

Fundamentals of Electric Vehicles (2011 delivered by EVCO members)

Curriculum outline

Sessions:

1. Introduction
2. Basic Electricity
3. Environment (ecological, energy, regulatory, history)
4. User Requirements
5. Primary Components 1
6. Primary Components 2
7. Conversion Process
8. Operation (Driving and Maintenance)
9. Who Killed the Electric Car
10. Advanced topics, additional information

Expanded with subject matter from the first course offering.

http://evconversions.ca/manual/index.php/EVCO_EV_Conversion_Course_Manual

The following material provides an expanded outline for each of the course modules.

The full narrative curriculum is provided in 10 separate documents corresponding to each course module. The full curriculum should be provided to course participants at each module (recommended pre-class reading is provided in this outline document). It is left to the module instructor(s) as to whether the full curriculum material should be distributed before, during or after the classroom session.

1 INTRODUCTION

Module objective:

To define what an electric vehicle is, including the range of types, sizes and capabilities. By the end of this module, the student should have a sense of what an electric vehicle is, realistic capabilities, the basics of the build vs. convert vs. buy approaches, the advantages and disadvantages of electric and electric-hybrid drive technologies and a rough sense of relative costs. This module should provide a context (historical, regulatory, environmental, etc.) for electric vehicle technology and introduce the framework for the remainder of the course.

An optional 'hands-on' mini-course should be offered after this course, so that students interested in doing a conversion can obtain a more thorough sense of what is involved.

Pre-requisite knowledge:

A basic knowledge of existing transportation paradigms (gasoline, diesel, electric, human powered) and vehicle types (bicycle, motorcycle, car, truck, etc.) A desire to know more about electric transportation options is assumed.

Pre-class reading:

Recommended – Brant: *Build Your Own Electric Vehicle* Chapter 1

Optional – Hackleman: *The New Electric Vehicles*

Optional – Perrin: *Life with an Electric Car*

Optional – Powers: *From Gasoline to Electric Power*

Required Materials:

Class Main Textbook (Brant: *Build Your Own Electric Vehicle*)

Class format:

Lecture

Post-class reading:

Optional – see list at end of course material for this module

Related reading:

Optional – see list at end of course material for this module

Related exercises:

Bring in a small EV and show it operating.

About EVCO

About the course (outline, number of sessions, faculty, rules, administration)

Who should take this course?

What is an Electric Vehicle?

Why Electric Vehicles? (Environment - pollution: air, water, soil, sound, thermal; climate change; energy security; multiple primary energy sources; energy efficiency & conservation; sustainable sources; can produce your own)

Kinds of Electric Vehicles

Scale (from skateboards to ocean-liners)

Configurations (e.g., tethered/grid-tied, battery EV, hybrids fuel cells, heat engines, human power as on-board energy sources)

Overview of primary components (board-based model as instructional aid)

Conversion Pros and Cons

2 BASIC ELECTRICITY

Module objective:

To provide a basic sense of how electricity works. The module covers the difference between AC and DC electricity, basic electrical components used to construct circuits (power sources, wiring, fuses, switches, relays, contactors, loads, etc.)

Pre-requisite knowledge:

A basic ability in mathematics and basic physics.

Pre-class reading:

Recommended – Brant: *Build Your Own Electric Vehicle* Chapter 9, page 218 to end of chapter

Recommended – Gover: *Gasoline to Electric Conversion Manual* Chapter 3

Required Materials:

Class Main Textbook (Brant: *Build Your Own Electric Vehicle*)

Class format:

Lecture

Post-class reading:

None

Related reading:

None

Related exercises:

Physical demonstration of simple circuits, preferably related to EV technology (e.g., the components demo board).

Demonstration of relationship of electricity and magnetism (electro-magnet or moving wires demonstration).

AC or DC, which to choose?

Circuits, switches, relays, contactors

Reading diagrams and schematics

Electricity and magnetism

3 ENVIRONMENT

Module objective:

To fit the EV within the context of the multiple environments in which it operates:

- ecological
- energy
- regulatory
- historical
- social.

To identify the environmental impacts of the current transportation paradigm, and how a shift to electric transportation will change those impacts, recognizing the impacts will vary from place to place depending on how electricity is generated in different areas, and that the oil industry's impact is not uniform across the planet.

To identify the laws and regulations that apply when acquiring, converting and operating an electric vehicle. It is recognized that these rules vary by jurisdiction, and are promulgated by different levels of government. Specific examples will be based primarily on the rules in effect in Ottawa, Ontario. The module will also cover implications of vehicle insurance, which is legally required for operation on Ontario roads.

Pre-requisite knowledge:

None

Pre-class reading:

Recommended – Brant: *Build Your Own Electric Vehicle* Chapter 2

Optional – Kemp: *The Zero-Carbon Car* Chapter 3

Optional – McMahon: *The Emperor's New Hydrogen Economy* Chapters 5-13 & 25

Optional – Ontario Highway Traffic Act

Required Materials:

Class Main Textbook (Brant: *Build Your Own Electric Vehicle*)

Class format:

Lecture

Post-class reading:

Optional – see list at end of course material for this module

Related reading:

Optional – see list at end of course material for this module

Related exercises:

None

Canadian Federal Acts and Regulations

Provincial Acts and Regulations

Air, water, sound, thermal pollution

Greenhouse Gases production from burning of carbon-based fuels

Comparing an EV to a gas car

Lifecycle/Total Costs

Impact on the electric generation, transmission and distribution grid

4 USER REQUIREMENTS

Module objective:

To identify the actual needs of the EV user, and from there, develop the energy requirements of an electric vehicle so the student has a realistic sense of how much power is required to propel the vehicle and how much energy is required to obtain the desired range. The make vs. buy decision.

Pre-requisite knowledge:

A basic ability in mathematics and basic physics.

Pre-class reading:

Recommended – Brant: *Build Your Own Electric Vehicle* Chapters 5 to 7

Recommended – Gover: *Gasoline to Electric Conversion Manual* Appendices A1.3 to A1.9

Optional – Brown: *Convert It* Chapter 5

Required Materials:

Class Main Textbook (Brant: *Build Your Own Electric Vehicle*)

Class format:

Lecture

Post-class reading:

Optional – see list at end of course material for this module

Related reading:

Optional – see list at end of course material for this module

Related exercises:

None

Anatomy of an electric vehicle

Choosing a donor car

Determining your requirements, and features of the finished car

Winter considerations

Battery pack

Lubricants

Heating

5 PRIMARY COMPONENTS 1

Module objective:

To provide a basic sense of what a rechargeable (secondary) battery does, and how it works. A description of various battery types and chemistries, including their important characteristics is provided. Considerations of how a battery should be charged and discharged are discussed. Basic operating parameters are contrasted across battery types as an aid in battery selection for a specific project. The potential for using a hybrid power system as a battery supplement may be covered. Instrumentation and safety-related components and why they are important.

Series vs. parallel battery connections

Cabling and Connectors

Charging

Charging stations

Battery monitoring and management

Instrumentation and Safety Equipment

Hybrid energy storage configurations

Pre-requisite knowledge:

None

Pre-class reading:

Recommended – Brant: *Build Your Own Electric Vehicle* Chapters 8 and 9

Recommended – Gover: *Gasoline to Electric Conversion Manual* Appendices A1.1 & A1.2

Optional – Brown: *Convert It* Chapter 8

Optional – Boschert: *Plug-in Hybrids*

Required Materials:

Class Main Textbook (Brant: *Build Your Own Electric Vehicle*)

Class format:

Lecture

Post-class reading:

None

Related reading:

None

Related exercises:

The instructor should have some sample components for students to actually touch, as well as illustrations of all the major components. EV components demo board.

The instructor should make use of some basic battery-powered circuits to demonstrate the concepts being covered in the module.

Anatomy of an electric vehicle

Energy and storage basics

Terminology

Current, capacity, and formulas

Battery Chemistry and types

Battery Arrays

Safety

How to size a battery pack

Cell and pack monitoring

Advanced Batteries

Battery Life

Battery / cell balancing

Battery pack ventilation

Battery Replacement and Recycling

Voltmeter

Ammeter

Fusing

Circuit Breakers

Cabling

Connectors

Emergency disconnect (power off)

Relays

Multiple disconnect points

6 PRIMARY COMPONENTS 2

Module objective:

To describe the major components and systems that comprise an electric vehicle, their purposes and how they relate to each other to create a functioning vehicle. Specific consideration is given to issues related to operation in the Ottawa climate.

Controller

Motor

Drive train

Pre-requisite knowledge:

None

Pre-class reading:

Recommended – Brant: *Build Your Own Electric Vehicle* Chapters 5 to 7

Recommended – Gover: *Gasoline to Electric Conversion Manual* Appendices A1.3 to A1.9

Optional – Brown: *Convert It* Chapter 5

Required Materials:

Class Main Textbook (Brant: *Build Your Own Electric Vehicle*)

Class format:

Lecture

Post-class reading:

None

Related reading:

None

Related exercises:

The instructor should have some sample components for students to actually touch, as well as illustrations of all the major components. EV components demo board.

Controllers

Motors – configurations, sizing

AC vs. DC decision

Regenerative braking

Drive train (gearing, number of gears, electric vs. mechanical reversing)

Considerations for operating in harsh conditions (Ottawa winters and summers)

7 CONVERSION PROCESS

Module objective:

To provide a basic sense of what is involved in converting an existing vehicle to electric drive, including the removal of extraneous components and parts, selection, sourcing, layout and positioning of main components, construction of custom parts and battery restraints and enclosures, wiring, connectors, instrumentation, fusing, safety measures, etc. This module will likely take more than a single classroom session.

