Most readers enjoy having a better understanding of physical phenomena in everyday life, and being able to explain them to the layman. This has some extra relevance in view of the upcoming World Year of Physics 2005. This "Physics in daily life..." column is aimed at doing just that. Since it will span a wide variety of phenomena, most of which are outside the research expertise of the author, he welcomes comments, additions or corrections, especially from readers who happen to be more familiar with the topic.
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Physics in daily life: Moving around efficiently

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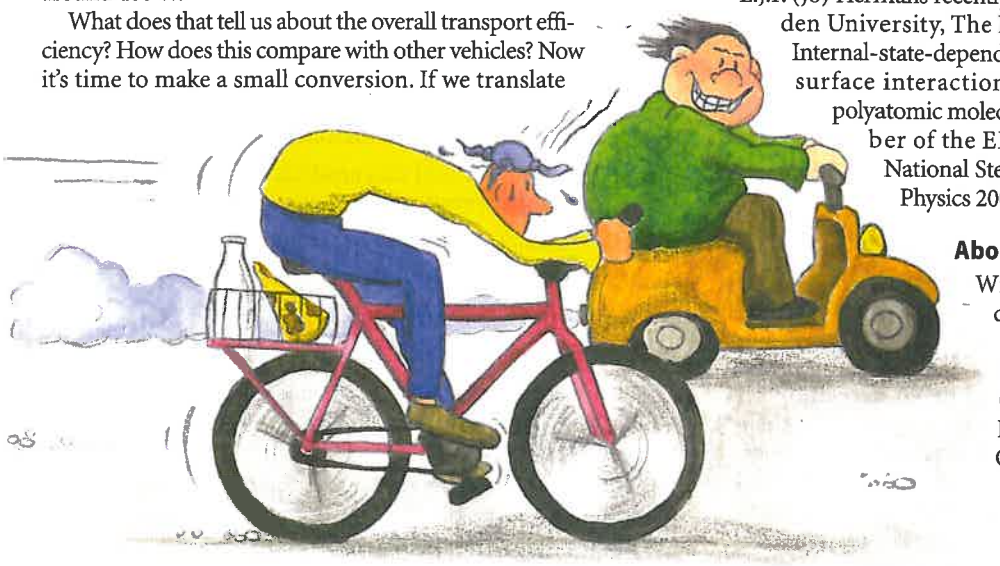
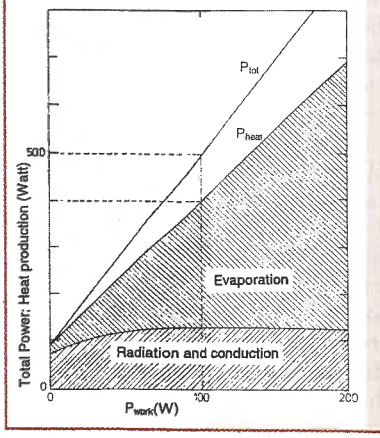
Ever considered the efficiency of a human being moving from A to B? Not by using our car or a plane, but just our muscles. Not burning oil, but food.

Many physicists will shout immediately: a bike! Use a bicycle! It is because we all know from experience that using wheels gets us around roughly 5 times as fast with the same effort as going by foot. But just how efficient is a bike ride? First, we have to examine the human engine. The power we produce is easily estimated from climbing stairs. If we want to do that on a more or less continuous basis, one step per second is a reasonable guess. Assuming a step height of 15 cm and a mass of 70 kg, this yields a power of roughly 100 W. Mountain climbers will find the assumed vertical speed quite realistic, since it takes us about 500 m high in an hour, and that is pretty tough.

Riding our bike is pretty much like climbing the stairs: same muscles, same pace. In other words: we propel our bike with about 100 W of power. But that is not the whole story. The efficiency of our muscles comes into play. With this type of activity, the efficiency is not so bad (a lot better than, e.g., weight lifting). We may reach 25%. The total energy consumption needed for riding is therefore around 400 W.

What does that tell us about the overall transport efficiency? How does this compare with other vehicles? Now it's time to make a small conversion. If we translate





◀ **Erratum:** This figure, omitted from the first Physics in daily life column, "The human engine: How to keep it cool," [EPN 34/4, page 153] demonstrates schematically that each 100 W of released heat that has to be compensated by evaporation requires a glass of water (0.18 l) per hour.

400 W continuously in terms of oil consumption per day, we find pretty much exactly one litre per day, given that the heat of combustion of most types of oil and gasoline is about 35 MJ per litre. In other words: if, for the sake of the argument, we ride 24 hours continuously, without getting off our bike, we have used the equivalent of 1 litre of gasoline in keeping moving. How far will that get us? That, of course, depends on the type of bike, the shape of the rider, and other parameters. If we take 20 km/h as a fair estimate, the 24 hours of pedalling will get us as far as 480 km. In other words: a cyclist averages about 500 km per litre.

That's not bad, compared to our car, or even a motorbike. So, we should all ride our bike if we want to conserve energy? Careful, there is a catch here. We have been moving on food, not oil. And it takes a lot more energy to get our food on the table than its energy content may suggest. A glass of milk, for example, takes roughly 0,1 litre of oil, a kg of cheese roughly 1 litre. It's because the cow has to be milked, the milk has to be cooled, transported, heated, bottled, cooled again, transported again, etcetera. Same (or worse) for the cheese. Etcetera.

Conclusion: Riding our bike is fun. It's healthy. It keeps us in shape. And if we have to slim down anyway, it conserves energy. Otherwise—I hate to admit it: a light motorbike, if not ridden too fast, might beat them all.

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. Presently he chairs the National Steering Committe for the World Year of Physics 2005.

About the illustrator

Wiebke Drenckhan (26) is currently doing her PhD in the "Physics of Foams" in Trinity College Dublin, Ireland. She has studied and worked in Germany, USA, New Zealand and France, being largely supported by the German National Merit Foundation. Additionally to taking a scientific approach to the world, she likes to capture its oddities in cartoons.