Lift the Stage

Trace pressure and force through a hydraulic lift.

HS-PSII-3.5 "Describe how a change in the pressure of as static fluid in an enclosed container is transmitted equally in all directions (Pascal's Principle) and apply Pascal's Principle to determine the mechanical advantage of a hydraulic system."

NAME _____ DATE _____

1 READ AND MARK

Read it twice

YOUR JOB Underline the sentence that explains how a pressure change travels through the oil. Circle the input force and both piston areas you need to calculate the lift's mechanical advantage.

A Lift Beneath the Stage

1. Before a theater performance, a crew member uses a hydraulic lift to raise a heavy platform. The lift has two pistons connected by a sealed tube filled with oil. The oil is nearly incompressible, so pressing one piston changes the pressure throughout the still, enclosed fluid. According to Pascal's principle, that change in pressure is transmitted equally in every direction. It reaches the other piston even when the tube bends around equipment. Equal pressure changes do not mean equal forces: the force on a piston also depends on the area of its face.

2. Suppose the crew member pushes the small piston with 90 newtons of force. Its face has an area of 5 cm^2, while the platform rests on a large piston with an area of 100 cm^2. To find the added pressure in the oil, divide the input force by the small piston's area. The same added pressure acts on each square centimeter of the large piston's face. Multiply that pressure by the large area to find the ideal upward force. For this calculation, ignore friction and the weight of the pistons, which would reduce the useful lifting force.

3. A second way to find the ideal force gain is to divide the large piston's area by the small piston's area. This ratio is the system's mechanical advantage: it tells how many times greater the output force is than the input force. It does not create energy. When the large piston rises a short distance, the small piston must move farther so that equal volumes of oil shift through the system. A real lift also loses some useful force to friction. The pressure change is still transmitted through the oil, even though the usable output can be lower than the ideal value.

2 ANSWER WITH EVIDENCE

Use the passage

1. The tube bends around equipment. How does the pressure change reach the large piston, and does this mean the two pistons exert equal forces?

2. Calculate the added pressure produced by the 90-newton push. Show your calculation and include units.

3. Use the transmitted pressure change to calculate the ideal upward force on the large piston. Show your calculation.

4. What is this lift's ideal mechanical advantage? Use the piston areas to calculate it, then explain why the small piston must move farther.

3 YOUR TURN

Your own words

Design a different ideal hydraulic lift. Choose two piston areas and an input force, then calculate the output force and mechanical advantage. In 3 to 5 sentences, explain how the pressure change travels and compare the distances the pistons move.

Lift the Stage

PART 1 · READ AND MARK

Underline the sentence that explains how a pressure change travels through the oil. Circle the input force and both piston areas you need to calculate the lift's mechanical advantage. Accept any marking that follows this job and points at the right text.

PART 2 · ANSWERS

#	QUESTION	ANSWER
1	The tube bends around equipment. How does the pressure change reach the large piston, and does this mean the two pistons exert equal forces?	**The pressure change travels equally in every direction through the enclosed oil, including around the bend. The forces need not be equal because the piston areas differ.**
2	Calculate the added pressure produced by the 90-newton push. Show your calculation and include units.	**90 N ÷ 5 cm^2 = 18 N/cm^2.**
3	Use the transmitted pressure change to calculate the ideal upward force on the large piston. Show your calculation.	**18 N/cm^2 × 100 cm^2 = 1,800 N.**
4	What is this lift's ideal mechanical advantage? Use the piston areas to calculate it, then explain why the small piston must move farther.	**100 cm^2 ÷ 5 cm^2 = 20. The small piston moves 20 times as far as the large piston to shift an equal volume of oil.**

PART 3 · YOUR TURN (SAMPLE ANSWER)

My lift has a 3 cm^2 input piston, a 15 cm^2 output piston, and an input force of 30 N. The added pressure is 30 ÷ 3 = 10 N/cm^2, so the ideal output force is 10 × 15 = 150 N and the mechanical advantage is 15 ÷ 3 = 5. The pressure change travels equally in every direction through the enclosed fluid. The input piston moves five times as far as the output piston to shift the same volume of fluid.

For Part 3, accept any positive areas with a larger output piston and calculations consistent with Pascal's principle. The distance comparison should be inverse to the area ratio.