Basic Course Information

Title:
Automotive Engineering

Transcript abbreviations:

Length of course:
Full Year

Subject area:
College-Preparatory Elective ("g") / Laboratory Science – Integrated Science

Integrated (Academics / CTE)?
Yes

Grade levels:
11th, 12th

UC honors designation?
No

Course learning environment:
Classroom Based

Course Description

Course overview:
Automotive Engineering is a study of the interaction of science and technology as they apply to the automotive transportation system and the engineered sub-systems that are responsible for the functioning of the automobile. These include integrated mechanical, electrical, chemical, and computer engineered systems. The mathematics and specific concepts associated with these systems will also be explored. Students will develop their understanding of science, as it applies to the study of engineered automotive systems, by building on their knowledge of physics and mathematics while conducting investigative research. Students will be engaged in a theoretical program that integrates academic study with technical skills. This course is proposed to prepare and motivate students to pursue a post-secondary education in science and engineering programs.

1. **STUDENT PERFORMANCE OBJECTIVES**

Upon successful completion of the course, students will:

- Develop an understanding of the relationship that exists between science and its application in the engineering and design of automobile.
- Utilize project-based learning strategies to develop students' critical thinking and problem-solving skills.

- Understand key elements of how concepts underlying a problem can lead to design and production of a viable solution. They will learn how the scientific method can help solve practical problems.
- Conduct research and apply tools and technologies employed by engineers in the solution of problems.
- Comply with safety standards and environmental regulations
- Explain the operation of vehicle systems
- Identify and describe the operation of related vehicle components
- Demonstrate diagnostic and repair skills according to industry standards
- Perform basic maintenance and service procedures according to industry standards
- Access service manuals, information, and specifications using electronic and printed sources
- Recognize career opportunities in the automotive industry
- Demonstrate positive work ethics and teamwork

Prerequisites:
Algebra 1 (Required)

Co-requisites:
Physics or Chemistry (Recommended)
Algebra 2 (Recommended)

Course content:
Unit 1
Students will use electrical training boards to identify common materials such as tin, nylon, vinyl, and copper and identify how their properties are useful to engineering design. Students analyze why materials are chosen. Students will implement the scientific method and compare and contrast it with the engineering design process.

Sample Assignment(s):

- **Differential Worksheet:** Students will learn about differentials and gear ratios using a differential assembly. Students will be given a math worksheet where they will practice calculating the radius, circumference, and area of a circle. They will use this information to also calculate the gear ratios on various differentials.
- **Identifying the Role of a Catalyst:** Students will learn the basic fundamentals of a catalyst. Students will use household items such as baking yeast, hydrogen peroxide, eyedroppers, and a wooden match to demonstrate the role of a catalyst. (This lesson is a introduction to “Converting with Catalysts” in chapter five)
- **Investigating Heat Transfer:** Students will investigate how heat is transferred. Students will learn the difference between exothermic and endothermic reactions. Students will transfer heat energy from a fuel to water, causing the water to boil. Then they will use the boiling water to transfer heat to cold water.
- **Increasing Oxygen in Fuel:** Students will measure the ethanol content of gasoline. Students will learn various distillation techniques such as filtration and distillation. Students will observe how gasoline and ethanol will mix and how gasoline and water will not mix. The gasoline will float on water, forming two layers. Mixing all three the ethanol will separate from the gasoline and mix with the water. Two layers will again form. The gasoline without the ethanol will float on the mixture of water and ethanol.
- **Measuring Pressure and Vacuum:** Students will build a manometer and perform experiments to understand the principles of pressure and vacuum.
- **Calculating Airflow:** Students will begin to study engine displacement and will use the data they collect from various vehicles to calculate air flowing through the filter using their displacement values.

