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Physics in daily life: Cycling in the wind

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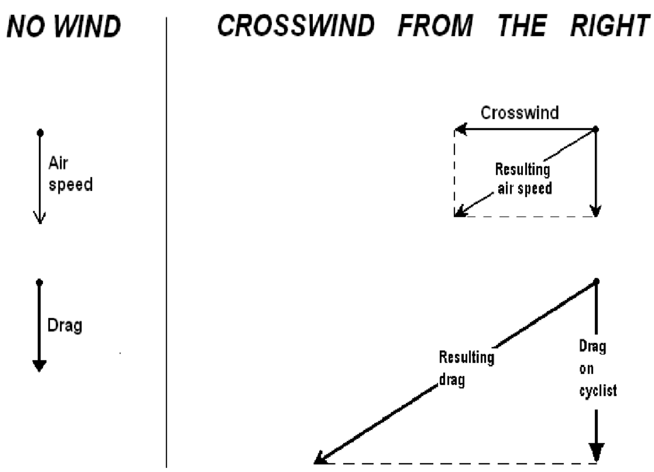
When riding our bicycle, wind is bad news, usually. For one thing, it spoils our average when making a round trip. The reason is obvious: we spend more time cycling with headwind than with tailwind.

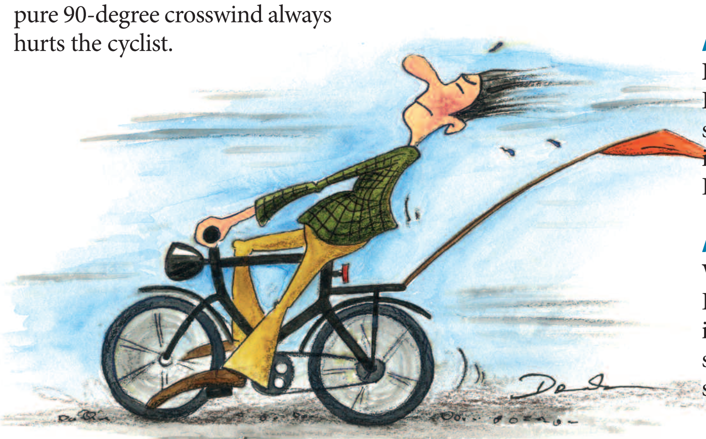
And what about a pure crosswind, blowing precisely at a right angle from where we are heading? That cannot possibly hurt the cyclist, one might think. Wrong. A crosswind gives rise to a much higher drag. Why is that? Don't we need a force in the direction of motion to do that?

So let us have a look at the relevant forces. The key is that air drag for cyclists is proportional to the relative air speed *squared* (just like for cars, *cf.* EPN 35/4, p. 130). This v^2 dependence spoils our intuitive feeling, as is easily seen from a vector diagram: See the figure, which illustrates the situation of a cyclist 'heading north'.



The figure says it all: In the wind-free case (left) the cyclist feels an air speed equal to his own speed, and experiences a certain drag which we may call *D*. With a crosswind blowing from the East, the resulting relative air speed is much larger, and so is the drag. In our example, the relative air speed is taken twice the cyclist's speed (it comes at a 60° angle from the right). Consequently, the resulting drag is 4*D*. So its component in the direction of motion is 2*D*, or twice what it was in the wind-free case.

In order to profit from the wind, it has to blow slightly from behind. Of course, the angle for which the break-even point is reached, depends on the wind speed relative to that of the cyclist. In our example, where their ratio is $\sqrt{3}$, the break-even angle is 104,5 degrees, as calculated by Fokke Tuinstra from Delft. But a pure 90-degree crosswind always hurts the cyclist.



In fact it's even worse. Also the relevant frontal area, which determines the drag, is increased dramatically. It is no longer that of a streamlined cyclist as seen from the front, but a *sin* α projection of the cyclist plus his bike. And with α being 60° in the example, this is practically the full side view of the bicycle and his rider. Even the crouched position does not help much in this case.

Clearly, riding our bike in the storm is really brave. It makes good exercise. And it yields some funny physics, too. ■

About the author

L.J.F. (Jo) Hermans recently retired as professor of Physics at Leiden University, The Netherlands. Main research topics: Internal-state-dependence of intermolecular and molecule-surface interactions, and nuclear spin conversion in polyatomic molecules. In the 1990s he served as a member of the EPS council.

About the illustrator

Wiebke Drenckhan (28) is a postdoctoral fellow at Trinity College Dublin, Ireland, where she is trying to unravel some of the mysteries of the physics of foams and other complex systems. Much of her spare time is invested into sharing her views on science from a slightly different perspective, namely that of a cartoonist.

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