Forces in Flight

Use wind tunnel data to compare lift, drag, gravity, and thrust.

P.6.6.6 "Investigate forces (gravity, friction, drag, lift, thrust) acting on objects (e.g., airplane, bicycle helmets). Use data to explain the differences between the forces in various environments."

NAME _____ DATE _____

1 READ AND MARK

Read it twice

YOUR JOB Underline each force named in the passage, then circle the words that tell you its direction. Number the two places where changing air speed changes a force.

A Plane That Stays Put

1 A small model airplane sits on a stand in a wind tunnel. A fan sends air past its wings, but the stand keeps the plane in place. Sensors measure the upward lift from moving air and the backward drag. The model's weight, a downward force from gravity, stays at 2 newtons in every test.

2 The table shows what happens when the fan changes speed. With still air, the wings produce no measurable lift or drag. Faster air pushes on the wings and body more strongly. Because the plane is held still, the stand supplies any extra force needed to balance the forces measured by the sensors.

FORCES ON THE MODEL AIRPLANE

Air speed (m/s)	Lift (newtons)	Drag (newtons)
0	0	0
4	0.5	0.2
8	2.0	0.8
12	4.5	1.8

3 Imagine the plane flying freely instead of resting on the stand. For level flight, upward lift must balance downward gravity. Forward thrust from its motor must balance backward drag to keep a steady speed. If lift is greater than its weight, the plane tends to rise unless its controls change the lift. A faster fan does not change its weight.

2 ANSWER WITH EVIDENCE

Use the passage

1. At an air speed of 4 m/s, compare lift with gravity. Could the plane fly level with these forces if the stand were removed? Explain.

2. At an air speed of 8 m/s, how do lift and gravity compare? How much forward thrust would balance drag?

3. How does drag change between 4 m/s and 12 m/s? What does this mean for the thrust needed to keep a steady speed?

4. At an air speed of 12 m/s, which is greater, lift or gravity, and by how much? What would the plane tend to do without the stand?

3 YOUR TURN

Your own words

Plan a fair test of a cyclist wearing a smooth helmet in still air and in a headwind. In 3 to 4 sentences, name one condition to keep the same, tell what force to measure, and use two drag values from the table to predict the difference in forward push needed at a steady speed.

ANSWER KEY

Forces in Flight

GRADE 6 · P.6.6.6

PART 1 · READ AND MARK

Underline each force named in the passage, then circle the words that tell you its direction. Number the two places where changing air speed changes a force. Accept any marking that follows this job and points at the right text.

PART 2 · ANSWERS

#	QUESTION	ANSWER
1	At an air speed of 4 m/s, compare lift with gravity. Could the plane fly level with these forces if the stand were removed? Explain.	**Lift is 0.5 newton, less than the 2-newton force of gravity. It could not fly level with these forces.**
2	At an air speed of 8 m/s, how do lift and gravity compare? How much forward thrust would balance drag?	**Lift and gravity are both 2 newtons. Forward thrust of 0.8 newton would balance drag.**
3	How does drag change between 4 m/s and 12 m/s? What does this mean for the thrust needed to keep a steady speed?	**Drag rises from 0.2 to 1.8 newtons. The plane would need more thrust to keep a steady speed.**
4	At an air speed of 12 m/s, which is greater, lift or gravity, and by how much? What would the plane tend to do without the stand?	**Lift is greater than gravity by 2.5 newtons. The plane would tend to rise.**

PART 3 · YOUR TURN (SAMPLE ANSWER)

I would keep the cyclist's ground speed the same in both trials. I would measure the backward drag on the helmet in still air and in a headwind. In the table, drag rises from 0.2 newton at 4 m/s to 0.8 newton at 8 m/s. I predict the headwind would increase drag on the helmet, so the cyclist would need more forward push to keep a steady speed.

Accept other conditions that make the helmet tests fair, such as keeping the rider's position the same. Students should use two correct table values and connect greater drag with a need for greater forward push at steady speed.