- **LAB Assignment:** Students will be provided the materials needed to assemble their fuel cell car. Once they have assembled their vehicle they will conduct four separate experiments each experiment requires students to document their data which will be collected at the end of the lab. **Experiment 1:** (Electrolysis) In this experiment students will produce hydrogen and oxygen using a reversible fuel cell. They will observe the volume of hydrogen produced compared to the volume of oxygen produced. **Experiment 2:** (Efficiency) In this experiment students will evaluate the use of oxygen in a reversible fuel cell. They will compare the productivity of the fuel cell with oxygen compared to the productivity of the fuel cell when oxygen is not used. **Experiment 3:** (Resistance) In this experiment students will evaluate the effect of resistance on the reversible fuel cell. They will compare the amount of time the fuel cell will power the car with no resistance to the amount of time the fuel cell will power the car when resistance is added. **Experiment 4:** (Ohm's Law) Students will calculate the number of watts being produced by your fuel cell using equations derived from Ohm's Law. This experiment prepares students for Unit Eight which uses Ohm's Law when building electrical circuits and also allows students to learn about alternative fuel systems and the effects of each.

Unit 2
Students will manage the service hours in the shop working on various projects or class work. They will each have the opportunity to become shop foreman and manage time, materials, and personnel.

Sample Assignment(s):

- **Automotive Problems:** Students will learn how to read, and prepare repair estimates for customers. Students will be asked to perform managerial occupations within groups. They will learn how to calculate employee salary and balance a budget. Students will work in the lab to complete their hours, "self management," by using various resources to prepare a business plan. At the end of the lab students are asked to present their budget and business proposal.

Unit 3
Introduce students to a modern commercial automotive shop. Use a tool box to introduce them to basic hand tools and how each tool is used for a specific purpose. Discuss the various tools an engineer uses on a day to day basis.

Sample Assignment(s):

- **Reading a Ruler:** Students will learn how to read a ruler. This will prepare them to understand automotive measurements in chapter six. Students will also review basic mathematical skills needed in automotive engineering.
- **Reaction Time:** Students will learn about reaction time, computing averages and standard deviation, and how it affects things like braking distance, athletics, and shop safety. They will be paired up in teams and given a ruler. One teammate will drop a ruler in between their partners thumb and forefinger. The data collected will be used to calculate the mean, median, and mode of their partner's reaction time.

Unit 4
Students will review all power tools in the shop and the location of air hoses, racks, drill press, and other power tools.

- Instructor will demonstrate the carbon pile tester and Snap On automatic tester. Explain the basic components of the starting system: battery, starter, and alternator. Students will learn the purpose of the inductive amp pickup, and the difference between positive and negative post on a battery. Describe the difference between an AGM (all glass matt battery), conventional,

lithium ion, and nickel metal hydrate batteries. They will test each battery appropriately using industry standards and explain why each battery has a certain testing procedure based on its chemical properties. Describe the chemical makeup of the battery and the safety precautions necessary when working with batteries. Describe the chemistry of the lead-acid battery. ($PbO_2 + SO_4^{-2} + 4H^+ + 2e^- \rightarrow PbSO_4 + 2H_2O$)

- **Inflation:** Students will measure the pressure and the area of contact of the tire of an automobile on the ground. They will use this data to estimate the weigh of the vehicle by computing the amount of force the tire exerts against the road.

- **Checking Fluid Temperature:** Students will learn about volume and the effects heat has on the volume of transmission fluid. Students will also learn the procedures and steps for dimensional analysis problems.
- **Lowering the Boom:** Students will learn how hydraulics transfer force and also compare the different lifting forces of several jacks. Students will use Pascal's law to calculate the pressure exerted with each jack. Students will also use the ABS and brakes trainer to view the effects of ABS on a vehicle. Students will "jack" vehicles and place jack stands in safe appropriate places. (This exercise will prepare them for lowering the boom and other labs dealing with Pascal's law)

Unit 5

Students will learn to apply physics concepts (acceleration, mass, force, friction) in a lab setting. They will learn about the engineering process in relation to catalytic converters.

