M is being towed up a hill by train car *without friction*. It is accelerating *up* the slope with a constant acceleration a. Inside the boxcar, an object of mass m hangs on a string attached to the boxcar's ceiling. While the car is moving, the string makes an angle θ_2 with the normal to the boxcar's ceiling.

Your goal is to find the magnitude of the boxcar's acceleration (a) in terms of the angles θ_1, θ_2 and acceleration due to gravity g. Do this by answering the following questions:

1. **System** - Begin by choosing the mass as the system
2. **List all forces on the system**
3. **Draw a Free Body Diagram** - Draw a free body diagram for the system labeling all forces and identifying angles θ_1 and θ_2
4. **Apply the momentum principle** - $\vec{F}_{net} = m\vec{a}$
   - Write out separate equations for the momentum principle in the x and y directions for the system
   - Solve these two equations for the magnitude of the acceleration – a
5. **Choosing an Appropriate System** - We chose the mass as the system, but we could have chosen the boxcar and hanging mass inside. Was the mass the best choice for a system or would the boxcar and mass system have been just as useful? Explain.

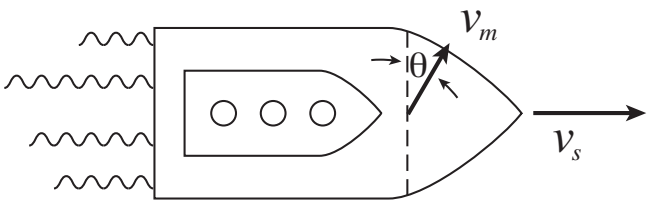

Figure 3: A speedboat moves at a constant velocity v_s with respect to the water as a man moves at a constant velocity v_m at an angle θ with respect to the boat.

Problem 2: Walking on a Ship

A ship cruises forward at v_s relative to the water. On deck, a man walks diagonally toward the bow such that his path forms an angle θ with a line perpendicular to the boat's direction of motion. He walks at v_m relative to the boat.

(a) What is the man's acceleration in terms of the known quantities?

(b) Determine an algebraic expression for the man's speed relative to the water in terms of the known quantities.