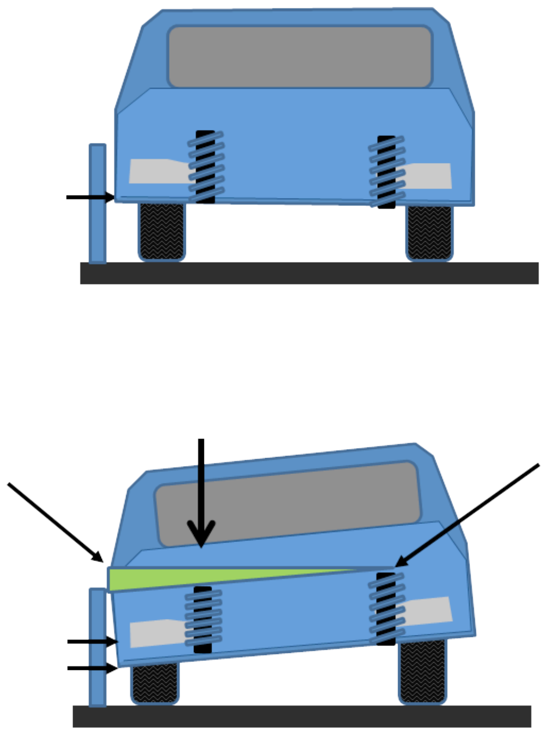
How Much Energy Does it Take to Compress an Automotive Suspension?

In the BLOSSOMS video, "Quantifying the Energy in Everyday Things and Events", the question was posed:

How much energy does it take to compress the suspension spring in a Honda Accord by 2cm?

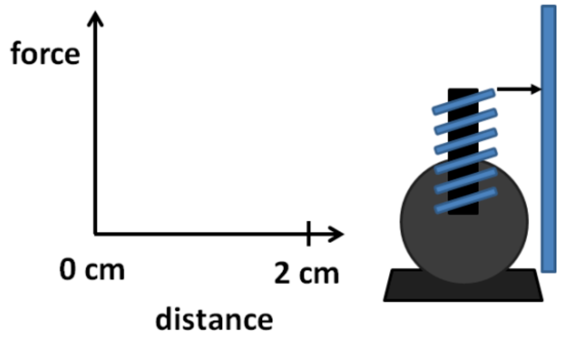
The video shows a simple experiment in which a person weighing 200 lb sat on the hood. We measured that, when the weight was applied, the fender travelled down by 3cm. We estimated that this corresponded to 2 cm of compression of the spring since the spring is in a different location than the fender. To understand this phenomenon of the fender moving and the spring compressing by different amounts, study the figure below.



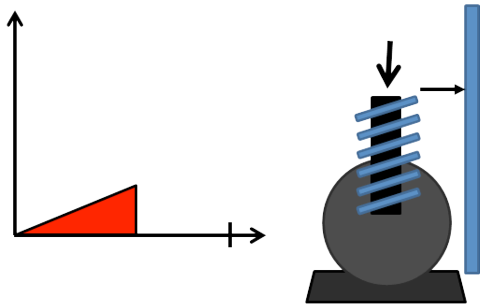
Initially, the meter stick is placed near the fender on the passenger side (which is the left side in the figure above). This was simply a convenient place to make the measurement of downward movement. In fact, we wanted to know the compression of the suspension spring which was substantially inboard of the fender.

When the weight of the person was applied to the hood (roughly above the suspension spring) we could see the fender move down. Since the meter stick was in place, we could measure the deflection of the fender as 3 cm. We observed that the motion of the car was a rotation about the location of the suspension spring on the driver's side (the right side in the figure above). With that rotation by a small angle, the downward motions of the various parts of the car body are proportional to their horizontal distance from the pivot point. I estimated that the distance from the spring being compressed to the pivot point is about 2/3 of the distance from the fender to the pivot point. So, I surmised that the suspension spring compressed by about 2 cm.

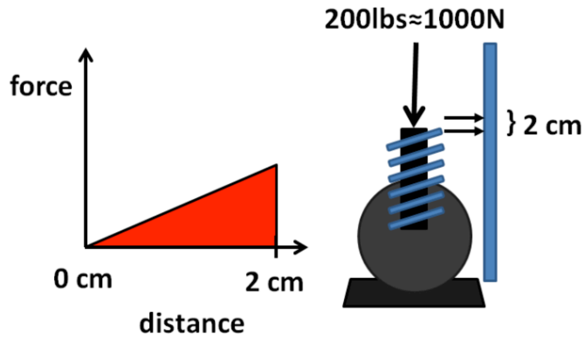
Now, how much energy was put into the system by the person when they applied their weight to the car? We calculate the work done by computing the integral of force over a distance. The integral is just the area under a curve. Let's consider the set-up of the car and the force initially. There is no force applied by the person at first and the deflection of the spring is zero.



