

A driver accelerates to a cruising velocity v , maintains that speed for a distance d . Just before the end, they slam on the brakes and turn all the vehicle's kinetic energy into heat in the brakes stopping the vehicle. (To make this simpler, the vehicle doesn't have regenerative braking.) The acceleration gives the car kinetic energy; braking throws that kinetic energy away in the form of heat.

Assume the car accelerates and slows (i.e., it gains and then loses kinetic energy) once in each duration, time $t = d/v$.

The rate at which energy is turned into heat by the brakes is the same as the rate of energy expenditure by the vehicle's power plant to accelerate, move, then stop the vehicle.

$$\frac{KineticEnergy}{Time_{driving}} = \frac{\frac{1}{2}mv^2}{d/v} = \frac{\frac{1}{2}mv^3}{d}$$

Energy goes not only into the brakes while the car is stopping, the moving vehicle also accelerates the air it encounters. A car leaves behind this accelerated, swirling air, moving at a speed similar to the vehicle's velocity, v . The swirling air basically makes a "tube" with a volume created in a time t . This volume is Avt , where A is the front-cross-sectional area of the tube. This is similar to, but not the same as the area of the front of the vehicle. If the vehicle's coefficient of drag is less than 1, the tube of air has an effectively smaller cross sectional area than the vehicle. If the coefficient of drag is larger than 1, the tube of air has an effectively larger cross sectional area than the vehicle. I'll ignore the coefficient of drag and just let the cross sectional area term, A , absorb it. The tube of air has mass $m_{air} = \rho Avt$ (where ρ is the density of air) and swirls at speed v , so its kinetic energy is:

$$\frac{1}{2}m_{air}v^2 = \frac{1}{2}\rho Avtv^2 = \frac{1}{2}\rho Atv^3$$

The rate of kinetic energy generation in this tube of swirling air is the kinetic energy term divided by time t :

$$\frac{\frac{1}{2}\rho Atv^3}{t} = \frac{1}{2}\rho Av^3$$

The total rate of energy produced by the vehicle's power plant (assuming a quick enough acceleration and deceleration we don't need to use differential equations) is the sum of those two terms.

Thus the **Rate of Kinetic Energy Generation While Driving** is given by:

$$\frac{\frac{1}{2}mv^3}{d} + \frac{1}{2}\rho Av^3$$

And all of that comes from the vehicle's power plant (ignoring coasting downhill, etc).

—————**Bonus**—————

You can work out whether the kinetic energy dumped into the brakes or the kinetic energy dumped into moving the air out of the way is more important by comparing the two and figuring out which matters more for your particular vehicle.

We're assuming you get up to the same velocity in the following discussion.

To do that comparison, let's ratio the two terms. Doing so cancels the $\frac{1}{2}$ and the v^3 , leaving us with:

$$(m/d)/(\rho A)$$

Clean up once more:

$$\frac{m}{\rho d A}$$

If this is larger than 1, then the mass of the vehicle matters more than the air resistance and if that ratio is less than 1, then air resistance matters more.

The Scout Traveler (by itself) has an area of: 80 inches * 76.3 inches = 2.03 meters * 1.94 meters = 3.94 m^2 . Include coefficient of drag, which we don't know, but let's use a truck-like $C_d = 0.56$. That gives us an $A = 0.56 * 3.94 m^2 = 2.2 m^2$.

Density of air, ρ , is 1.3 kg/m^3 .

Mass of the R1S is a reasonable estimate for the mass of the Traveler: 3050 kg.

We solve for the driving distance where the relative importance takes over:

$$1 = m/(\rho d A) \text{ multiply both sides by } d. \quad d = m/(\rho A)$$

$$d = 3050kg/(1.3kg/m^3 \times 2.2m^2) d = 1066meters.$$

Essentially what this is saying, given not totally unreasonable speeds and accelerations:

If you drive less than 1066 meters, then the mass of the Traveler matters more for energy expenditure. If you drive more than 1066 meters, then the air resistance matters more.

A travel trailer might double the coefficient of drag of its tow vehicle.