Friction: Reducing Energy Losses in Design

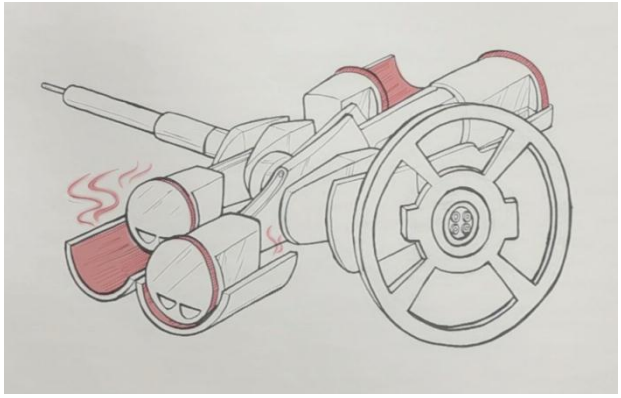
Companion to the video: Script and Illustrations

To move a product, like a car, or part of a product, like a piston, you have to convert fuel or electricity to mechanical energy.

Although the engine's efficiency depends most on its thermodynamic cycles, a car engine's pistons still lose over a thousand watts of power to friction as they slide.

Whenever one material moves against another, some energy will be lost to friction.

That energy becomes unwanted heat, deformation, and wear – which reduces the engine's lifetime and increases costs.



So your job as a designer is to get rid of unwanted friction wherever you can find it.

Friction depends on the roughness of the surfaces in contact, the materials themselves, and on whether the object is at rest or in motion.

This is quantified as the coefficient of friction, mu. The higher the number, the more resistance.

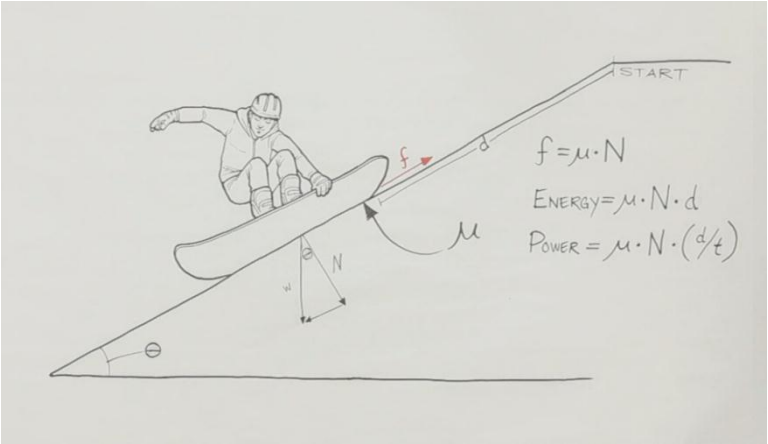
Friction also depends on the force pushing the objects together.

On a snowboard, for instance, that's the normal force, from gravity pulling down.

Obviously it'd be hard to go anywhere without snow because the ground has too much friction.

But, note that the friction force DOESN'T depend on velocity, or surface area, only mu and the normal force.

To find the energy used to overcome friction, multiply friction force by distance. To find out power loss, multiply friction force times velocity.



Once we know where friction comes from, we can reduce it.

One way is to reduce surface roughness by choosing smoother surfaces…

Or we can use materials that slide well against each other.

If you can't change the parts' materials, you can add a layer of different material between moving parts, to reduce friction. These are called bushings.

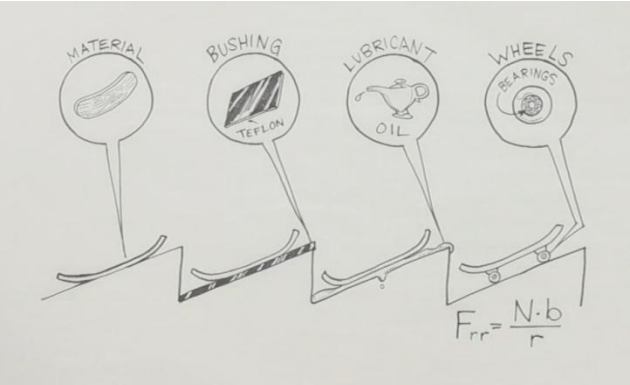
You can also use a fluid lubricant like oil. This replaces sliding friction with much smaller fluid drag.

Liquid isn't the only lubricant – air, or even a powder like graphite, can work.

You could also change sliding friction to much smaller rolling resistance using bearings or wheels, like you'd find on skateboards.

Rolling resistance depends on how much the materials deform, so good bearings are made from hard materials like metal or ceramics. The skateboard's wheels are made of hard plastic.

Bigger wheels reduce rolling resistance, too.

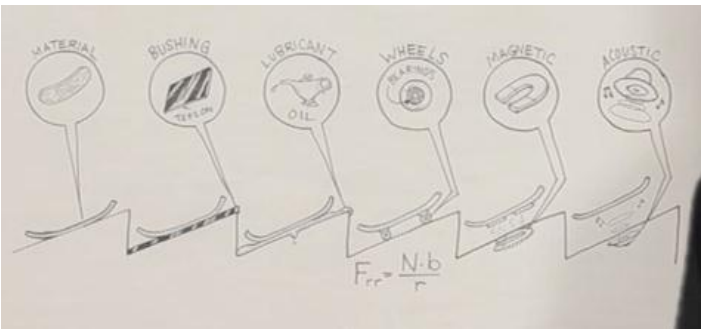


But friction isn't always bad, and the skateboard shows us why.

Friction provides the traction you need to turn and to stay on the board.

The only way to eliminate unwanted friction entirely is to make sure that parts don't touch each other at all. You'll see this in trains that use magnetic levitation.

Acoustic lubrication does this by lifting an object a tiny bit over and over.



Small design changes to reduce friction can save tons of energy for your users.

And they'll appreciate it. TWO TO FOUR PERCENT of gross domestic product is lost to friction, and parts wearing out from it!

Imagine the sustainability impact of cutting that number in half or more. That's EXACTLY what smart design can do.