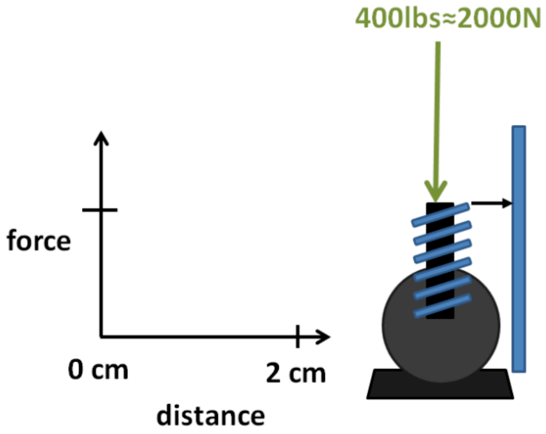
As the person begins to push down on the car body, the suspension spring begins to compress. As the force increases, the distance the spring is compressed increases proportionally. The video refers to this as a linear relationship between force and compression of the spring.



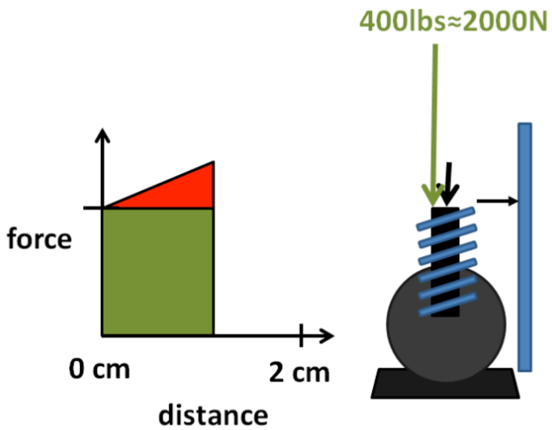
When finally the full weight of the person is on the car, the spring had compressed by 2cm. The weight was 200 lbs which is about 1000N. The area under the curve is the area of a triangle which is one half the base times the height. So that's ½ 1000N times 2 centi-meters. That computes to 1000 centi-Joules or 10 Joules.



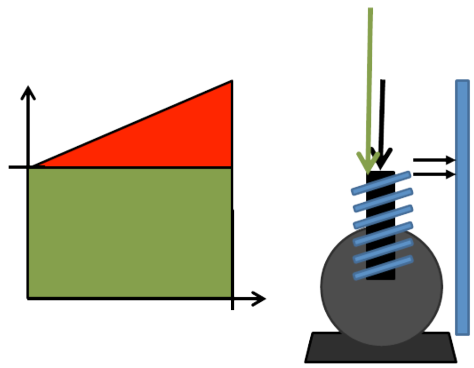
This is one interpretation of the answer to the question “How much energy does it take to compress the suspension spring?” We measured and calculated how much energy must be added from outside the system. But, we could also consider the influence of the forces and energy related to the car in which the suspension spring in installed. As mentioned in the video, the car weighs much more than a person (roughly 8 to 10 times more). That weight is distributed on 4 suspension springs, and we estimated that roughly 400 lbs or 1.8kN of the car’s weight is on each wheel. (In the interest of full disclosure, I have checked on the weight of a Honda Accord and it is 2000lbs, so a better estimate would have been 500 lbs or 2.2 kN on each suspension spring. The key thing is that, for the purpose of ranking these items, the 2kN estimate will be just fine).



As I put my weight onto the hood of the car, that causes the spring to compress. The weight that I apply to the hood is added onto the 2000N that was already on the spring due to the car’s own weight. So now the picture for integrating the force and distance is a bit different than before. There is the triangle as previously considered, but also a rectangle below that.



When the total weight of the person is applied to the hood of the car, that was about 1000N applied to the spring in addition to the 2000N due to the car’s own weight. The total energy stored within the spring would therefore be the area of the triangle and the area of the rectangle below it. As before, the triangle’s area represented 10J of energy. The rectangle adds to that 2000N times 2 cm or 40 Joules of energy. Adding together the 10J of work done by the person and the additional 40J of work done by the car, we estimate 50J of total work. So our answer is roughly either 10J or 50J depending on how we interpret the question.



Was the question asking how much energy is added from outside the system defined as the car or how much energy was added from outside the system defined as the suspension spring only (not including the car)? In either case, the key conclusion is the same. The amount of energy is very small compared to the other items on our list.