Sample Assignment(s):

- Describe and demonstrate NATEF standards regarding proper handling, storage, and disposal of chemicals and materials used in an auto shop. Students will study the environmental science
- **Buckle Up:** Students will relate Newton's first law of motion to automobile safety restraints and features.
- **Constant Force and Changing Mass:** Students will learn how mass affects a vehicles acceleration. Students will apply a force to the cart by suspending a weight over a pulley. By changing the weight a relationship between mass and acceleration should be evident. Students will record their data in a lab notebook.
- **Constant Mass and Changing Force:** Students will use what they learned in the previous lab to investigate how increasing applied force on a car affects its acceleration while keeping the mass of the system constant. Students will collect their data in a lab notebook and present the difference between the two experiments.
- **On a Roll:** Students investigate the relationship between the stopping distance and the height from which a ball rolls down an incline.
- **Traxxas:** Students will hypothesis how weight and angle of an incline affects the coefficient of friction. Students will estimate what values of the static and kinetic coefficients are for different surfaces in contact with one another. They will use Traxxas RC cars on various terrains, carrying different weight, and using different motors to collect time and distance data. Students will use different angles of incline to see what effect they have on force and the coefficient of friction. Students will include a distance vs. time graph in their final lab reports.
- **Weighing an Elephant:** Students will determine the relationship between masses and distances from the fulcrum for a balanced see-saw. Students will use a variety of smaller masses, meter sticks, and fulcrums that enable them to discover how levers work, describe their forces and torques mathematically, and finally solve the problem in which to balance an elephant. 1^{st}, 2^{nd}, 3^{rd} class levers will be added.
- **Converting with Catalysts:** Students will learn the components and materials of a catalytic converter. They will also learn about the chemical reactions that occur in the system. They will learn about the engineering process in relation to catalytic converters. Students will learn what a catalysts purpose is and the various types of catalysts.Take students to the lab and explain

auto shop layout and safety precautions. Explain the hazards of carbon monoxide and the need to have the bay doors open. Have students measure the area, perimeter of the shop and calculate the area of each of the workstations. Students will describe how the layout of the shop impacts productivity.

Throughout each laboratory activity and key assignment students will keep a detailed engineering notebook where they will write down each laboratory procedure before conducting a lab, record their data during lab, and analyze their results once they complete their assignments. Engineering notebooks will also allow the students to write down any notes during classroom lectures.

- **LAB Assignment:** Student will measure the lab space and equipment in “shop layout”. They will use dimensional analysis to solve and convert their measurements. Students will draw out the lab floor plan which includes the laboratory space, classroom space, yard space, and storage space. They will present their orthographic drawings as a group and show all measurements of each section. Students consider the engineering design process used to design or engineer various projects. This project helps students become familiar with shop tools and layout.

- **LAB Assignment:** Students first discuss linear motion and explain that the idea of motion is relative in a lab involving ‘Traxxas’ remote control cars. Students learn to distinguish between instantaneous speed and average speed. They also, with examples from the textbook and demonstrations, distinguish between speed and velocity, and describe how to tell whether a velocity is changing. Students will analyze data that they collect by racing the vehicles through various marks. Students will analyze the data they collect and set up time and distance graphs. Students will also review and learn about the effects of using different gear ratios and how vehicles use different gear ratios in various locations. Students will write a **lab report** showing all their measured values for increases in weight, and different angles for the surfaces. Students will show all calculations for the coefficients of static and kinetic friction. Students will have their hypothesis for what gives rise to different coefficients of friction and write if their hypothesis was confirmed or not based on the evidence from the experiments. Students will also include distance vs. time graphs of the various surfaces used.

- **LAB Assignment:** Using meter sticks, finishing nails, a drill, spring scales, wood for a meter stick support and string, students build three different kinds of levers in order to compare and contrast the different purposes of those three different kinds of levers. This will allow them to learn the significance of the relative positions of the fulcrum, effort, and resistance for each lever. First-class levers may be used to gain speed, force, or change direction. Second-class levers have a greater advantage than first-class because the load is always between the effort and the fulcrum, so the effort arm is always longer than the load arm. They cannot be used to gain speed or change direction. A third-class lever can be used only to gain speed. For each lever they will calculate and record the lever arm of effort, torque of effort, direction of effort’s torque, total clockwise torque, and total counterclockwise torque. Students will write an essay on the fulcrum point and design of each lever, where each kind of lever is used in real life applications and mechanical advantage of each.

Unit 6

Students will work with various precision engineering measuring tools and learn how to take accurate readings. As well as collect and interpret data based on their readings.

Sample Assignment(s):

- **Reading a Micrometer:** Students will learn how to use common automotive engineering precise measurement tools. They will use different automotive parts to practice their skills.
- **Measuring Static Friction:** Students will learn about the coefficient of static friction. Students will measure the coefficient of static friction for rubber and metal on wood by measuring the height and horizontal distance the objects slide.
- **Friction Stops:** Students will learn how weight affects stopping distance. Students will also experiment with friction using a ruler and two washers (one washer with more weight than the other).
- **Torque Feeler & Measuring Torque:** Students will illustrate the qualitative difference between torque and force. Students will use a meter stick and different masses placed at various locations along the meter stick to differentiate between torque and force. For measuring torque students will execute a similar lab on a larger scale by applying torque on a hex head bold and applying weight to the handle. Students will record their measurements and explain what they learned from the two labs.
- **Transmitting Torque:** Students will model a torque converter and learn about the fluid transmitting force between the impeller and the turbine. Students will place two fans facing each other and use them to demonstrate the function of a torque converter by identifying what each fan represents.

- **LAB Assignment:** Students will hypothesize where the torsion balance will occur using Coulomb's Law. They will determine the static electric charges created by rubbing fur or other materials. The lab will also use a ring stand with a wooden dowel, two pith balls, string, charging rod, protractor, electronic balance, and a ruler. Students will obtain an average mass for two pith balls and measure the length of the sting (L) to the center of the pith ball. They then suspend the two pith balls from the wooden dowel attached to the ring stand such that their strings ha point of origin. Using the fur, they charge the rod negative and transfer the charge to the two pith balls, and then measure the angle that the two strings make with each other at the point of origin. Students learn that Coulomb's law describe the relationship between the electrostatic force (F_e) and the electric charges (Q_1, Q_2), and the distance between the two charged particles (d). Using two pith balls and a string, students can construct a torsion balance. The repulsive electric force between two negatively charged pith balls (F_e) will balance the gravitational force (F_g). Students can then calculate the electric charge carried by two pith balls by drawing free body diagrams and applying two dimensional vector analysis. Other related questions can also be discussed: If an ampere is defined as the flow of electrons in Coulomb/second (C/s), how many amps would each pith ball generate if it flowed in a wire.

Unit 7
Students will learn how to fill out official documents as well as how to organize and prepare their engineering notebooks.

Sample Assignment(s):

- **Service Information & Work Orders:** Students decode vehicle identification numbers using Alldata (a source of automotive OEM information database). Students will also define common automotive abbreviations that they will be using often when servicing vehicles.

- **Explaining Oxidation and Reduction:** Students learn about oxidation/reduction reactions and how different metals react differently. Students will explain how corrosion occurs on battery terminals and students will also use battery testers to conduct their own experiments with each component in the starting system.

Unit 8
Students will learn about Ohm's Law, and electrical and electronic components as used in the transportation industry.

Sample Assignment(s):

- **Ohm, Ohm on the Range:** Students will determine the relationship between the current and the voltage across the resistances in series circuits.
- **Investigating Electrolytes:** Students will make a wet-cell battery and learn about the chemical reactions that take place in a battery.
- **Its all about magnetism:** Students will construct an electromagnet in lab and conduct various experiments.
- **Grounded:** Students will construct a grounded circuit. Students will learn about various conductors and electrical wiring.
- **Demonstrating Generator Action:** Students will induce a current in a coil. They will demonstrate generator action.
- **How does a coil work?:** Students will induce a voltage in a secondary coil. Students will learn about magnetic induction.
- **Using a Switching Transistor:** Students will build an electrical circuit and demonstrate a transistor's switching action. (Starter relay simulation)
- **CL1919:** Students will build series and parallel electrical circuits. Students will learn how to test Resistance, Amperage, and Voltage. Students will begin to understand electrical fundamentals.
- **Electrical Trainers:** Student will use their basic electrical skills and use them to test electrical automotive systems. Students will use SSCC to diagnose faults in electrical circuits.
- **CAN-bus:** Students will learn computing and multiplexing. Can-bus is a fast computer data bus similar to the network used for linking computers. The course looks at the role of Electronic Control Units (ECUs), linked by a CAN bus, in controlling automotive systems. Modern motor vehicles can contain over a hundred ECUs, controlling everything from the Anti-lock Braking System (ABS) to the position of the driver's seat. An ECU contains a microprocessor, running software to control the devices attached to it, and to communicate using the CAN protocol, with other ECUs. In this course, MIAC's (Matrix Industrial Automotive Controllers) are used as ECU's. Each MIAC is running a program that allows the user to make it act as one of five types of nodes.

Unit 9
Students will identify proper fasteners, gaskets, seals and their appropriate use and application.

Sample Assignment(s):

- **Fasteners, Gaskets, Seals, and Sealants:** Students will use various bolts to identify various bolt thread pitch, size, and length. Students will consider why even the smallest of details such as bolt specifications matter in engineering. Students will study how engineers must make detailed reports specifying each part of their project.
- **Not Just Any Bolt Will Do:** Students will grade a bolt for strength by using a torque wrench. They will collect their data from various bolts. Students will understand tensile strength and bolt grade.

Unit 10

Students will work in groups. Each group is assigned one engine. Students will take the engine apart and put it back together. They will familiarize themselves with the design of their engine. Students will present the data they have collected and implement some of the engineering principles in their report.

Sample Assignment(s):

Students will:

1. Remove cylinder head; inspect gasket condition; install cylinder head and gasket; tighten according to manufacturer's specifications and procedures.
2. Clean and visually inspect a cylinder head for cracks; check gasket surface areas for warpage and surface finish; check passage condition
3. Inspect and/or measure camshaft for runout, journal wear and lobe wear.
4. Disassemble engine block; clean and prepare components for inspection and reassembly
5. Determine piston-to-bore clearance
6. Reassemble engine block
7. Collect measurements and integrate math calculations (such as calculating displacement)
8. Identify materials used

Once a group is finished each team member will take one important part of the engine. For example, one team member will do a report on the piston, another on the crankshaft, another on the camshaft, so on until each team member has a part to study. Each team will present their findings to the class about the engineering principles that are involved in the operation of their engine.

- **Hot Gases Are Really Cool:** Students will learn about the relationship between temperature and pressure. They will learn about diesel engine operation in relation to this topic. Students will use a plastic bottle filled with water to demonstrate the opposite of what occurs to the air within an engines cylinder on the compression stroke.
- **Increasing Engine Displacement & Calculating Engine Displacement:** Students will use data (bore and piston stroke measurements) they collect from various engines to calculate engine displacement. Students will consider the effects of overboring the cylinders. Students will collect their data and present to the class what their modifications would be to their assigned engine and why.
- **Testing Compression & Measuring Compression:** Students will learn how to conduct compression test on various vehicles. Using their data they will diagnose whether or not the readings are within tolerance. They will discuss how compression plays an important role in the combustion engine and what occurs to the air and fuel mixture.
- **Calculating MAF values & Determining Rate of Change:** Students will use a Snap-on scan tool to monitor various engine sensors. They will use the information they collect using the scan tool to calculate Mass Air Flow sensor values. Students will also calculate rate of change using data from Manifold Absolute Pressure sensor. Students will list the purpose of multiple sensors used in a combustion engine, and they will explain the engineering principles used for each one such as composition, placement, and discuss possible improvements.

- **LAB Assignment:** During engine disassembly students will use automotive measuring tools to determine the engines bore, piston, and camshaft dimensions. They will use their measurements to calculate piston displacement, engine displacement, power, work, horsepower, volumetric efficiency, and mechanical efficiency. As a helpful resource students will have math teacher's help them with calculations and the formulas are explained in class. Students will include calculations and engine specifications in their reports. They will explain

the efficiency and design of their engine. They will also discuss the possible improvements they would make on the design of their engine.