Pre-requisite knowledge:

A basic ability to use tools and conceptualize objects in 3 dimensional space.

Pre-class reading:

Recommended – Brant: *Build Your Own Electric Vehicle* Chapter 10

Recommended – Gover: *Gasoline to Electric Conversion Manual* Chapter 4

Optional – Brown: *Convert It* Chapters 6 to 12

Optional – Powers: *From Gasoline to Electric Power*

Required Materials:

Class Main Textbook (Brant: *Build Your Own Electric Vehicle*)

Class format:

Lecture and Workshop

Post-class reading:

None

Related reading:

None

Related exercises:

The instructor should make use of some basic battery-powered circuits to demonstrate the concepts being covered in the module. EV components demo board.

Students should be offered the option of attending a hands-on workshop that gives substance to the theory covered in the classroom to obtain the maximum educational benefit from this module.

Bringing in the conversion demo trailer and examining it in the parking lot might be worthwhile, if available lighting makes this viable.

Shop requirements and tools required

Safety Precautions

Sourcing components (or buying a kit)

Taking initial measurements (pre-conversion)

Gutting the vehicle, carefully

Preparing the vehicle for electrics

Motor, Adaptor plate, Transmission, Gearbox

Battery placement, box fabrication

Wiring the battery pack

Light Wiring

Dashboard Monitoring system

Testing the system

Overview of Conversion Steps

The Vehicle

Preparing the Vehicle

Primary Assembly and Initial Installations

Final Installations, Wiring, and Preliminary Testing

Final Setups and Configurations, Completions!

Vehicle Specifications

List of Manufacturers

Professional EV Builders

Glossary

8 OPERATION (DRIVING AND MAINTENANCE)

Module objective:

To describe the typical maintenance activities related to the operation and ownership of an electric vehicle to ensure safe operation and maximize performance. There are also some differences in the way one drives an electric car to get the most from it relative to typical driving behaviour in a vehicle powered by a heat engine (e.g., it's OK that the motor stops when the car is stopped in traffic).

Pre-requisite knowledge:

How to drive a vehicle and carry out basic preventative maintenance procedures.

Pre-class reading:

Recommended – Brant: *Build Your Own Electric Vehicle* Chapter 11

Recommended – Gover: *Gasoline to Electric Conversion Manual* Chapters 4.11 to 4.13 and 5

Optional – Brown: *Convert It* Chapters 13 and 14

Optional – Perrin: *Life with an Electric Car*

Required Materials:

Class Main Textbook (Brant: *Build Your Own Electric Vehicle*)

Class format:

Lecture

Post-class reading:

None

Related reading:

None

Related exercises:

In the workshop environment, carrying out the basic maintenance activities would have value in reinforcing the actual things to be done.

Lifecycle/Total Costs

Opportunity charging

Charging stations and connectors

Maintenance program (tire pressures, checking connections, reading instrumentation)

Power use monitoring

Electrolyte level checks (flooded lead-acid batteries)

Monitoring battery temperature

Tools to keep on-board

Driving a quiet vehicle

9 WHO KILLED THE ELECTRIC CAR?

Module objective:

To screen the movie, Who Killed the Electric Car, and then have a discussion around the various issues raised in the movie.

The premise of the discussion is the electric car is not dead, particularly in view of the resurgence of interest in EVs in the 2010-2011 timeframe.

Pre-requisite knowledge:

Previous course modules

Pre-class reading:

None

Required Materials:

None

Class format:

Movie screening and lecture

Post-class reading:

None

Related reading:

None

Related exercises:

After the screening of the movie, the class should be engaged in a discussion about the film, and in particular noting that the electric car did not die (kept alive by enthusiasts), and is now enjoying an unprecedented resurgence.

10 ADVANCED TOPICS AND ADDITIONAL INFORMATION

Module objective:

To provide an overview of several topics related to electric vehicle design and operation that are not typically done in conversions by individuals, e.g., regenerative braking, hybrid systems.

Pre-requisite knowledge:

None

Pre-class reading:

Recommended – Brant: *Build Your Own Electric Vehicle* Chapter 5

Recommended – Gover: *Gasoline to Electric Conversion Manual* Chapters 1.2 to 1.4

Optional – Boschert: *Plug-in Hybrids*

Required Materials:

Class Main Textbook (Brant: *Build Your Own Electric Vehicle*)

Class format:

Lecture

Post-class reading:

None

Related reading:

None

Related exercises:

None

AC systems

Regenerative braking

Aerodynamics

Vehicle to Grid concept

House-Car (house charges car, car can power house)

Prototypes

RECOMMENDED READING LIST

ADDITIONAL RELATED MATERIAL