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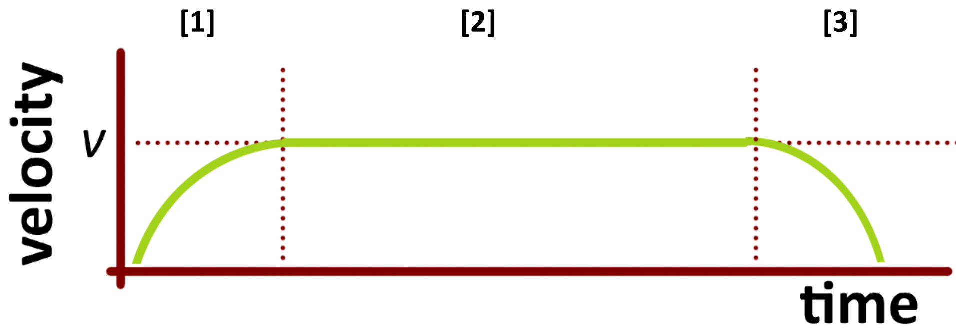
Cars! – Part 2

Continuing: we decompose an automobile trip into three regimes. The schematic **velocity vs. time:**



The car **[1]** accelerates to some velocity ***v***, **[2]** travels with a constant velocity, for example on a highway, and **[3]** slows down and stops.

Consider Regime 2: *Constant velocity*

Here's the important part! We're going to figure out how much power we need in Regime 2, and how this depends on *v*. The answer, in addition to being interesting and **non-obvious**, impacts how we think about high- and low- efficiency cars, and other modes of transport.

Q8. A naive graph. Make a wild guess for what a graph of power vs. velocity might look like. Is it constant? Does it plateau? Is it a straight line? Make two schematic graphs, one for heavy cars and one for light cars.

Q9. What form(s) of energy change in magnitude during [2]? *(?!)*

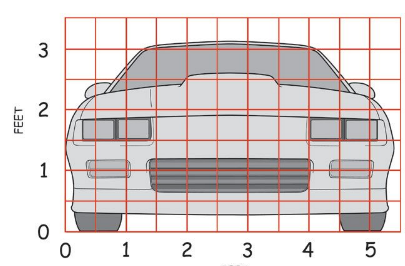
Q10. Why can't we ignore air resistance in Regime 2?

Q11. Imagine that every bit of air the car hits goes from rest to speed v, and tossed aside by the car. (This is a pretty good approximation.) **Draw a picture** that shows the volume of air the car hits when traveling.

Q12. Suppose we knew the mass of the displaced air (M_{air}). Write an expression for the kinetic energy of the displaced air:

Q13. Suppose the car is traveling in Regime 2 for a time t. What **distance** (d) does it travel? In other words, write an equation for d in terms of v and t, and also indicate d on your drawing. We're going to use this to figure out the mass of the displaced air.

Q14. Suppose the car has a frontal area A (see figure, below). What is the **volume** of air that's displaced?



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Q15. Based on what we've discussed: Do you think the power we need in Regime 2 depends on the **mass** of the car? The **area** of the car?

Q16. The mass of the air that's displaced is equal to **its density x its volume**. (Recall that density is mass / volume.) Write an expression for the **mass of the air** in terms of density, v, A, and t.

Q17. Write an expression for the **kinetic energy of the air** in terms of density, v, A, and t.

Q18. Write an expression for the **power needed to move the car** in terms of density, v, A, and t. This is the power we need to supply in Regime 2! Regardless of whether you are comfortable with Q17-18, you can hopefully see that there are several factors of v involved!

Q19. The equation in Q18 is not important. The concepts behind it are! Answer in one sentence: Why do we need to supply power in Regime 2?

Q20. Now what would we predict for the shape of a power vs. velocity graph for cars? What if we include cars of different masses (but similar shapes)? Really?...