

Ladder Problem Analysis Assignment

Student Workbook

July 18, 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 θ 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 θ :

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

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:

$$w = \underline{\hspace{10cm}}$$

$$W = \underline{\hspace{10cm}}$$

Part 3: Final Calculations (40 points)

8. Show the detailed calculation of N with units:

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

$$= \underline{\hspace{10cm}}$$

$$= \underline{\hspace{10cm}} \text{ N}$$

9. Calculate f showing all steps and units:

$$f = (w + W - N) \tan \theta$$

$$= \underline{\hspace{10cm}}$$

$$= \underline{\hspace{10cm}} \text{ N}$$

10. Calculate N' showing all steps and units:

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

$$= \underline{\hspace{10cm}}$$

$$= \underline{\hspace{10cm}} \text{ N}$$

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

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

$$= \underline{\hspace{10cm}}$$

$$= \underline{\hspace{10cm}} \text{ N}$$

Analysis Questions (Bonus: 10 points)

- Why is the force at the top (N') much smaller than the force at the bottom?
- How would the forces change if the angle θ were smaller?
- Why is it important that the rain gutter is assumed to be frictionless?
- What assumptions are we making about the ladder's structure in this problem?