Fundamentals of Hybrid Vehicle Technology

What is a “HYBRID” vehicle?
What is a hybrid vehicle?

- A hybrid vehicle is one that uses a combination of an internal combustion engine (ICE) and a battery electric drive system to improve fuel economy and reduce emissions.

- The most common type of hybrid car combines Gasoline ICE and Electric Motor.
The vehicle utilizes an ICE and an electric motor for propulsion.

Credit to www.fueleconomy.gov/feg/hybridtech.shtml
Fundamentals of Hybrid Vehicle Technology

What is a hybrid vehicle

- The power source for both power plants are stored on-board the vehicle
- Gasoline for the ICE is stored in the fuel tank
- Electricity is stored in a high voltage Hybrid battery pack for the electric motor
Fundamentals of Hybrid Vehicle Technology

What is a hybrid vehicle

- The gasoline engine also powers an electric generator to recharge the battery pack
- Depending on driving conditions one or both sources are used to power the vehicle
A typical layout of a Hybrid Vehicle
Fundamentals of Hybrid Vehicle Technology

What is a hybrid vehicle
Fundamentals of Hybrid Vehicle Technology

What is a hybrid vehicle

- **Acceleration**
  - Electricity and gasoline (additional electricity extracted from batteries)

- **Deceleration**
  - Charging batteries

- **Stopping**
  - Engine automatically stopped
Hybrid Safety, Tools and Equipment

- Read the owners manual/service manual/quick reference card
- Familiarize yourself with the instructions and warnings supplied in the owners manual, service manual and quick reference card provided for the vehicle.
Hybrid Safety, Tools and Equipment

- **Look for warning Labels**

  ✓ **High voltage components are clearly identified by warning labels that are attached to the vehicle.** Additionally, **high voltage cables and wiring are generally colored orange for easy identification.**
Hybrid Safety, Tools and Equipment

- Working on high voltage electrical systems

✓ High voltage systems must be isolated (that is the power disconnected and secured that it cannot be inadvertently turned back on) and confirmed to be de-energized by testing.

✓ Always isolate the source of electricity in accordance with manufacturer’s instructions.
Hybrid Safety, Tools and Equipment

- Working on high voltage electrical systems

✓ The high voltage system may remain powered for a period of time even after the vehicle is shut-off or disabled.
✓ Refer to manufacturer’s instructions for guidance.
High Voltage service plug

Credit to www.vehicleservicepros.com

Credit to http://www.boronextrication.com
Hybrid Safety, Tools and Equipment

- Hybrid Vehicles introduce hazards into the environment in addition to those normally associated with the repair and maintenance of vehicles. For example, roadside recovery, first respondents and other vehicle related activities including seemingly non-hazardous activities, such as valeting. These risks include:
Hybrid Safety, Tools and Equipment

✓ Components that may retain a dangerous voltage even when a vehicle is switched off and/or ‘discharged.’

✓ Electric motors or the vehicle itself that may move unexpectedly due to magnetic forces within the motors.

✓ Manual handling risks associated with heavy battery pack replacement or disposal.

✓ The storage of electrical energy with the potential to cause explosion or fire.
Hybrid Safety, Tools and Equipment

➢ The potential for the release of explosive gases and harmful liquids if batteries are damaged or incorrectly handled.

➢ The presence of high voltage components and wiring capable of delivering a fatal electric shock.

➢ The possibility of people being unaware of vehicles moving as when electrically driven they are silent in operation.

➢ The potential for the electrical systems on the vehicle to affect medical devices such as pacemakers.
Hybrid Safety, Tools and Equipment

HOW TO REDUCE RISKS

✓ It is important that the correct equipment is used. Never modify or improvise equipment.
✓ Warn others about the current state of the vehicle being worked on.
✓ Only use insulated tools when carrying out repair or maintenance work on vehicles.
Hybrid Safety, Tools and Equipment

✓ Be over protective when it comes to safety clothing.
✓ Use safety signs to assist in ensuring that correct procedures are being adhered to.
✓ Lock off and isolate before working on hybrid vehicles.
Hybrid Safety, Tools and Equipment

✓ As with all vehicles you must follow approved safety procedures by using approved personal protective equipment and manufacturer-specific repair information. When working on hybrid electric vehicles’ high-voltage systems, additional items may need to be utilized such as Class 0 high-voltage insulated gloves and **CAT III 1,000V insulated tools**.

✓ It is also recommended that you test the gloves for leakage every time you use them. This is accomplished by blowing into the gloves (similar to a balloon) and squeezing or rolling them to see if any air leaks out. If there are any air leaks or signs of cracking **DO NOT USE** the gloves and replace them prior to starting work on a high voltage system.
Hybrid Safety, Tools and Equipment

✓ Using a CAT III 1,000V DMM along with CAT III test leads is also required. It is also a very good idea to advise all other technicians working in the shop that they are working on a high-voltage system; they should either wear approved safety gear or stay out of your workspace.
Hybrid Safety, Tools and Equipment

✓ Cordon off your workspace.
✓ Use of repair information sources and following all warnings is critical to assure you are safe when working on all hybrid systems.
Dual motor/generator hybrid systems
Discussion: Advantages/Disadvantages
Hybrid glossary

- **EREV** - Extended Range Electric Vehicle
- **Full hybrid** - the ability to run on either the engine, the electric motor, or a combination of the two
- **Mild hybrid** - a car which cannot be powered by the electric motor alone
- **Parallel hybrid** - both the engine and motor are connected to the transmission which powers the wheels
- **PHEV** - Plug-in hybrid electric vehicle (can be charged by plugging-in)
- **Series hybrid** - only the electric motor can drive the wheels, the engine simply charges the batteries
Motors

- Synchronous permanent-magnet AC motor

The motors work on three-phase alternating current, with powerful permanent magnets. The job of the inverters and the control electronics is to convert the DC supply from the battery to a suitable voltage (up to 500V AC on 2004-2007 Prius), current and phase for the desired torque on the motor/generator. The electric motor in a hybrid car can also function as a Generator.
Motors

- Power Split Device
- Generator/Starter
- 4 Cylinder Internal Combustion Engine
- Electric Motor
Regenerative braking is an energy recycling method used on hybrid and electric cars. The idea is to convert the kinetic energy (which is usually lost as heat during braking) into usable electricity to recharge the battery pack. Energy is usually captured by using the main electric motor as a generator, which is connected to the wheels automatically when braking is started.
Regenerative Braking Cont’d

- The kinetic energy of the vehicle is used to drive the electric motor during regenerative braking. This causes the vehicle to slow down, thus reducing the amount of friction at the brake lining needed to slow the car, resulting improved brake pad service life.

- Discussion Question: Abrupt Stop or Gradual Stop?
Battery Modules

Three major types of batteries that are used in hybrid cars are lead-acid, nickel-metal hydride (NiMH) and lithium-ion (Li-ion).
The battery pack of the second generation Toyota Prius consists of 28 Panasonic prismatic nickel metal hydride modules—each containing six 1.2 volt cells—connected in series to produce a nominal voltage of 201.6 DC volts. The total number of cells is 168, compared with 228 cells packaged in 38 modules in the first generation Prius. The pack is positioned behind the back seat.

The weight of the complete battery pack is 53.3 kg. The discharge power capability of the Prius pack is about 20 kW at 50 percent state-of-charge. The power capability increases with higher temperatures and decreases at lower temperatures. The Prius has a computer that’s solely dedicated to keeping the Prius battery at the optimum temperature and optimum charge level. The Prius supplies conditioned air from the cabin as thermal management for cooling the batteries. The air is drawn by a 12-volt blower installed above the driver’s side rear tire well.
Motors

- Toyota Prius Nickel Metal Hydride Battery (H.V.)

Credit to: green tec auto
12 volt battery
12 volt battery

- When disconnecting the 12 volt battery for replacement or service, always disconnect the Negative Terminal first and reconnect it last.

- (Always refer to manufacturers specification or manual prior to removal)

- **Jewellery is strictly prohibited when working on any electrical system, as it is electrically conductive and can lead to electric shock**
AC/DC Converters - Inverter/Converter
Motors- Inverter/Converter

- Inverter/Converter boosts and inverts high voltage electricity from the HV battery pack to 3-phase AC electricity that drives the electric motor.

- The Inverter/Converter also converts AC electricity from the electric generator and electric motor (regenerative braking) to DC that recharges the HV battery pack.
Operating a Hybrid Vehicle

Starting/ Shutting down a hybrid vehicle

Press your foot on the brake. The Toyota Prius is designed not to start until the driver presses their foot firmly on the brake. This is a safety feature intended to ensure the car can’t lurch forward or backward when the electrical engine comes on. Place your right foot firmly on the brake before attempting to start the car.
Starting/Shutting down a hybrid vehicle
Cont’d

- **Insert the key.** If your Toyota Prius came equipped with a smart key that does not need to be inserted, you simply need to have it in the vehicle while the engine is running. Otherwise, insert the key or key fob in the appropriate place. In most newer Prius models, you need only to have the smart key in the cabin of the vehicle.

- In older Prius models, place the key into the ignition hole with the fob's buttons-side facing towards the roof of the car without turning the key.
Operating a Hybrid Vehicle
Starting/Shutting down a hybrid vehicle

- **Press the power button.** With your foot still firmly on the brake, press the power button. Hold the button for a second, and listen for a beep to let you know that the electrical engine is ‘starting’. If you do not hear a beep, press the button again for a bit longer.

- The electric motor will ‘start’ but the gasoline one may not until it needs to.

- **Look for the “Welcome to Prius” screen.** The display on the dashboard of the Prius will come on when the engine starts. The screen will show the words, “Welcome to Prius” before switching over to displaying pertinent driver information. The word “READY” will appear on the screen to indicate that the Prius is ready to be driven.

- Take the vehicle out of park and put it into drive in order to begin driving.
Operating a Hybrid Vehicle
Starting/Shutting down a hybrid vehicle

- Hold the brake pedal and bring the vehicle to complete stop when you have to shut down.
- You should engage the parking brake and press the ‘P’ button that is placed above the gear selector.
- Wait for the dash display to turn off when you hit the ‘Power’ switch.
- Ensure that the ‘Power’ switch is not illuminated.
Operating a Hybrid Vehicle

Emergency Shutdown

To shut off the vehicle before coming to a stop in an emergency, push and hold down the power button for more than 3 seconds. This procedure may be useful at an accident scene in which the READY indicator is on, Park cannot be selected, and the drive wheels remain in motion.
Operating a Hybrid Vehicle

- Most manufactures make it easy to find the **High Voltage service plug** because they usually locate this plug in the rear cargo compartment near the battery. Most manufactures use a Slide-Up/Pull Back Lever type of plug.

- Some manufacturers use a service plug which simply requires you to turn it to a certain position without having to remove it from the vehicle.

- After these plugs are removed you should wait about **at least 30 minutes** for the onboard battery capacitors to dissipate their stored energy. After that it would be safe to work around the High Voltage cables. If you do decide to work on the Hybrid system itself then you will have to invest in a pair of safety gloves rated at **1000 Volts**.
HOW TO DISCONNECT THE HIGH VOLTAGE HYBRID BATTERY ON A TOYOTA PRIUS

1. Lift tab
2. Remove High voltage service plug
3. Lift tab
4. Remove High voltage service plug
The Importance of Scheduled Maintenance

Regular maintenance is essential to obtaining the highest level of performance, safety and reliability from your car. It can also increase your vehicle's resale value. Along with other important information related to vehicle service, you'll find factory-recommended maintenance guidelines and a log in which to document your vehicle's maintenance history.

In addition to scheduled maintenance, your vehicle requires ongoing general maintenance such as fluid checks and visual inspections. These procedures are explained in the "Vehicle Maintenance and Care" section of the Owner's Manual. Be sure to perform these procedures regularly to ensure the most trouble-free operation of your vehicle.
Miles or Months?

Generally car makers recommends obtaining scheduled service for your vehicle every 5,000 miles or 6 months, whichever comes first.

- For Example: If you drive 5,000 miles in less than six months, you should obtain maintenance at 5,000 miles - don't wait until 6 months.

With proper maintenance and care, your vehicle will last longer and deliver more dependable, economical performance. Follow the manufacturers maintenance recommendations and you'll enjoy maximum reliability and peace of mind from your vehicle for many years to come.
MINOR SERVICE 5,000km or 3 months
*10,000 miles or 12 months for synthetic oil

- Check installation of driver's floor mat
- Check for open campaigns/recalls
- Replace engine oil and oil filter*
- Replace drain plug gasket
- Set tire pressures to correct psi
- Inspect wiper inserts/blades
- Check all exterior light bulbs are functioning
- Visually inspect brake linings/drums and brake pads/disks
- Inspect and adjust all fluid levels
- Reset maintenance reminder light
- Perform multi-point inspection with print-out

Additional Maintenance Items for Special Operating Conditions

- Driving on dirt roads or dusty roads:
  - Inspect ball joints and dust covers
  - Inspect drive shaft boots
  - Inspect engine air filter
  - Inspect steering linkage and boots
  - Replace engine oil and oil filter
- Driving while towing, using a car-top carrier, or heavy vehicle loading:
  - Tighten nuts and bolts on chassis and body
- Extensive idling and/or low speed driving for a long distance such as police, taxi or door-to-door delivery use:
  - Tighten nuts and bolts on chassis and body
  - Replace engine oil and oil filter
Maintenance/Serviceable Components

INTERMEDIATE SERVICE 20,000km or 6 months

*10,000 miles or 12 months for synthetic oil

► Check installation of driver's floor mat
► Check for open campaigns/recalls
► Replace engine oil and oil filter*
► Replace drain plug gasket
► Inspect engine air filter
► Inspect cabin air filter (if applicable)
► Rotate tires, check condition/tread depth
► Set tire pressures to correct psi
► Inspect wiper inserts/blades
► Check all exterior light bulbs are functioning

► Visually inspect brake linings/drums and brake pads/disks
► Inspect and adjust all fluid levels
► Inspect ball joints and dust covers
► Inspect condition of drive shaft boots
► Check condition of brake fluid
► Check operation of cooling system and/or indication of coolant leak
► Complete inspection of steering and suspension components
► Complete inspection of exhaust system
► Inspect fuel lines and fuel cap gasket
► Reset maintenance reminder light
► Perform multi-point inspection with print-out
Maintenance/Serviceable Components

MAJOR SERVICE 40,000km or 12months

*10,000 miles or 12 months for synthetic oil

- Check installation of driver’s floor mat
- Check for open campaigns/recalls
- Replace engine oil and oil filter*
- Replace drain plug gasket
- Replace engine air filter
- Replace cabin air filter (if applicable)
- Rotate tires, check condition/tread depth
- Set tire pressures to correct psi
- Inspect wiper inserts/blades
- Check all exterior light bulbs are functioning
- Visually inspect brake linings/drums and brake pads/disks
- Inspect and adjust all fluid levels
- Inspect front differential oil
- Inspect rear differential oil
- Inspect condition of drive axle boots
- Check condition of brake fluid
- Inspect transmission fluid or oil
- Check operation of cooling system and/or indication of coolant leak
- Inspect radiator and condenser
- Inspect engine coolant
- Inspect engine/inverter coolant
The End

Thank You!!