

Hybrids & Alternative Fuel Vehicles 5/E

Chapter 10 Regenerative Braking System

Opening Your Class

KEY ELEMENT	EXAMPLES
Introduce Content	This course or class covers operation and service of Hybrid and Alternative Fueled Vehicles . It correlates material to task lists specified by ASE and NATEF.
Motivate Learners	Explain how the knowledge of how something works translates into the ability to use that knowledge to figure why the engine does not work correctly and how this saves diagnosis time, which translates into more money.
State the learning objectives for the chapter or course you are about to cover and explain this is what they should be able to do as a result of attending this session or class.	Explain the chapter learning objectives to the students. <ol style="list-style-type: none">1. Describe how regenerative braking works.2. Explain the principles involved in regenerative braking.3. Discuss the parts and components involved in regenerative braking systems.4. Describe the servicing precautions involved with regenerative brakes
Establish the Mood or Climate	Provide a <i>WELCOME</i> , Avoid put downs and bad jokes.
Complete Essentials	Restrooms, breaks, registration, tests, etc.
Clarify and Establish Knowledge Base	Do a round robin of the class by going around the room and having each student give their backgrounds, years of experience, family, hobbies, career goals, or anything they want to share.

NOTE: This lesson plan is based on Hybrids 4th Edition

Chapter Images found on Jim's web site @

www.jameshalderman.com

LINK CHP 10: [Chapter Images](#)

ICONS	Ch10 Regenerative Braking System
	<p>1. SLIDE 1 Ch10 Regenerative Braking System</p> <p>Check for ADDITIONAL VIDEOS & ANIMATIONS @ http://www.jameshalderman.com/ WEB SITE IS CONSTANTLY UPDATED</p> <p>At the beginning of this class, you can download the crossword puzzle & Word Search from the links below to familiarize your class with the terms in this chapter & then discuss them</p> <p>Crossword Puzzle (Microsoft Word) (PDF) Word Search Puzzle (Microsoft Word) (PDF)</p> <p>DISCUSS FREQUENTLY ASKED QUESTIONS</p> <p>2. SLIDE 2 EXPLAIN FIGURE 10.1 This Honda Insight hybrid electric vehicle is constructed mostly of aluminum to save weight.</p> <p>3. SLIDE 3 EXPLAIN FIGURE 10.2 Toyota Prius hybrid electric vehicle. This sedan weighs more and therefore has greater kinetic energy than a smaller, lighter vehicle.</p> <p>4. SLIDE 4 EXPLAIN FIGURE 10.3 electronic brake control unit (EBU) is shown on left (passenger side) and the brake hydraulic unit is shown on right (driver's side) on this Ford Escape system.</p> <p>5. SLIDE 5 EXPLAIN FIGURE 10.4 typical brake curve showing speed on left and percentage of regenerative braking along bottom. Notice that base brakes are being used more when vehicle speed is low.</p> <p>DISCUSS FREQUENTLY ASKED QUESTION</p> <p>6. SLIDE 6 EXPLAIN FIGURE 10.5 frequency ("f") applied to stator windings of an AC synchronous motor can be varied to create either forward torque ("T") or</p>

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regenerative braking. If the frequency is changed from point 1 to point 2 as shown on chart, torque is changed from motoring (powering the vehicle) to generating and this change can be made almost instantly by the controller.

DISCUSS FREQUENTLY ASKED QUESTIONS

EXPLAIN TECH TIP

- 7. **SLIDE 7 EXPLAIN FIGURE 10.6** Toyota Prius regenerative braking system component showing the master cylinder and pressure switches.
- 8. **SLIDE 8 EXPLAIN FIGURE 10.7** Ford Escape regenerative braking system, showing all of components. Notice brake pedal position sensor is an input to ECU, which controls both brake and traction control systems.
- 9. **SLIDE 9 EXPLAIN FIGURE 10.8** “B” position on the shift display on this Lexus RX 400h means braking. This shifter position can be selected when descending long hills or grades. Regenerative braking system will be used to help keep vehicle from increasing in speed down the hill without the use of the base brakes.

DISCUSS FREQUENTLY ASKED QUESTIONS

- 10. **SLIDE 10 EXPLAIN FIGURE 10.9** ABS ECU on a Toyota Prius uses brake switch and pressure sensor inputs to control regenerative braking system. The circuit includes a voltage signal from sensor, regulated 5V supply to it, input from brake light switch (12 V when brakes are on), and ground connection
- 11. **SLIDE 11 EXPLAIN FIGURE 10.10** This graph compares the figures: at the far left a throttle lift typically giving about 0.1 g deceleration; second from the left a minimum regenerative braking of about 0.1 g; second from the right, a moderate regenerative braking is about 0.2 g; and on the far right a hard emergency stop resulting in braking of (at least) 0.8 g, which uses both the regenerative braking system, as well as the base

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	<p>hydraulic brake system.</p> <p>12. SLIDE 12 EXPLAIN FIGURE 10.11 This Honda valve train photo shows the small spring used to absorb the motion of the rocker arm when the cam is switched to a lobe that has zero lift. This action causes the valves to remain closed thereby reducing engine braking, which increases the amount of energy that can be captured by the regenerative braking system when the vehicle is slowing. The powertrain control module controls this valve action in response to inputs from the throttle position (TP) sensor and vehicle speed information.</p> <p>13. SLIDE 13 EXPLAIN FIGURE 10.12 master cylinder from a Toyota Highlander hybrid electric vehicle.</p> <p>EXPLAIN WARNING</p> <p>DISCUSS FREQUENTLY ASKED QUESTIONS</p> <p>14. SLIDE 14 EXPLAIN FIGURE 10.13 When working on the brakes on a Ford Escape or Mercury Mariner hybrid vehicle, disconnect the black electrical connector on the ABS hydraulic control unit located on the passenger side under the hood.</p>