Design a 5:1 Gear Reduction

Difficulty	Time	Type
Intermediate	1-2 class periods	Engineering Challenge

Background

A rover motor spins too quickly and does not provide enough output torque for a wheel or lifting mechanism.

Engineering Problem

Design a gear system with an overall reduction close to 5:1 and demonstrate the expected speed and torque tradeoff.

Learning Objectives

- Calculate gear ratios
- Design single- or multi-stage systems
- Connect ratio to speed and torque
- Build or model a mechanism

Materials

- Gear sets or CAD gear models
- Axles and supports
- Calculator
- Tachometer or rotation-count method
- Engineering notebook

Procedure

1. Review the required input and desired approximate 5:1 reduction.
2. Create three possible gear-train layouts and calculate each overall ratio.
3. Select a design based on ratio accuracy, part count, size, and direction of rotation.
4. Build or model the selected train.
5. Mark input and output gears.
6. Rotate the input a known number of turns and count output turns.
7. Compare measured and calculated ratio.
8. Explain the expected effect on output speed and ideal torque.

Engineering Requirements

- Target an overall reduction between 4.8:1 and 5.2:1
- Show calculations for three concepts
- Support and align every axle
- Demonstrate rotation without gear skipping
- Compare calculated and measured ratio

Constraints & Safety

- Use available gears only

- Do not force mismatched gears
- Ignore friction only when labeling the result as ideal
- Mechanism must fit within the assigned footprint

Deliverables

- Three gear-train sketches
- Ratio calculations
- Selection justification
- Built or CAD mechanism
- Measured ratio data
- Speed/torque explanation

Reflection Questions

1. Why might measured rotation differ from the calculation?
2. What changed when an idler gear was added?
3. How would you reverse output direction?
4. Where is energy lost in the real system?

Engineering Tip
For a compound train, multiply the ratio of each stage.

Common Mistake
Counting gear teeth only within one stage will not give the total ratio of a compound system.

Stretch Goal

Add a selectable second ratio for high speed and high torque.

Career Connection

Mechanical and drivetrain engineers design transmissions and gearboxes for aircraft systems, vehicles, robotics, and manufacturing equipment.