Name ______________________________ Date ________

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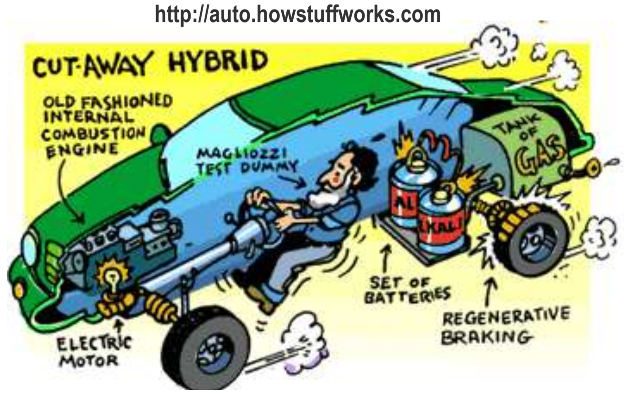
Energy Transformations and the Hybrid Car

http://auto.howstuffworks.com



The first law of thermodynamics tells us that energy cannot be destroyed. So when your car slows down upon braking, the kinetic energy that thrust it forward has to go somewhere. Most of it simply dissipates as heat and becomes useless, low-quality energy. That energy, which could have been used to do work, is essentially wasted as it disperses into different parts of the environment and then eventually radiated back into space. There isn't much that you can personally do to stop this inevitable waste of energy because, no matter what, braking is an essential part of the driving process. However, automotive engineers have given this problem serious thought and investigation, and have come up with a braking system that can recapture much of the car's kinetic energy, convert it into electricity to be used to recharge the car's batteries and once again become the potential chemical energy stored in the battery for later use. This system is called regenerative braking. At present, these kinds of brakes are primarily found in hybrid vehicles like the Toyota Prius, and in fully electric cars, like the Tesla Roadster. In vehicles like these, keeping the battery charged is of considerable importance because the more the battery stays charged and remains the primary source of the car's energy, less fossil fuel is being burned.

In a traditional braking system, brake pads produce friction with the brake rotors to slow or stop the vehicle. Additional friction is produced between the slowed wheels and the surface of the road. This friction is what turns the car's kinetic energy into heat. With regenerative brakes, on the other hand, the system that drives the vehicle does the majority of the braking. When the driver steps on the brake pedal of an electric or hybrid vehicle, these types of brakes put the vehicle's electric motor into reverse mode, causing it to run backwards, thus slowing the car's wheels. While running backwards, the motor also acts as an electric generator, producing electricity that's then fed into the vehicle's batteries. These types of brakes work better at certain speeds than at others. In fact, they're most effective in stop-and-go driving situations. However, hybrids and fully electric cars also have friction brakes, as a kind of back-up system in situations where regenerative braking simply won't supply enough stopping.

In a regenerative braking system, the trick to getting the motor to run backwards is to use the vehicle's momentum as the mechanical energy that puts the motor into reverse. Momentum is the property that keeps the vehicle moving forward once it's been brought up to speed. Once the motor has been reversed, the electricity generated by the motor is fed back into the batteries, where it can be used to accelerate the car again after it stops. Sophisticated electronic circuitry is necessary to decide when the motor should reverse, while specialized electric circuits route the electricity generated by the motor into the vehicle's batteries. In some cases, the energy produced by these types of brakes is stored in a series of capacitors for later use. In addition, since vehicles using these kinds of brakes also have a standard friction braking system, the vehicle's electronics must decide which braking system is appropriate at which time.

Hybrid electric vehicles use both an electric motor and an internal combustion to combine the driving range of an internal combustion engine with the fuel efficiency and emissions-free characteristics of an electric motor. If a hybrid is to have maximum fuel efficiency and produce as few carbon emissions as possible, it's important that the battery remain charged as long as possible. If a hybrid vehicle battery were to lose its charge, the internal combustion engine would be entirely responsible for powering the vehicle. At that point, the vehicle is no longer acting as a hybrid but rather just another car burning fossil fuels. Automotive engineers have come up with a number of other ways to maximum the efficiency of a hybrid car (like designing bodies that are more aerodynamic to minimize wind resistance and using more lightweight materials), but the one the most important is regenerative braking. Presently, these efficiencies are necessary due to the extreme difficulty in finding a place to recharge a hybrid. This makes longer trips difficult without relying on the hybrid's internal combustion engine, which actually cancels out some of the advantages of owning a hybrid.

The energy efficiency of the combustion engine a conventional car is only about 20 percent, with the remaining 80 percent of its energy being converted to heat through friction. The miraculous thing about regenerative braking is that it may be able to capture as much as half of that wasted energy and put it back to work. This could reduce fuel consumption by 10 to 25 percent. These kinds of brakes allow batteries to be used for longer periods of time without the need to be plugged into an external charger. These types of brakes also extend the driving range of fully electric vehicles. In fact, this technology has already helped bring us cars like the Tesla Roadster, which runs entirely on battery power. Sure, these cars may use fossil fuels at the recharging stage -- that is, if the source of the electricity comes from a fossil fuel such as coal -- but when they're out there on the road, they can operate with no use of fossil fuels at all, and that's a big step forward. But, the added efficiency of regenerative braking also means less pain at the pump, since hybrids with electric motors and regenerative brakes can travel considerably farther on a gallon of gas, some achieving more than 50 miles per gallon at this point, and that's something that most drivers can really appreciate.

AIM:

The Law of Conservation of Matter:

- Elements and compounds can change from one form to another, but there are no physical or chemical changes that can create or destroy atoms.

- pollution and the "circle of poison" → garbage can't ever really be "thrown out".

The First Law of Thermodynamics: The Law of Conservation of Energy

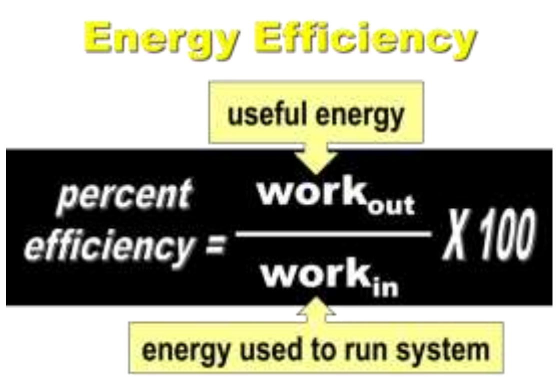
Energy cannot be created or destroyed, but it may be changed from one form to another.

The Second Law of Thermodynamics:

When energy is changed from one form to another, some of the useful energy is degraded to lower-quality, more dispersed, higher entropy, less useful energy *(usually dispersed heat)*

***Heat* Flow:** energy flows from heat sources (high quality) to heat sinks (low quality)

energy in = energy out **+ waste heat** (work in > work out)



Efficiencies of Common Energy Consuming Items

1. gasoline-powered engine:
2. steam turbine:
3 human body:
4 incandescent light:
5 fluorescent light (CFL):
6 LED light: