# Ladder Problem Analysis Assignment

Student Workbook

July 20, 2025

## Problem Analysis Guide

Given the ladder problem solution, complete the following analysis steps to deepen your understanding of the problem-solving process.

## Part 1: System Visualization (20 points)

1. Draw a detailed system diagram showing:
   - The ladder's position relative to the house
   - The person's position on the ladder
   - All relevant dimensions
   - The center of mass of the ladder
   - System boundaries clearly defined
2. Create a Free Body Diagram (FBD) showing:
   - All forces acting on the ladder
   - Proper force vectors with labels
   - The angle $\theta$ between the ladder and the ground
   - The coordinate system you're using
3. Identify and list all known quantities with their units:
   - Mass of person = _____ kg
   - Mass of ladder = _____ kg
   - Length of ladder = _____ m
   - Distance from wall = _____ m
   - Height of person on ladder = _____ m
   - Center of mass location = _____ m

## Part 2: Mathematical Analysis (40 points)

4. Show the step-by-step calculation of the angle $\theta$:

$$\theta = \arccos\left(\frac{2}{6}\right) = \_\_\_\_\_^\circ$$

5. Write out the three equilibrium equations with proper units:

- Sum of forces in x-direction: _____
- Sum of forces in y-direction: _____
- Sum of torques about the bottom of the ladder: _____

6. Show the complete algebraic steps to find $N$ starting from:

$$f = \left(\frac{1}{2}w + \frac{1}{3}W\right)\sin\theta\cos\theta = (w + W - N)\tan\theta$$

Include units in each step.

7. Calculate the weights $w$ and $W$ with proper units:

$w =$ _____
$W =$ _____

## Part 3: Final Calculations (40 points)

8. Show the detailed calculation of $N$ with units:

$$N = \left(1 - \frac{\cos^2\theta}{2}\right)w + \left(1 - \frac{\cos^2\theta}{3}\right)W$$
$$= \_\_\_\_\_$$
$$= \_\_\_\_\_ \text{N}$$

9. Calculate $f$ showing all steps and units:

$$f = (w + W - N)\tan\theta$$
$$= \_\_\_\_\_$$
$$= \_\_\_\_\_ \text{N}$$

10. Calculate $N'$ showing all steps and units:

$$N' = \frac{f}{\sin\theta}$$
$$= \_\_\_\_\_$$
$$= \_\_\_\_\_ \text{N}$$

11. Calculate the magnitude of the total force at the bottom:

$$F_{\text{bottom}} = \sqrt{f^2 + N^2}$$
$$= \_\_\_\_\_$$
$$= \_\_\_\_\_ \text{N}$$

## Analysis Questions (Bonus: 10 points)

a. Why is the force at the top ($N'$) much smaller than the force at the bottom?

b. How would the forces change if the angle $\theta$ were smaller?

c. Why is it important that the rain gutter is assumed to be frictionless?

d. What assumptions are we making about the ladder's structure in this problem?