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BOUNDARY LAYER

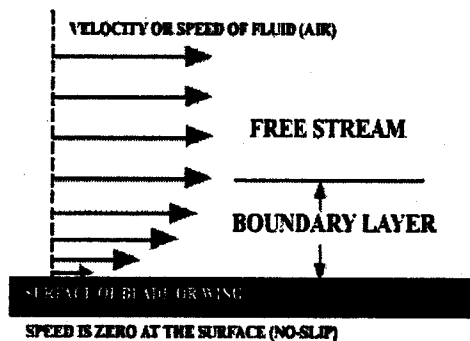
While cleaning my house the other day, I noticed that the ceiling fan was covered in dust. Yet, turning the fan on "high" did not remove any of the dust. I was surprised! Why didn't the fast, blowing air remove the dust? Good question!

Fan blades have a special shape called an airfoil. The air flows over the blade like water. You may not realize this, but air, like water, has viscosity – internal friction or "stickiness." It acts a little like honey except that it is much, much thinner. Because of this, the air directly touching the fan blade does not slip past but stays "stuck" to it. This layer of air "drags" against the air above it, which in turn, drags against the air just above it. Each layer drags less and less the farther it is from the blade. When the layers flow without dragging, they have reached *free stream* velocity. Up to that point the area is known as the *boundary layer*. Each layer of air within the boundary layer slips or moves faster than the layer that is closer to the surface of the blade.

Many pieces of dust are small enough to lie within the thin layer near the surface of the fan blade. No matter how hard the air blows by, the boundary layer provides a cozy zone where the wind speed is decreased to zero. The only way to

remove all the dust from the fan blades is to wipe it off!

Another way to think about this boundary layer is to imagine you are standing on the beach on a windy day. If you lie flat on the beach you feel less wind. This is partly because less of you is exposed to the wind but also because you are lying within the boundary layer of the

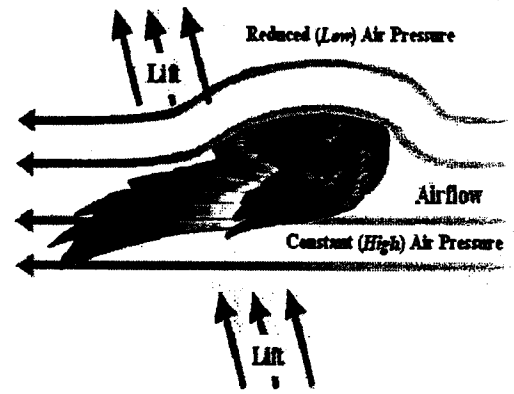


ground.

Why is the boundary layer so important? Without the layers of air slipping past each other in the boundary layer, all the air would have to move past the fan blade at once. This would slow the air down so much that it would barely be able to move past.

As I mentioned earlier, the shape of a wing (or blade) is called an airfoil. As it moves through the air, the airfoil forces air to go above and below it. The air moving over the upper surface has to move farther than the lower part of the wing. In order for the top air and bottom air to make it to the edge of the wing at the same time, the top air must go faster. A scientist named Bernoulli

discovered the air on the upper part has a lower pressure than the air moving underneath. This pressure difference creates *lift*. In very simplified terms, the air on top of the wing *sucks* the wing upwards. At the same time, the higher pressure of the air under the wing



helps *push* it upwards.

Speed is the most important part in making lift. More speed means more lift. Without a boundary layer letting air slip past wings, birds and airplanes could not create enough speed to lift them off the ground!

The *boundary layer* was discovered by Ludwig Prandtl at the beginning of the twentieth century. What science has only recently discovered, God has had in place from the beginning. God is a God of order. He created His world to have special ways to operate. If it weren't for that order, many things that we use every day would not work. Therefore, the same things that make it possible for birds to fly are what allow the dust to stick on my fan blades!

"But ask now the beasts, and they shall teach thee; and the fowls of the air, and they shall tell thee: ... Who knoweth not in all these that the hand of the LORD hath wrought this?"
- Job 12:7 & 9



Man continues to discover many things about our world. Where did it all come from?
Follow the instructions below and find out! The answer is at the bottom of the page.

ELEVEN	FOR	FISH	SHEEP	BY
HIM	COWS	RED	WERE	SIX
MARY	ALL	THINGS	BLUE	WHALES
CREATED	SHARKS	TWENTY	ALICE	THAT
HORSES	ARE	GREEN	IN	CATS
HEAVEN	AND	SUSAN	YELLOW	THAT
THREE	ELIZABETH	ARE	DOGS	IN
ORANGE	EARTH	EIGHT	VISIBLE	DOLPHINS
AMANDA	RABBITS	AND	PURPLE	INVISIBLE

1. Cross out all numbers.
2. Cross out all land animals.
3. Cross out all colors.
4. Cross out all water animals.
5. Cross out all girls' names

Look for the words hidden in the puzzle from the list below. The hidden words might be up, down, sideways, or slanted (not backwards). All the words come from the BOUNDARY LAYER on the other side.

WORD LIST

- | | |
|----------|-----------|
| BOUNDARY | LAYER |
| DUST | BLADE |
| LUDWIG | PRANDTL |
| SPEED | FAN |
| SLIPS | FRICITION |
| CREATED | GOD |
| BIRDS | AIRPLANE |
| WIND | |

T O F R I C T I O N B O A S T E Y M
 A T L T D R D E S O S I L T E H D I
 D S E S E A L H E C S I O O E D R R
 R C R E A T E D W P I I A T E I E A
 N E A S J U T E I E D E S A U D I A
 D A H L T I F L O B O U N D A R Y A
 L L T W E I S G B I T L G T N M P D
 R U F D T D C R T F R R B W U I R G
 V F D A T A Y K B S G E T R U N A B
 P M Y W N A E F I R E E S A O S N I
 T G O D I E C V K N L I S E D I D R
 W H N A E G S A A H E S L E E R T D
 E N A O E D E L T E S S E A H E L S
 L U E R N I P E T T M P S R Y V X F
 H N Y I T R M A N T S T E O I E Y Q
 O F W L I L E H S E T W A W E H R E
 Y U I A R C Y U A A E Y U D L L E E
 R A T S T I D B L A D E E C U S D M

Answer: "For by him were all things created, that are in heaven, and that are in earth, visible and invisible, ..." Colossians 1:16a.