Unit 11
Students will understand scientific principles in relation to chemical, physical and mechanical functions for various engine and vehicle systems.

Sample Assignment(s):

Multi-Point Inspection Report Card: Students will become familiar with various automotive systems by performing general NATEF tasks. They will discuss and write a report on each systems purpose and major parts. (Emphasis on the various engineering designs available for each system with the same underlying purpose)

- **Antifreeze in the Summer:** Students will investigate what effect antifreeze has on the cooling of a car radiator during the summer. They will determine the specific heat of a 50% mixture of antifreeze and water. They will measure the quantity of heat that is absorbed and the corresponding temperature change. In part B of the experiment students will discover whether coolant has a higher boiling point than pure water and how that affects the cooling system.
- **How Hot Are Your Hot Wheels:** Students will learn about the force of friction by measuring the efficiency of a toy car on an inclined track.
- **Brake Pedal Ratios:** Students will apply what they learned about hydraulic systems to calculate brake pedal ratios and understand brake system operation. Students will use the brake booster trainer to conduct experiments measuring force on a brake system with and without a brake booster.
- **Measuring Brake Rotors:** Students will learn how to measure and repair warped brake rotors using precise measuring tools.
- **Converting Energy in an ABS:** Students will review kinetic energy and how it plays a role in the Anti-lock Brake System. Students will roll a rubber wheel under different conditions where they will discover how ABS is an energy manager for the conversion of kinetic energy into heat.
- **Determining Tire Diameter:** Students will learn how to read DOT code on a tire and use the information to properly service tires. Students will study various tire designs used under various conditions. They will compare and contrast each style of tire.

Unit 12
Students will understand and evaluate the skills, knowledge and attitudes need to locate, obtain, and maintain employment in the Transportation Industry. Students will be able to establish goals for self-improvement ad lifelong education/training, and complete a sample resume, cover letter, and demonstrate appropriate interviewing techniques.

Sample Assignment(s):

- **LAB Assignment:** Students will be asked to compare and contrast four of the following engineering branches; aerospace, chemical, civil, electrical, mechanical, industrial, and computer science. They will then give a **PowerPoint presentation** of their findings. Students will utilize this project to develop critical thinking and problem solving skills by conducting research of the application of tools employed by engineers in the solution of problems, gain an understanding of the various fields of engineering, and how they relate to each other and the automobile. Students will **write a report** on their research. Students will also include information on a career of their choice including a description of the career; type of education needed, and average salary. This assignment will also include a guest lecturer from a local engineering firm and/or local college. This assignment allows students to explore various careers and begin thinking about a career of their choice. Students will also asses, compare,

and analyze the amount of education required in their career of choice as well as the different engineering branches.

- Students will also **compose and create a portfolio** with five sections (cover letter, resume, personal statement, and letters of recommendations). The portfolio will help students apply for a future job and they can continuously update their information for a future career. Students will also prepare their engineering notebooks which will include the projects, labs and research for the class for future use or study. It will include a summary of all major assignments.

Course Materials

Textbooks

Title	Author	Publisher	Edition
Engineering Fundamentals, an Introduction to Engineering	Saeed Moaveni	CL Engineering	5th, 2015
Automotive Services, Inspection, Maintenance and Repair	Tim Gilles	Delmar Cengage Learning	4th Edition/2

Multimedia

Title	Author	Director	Name of video series	Date	Website
SP2 - Safety & Pollution (OSHA)	[empty]	[empty]	on-line safety training	2017	https://sp2.org

Other

Title	Authors	Date	Course material type	Website
ALLDATA: OEM Repair Information for Professionals	[empty]	[empty]	Software - Resource for inspection, maintenance and repair	www.alldata.com
Engineering Notebook Guidelines	[empty]	[empty]	pdf	http://www.uta.ed

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Comment to UC:

Automotive Engineering was modeled after the course (Automotive Engineering) at Casa Robles High School which is UC approved as a "g" elective.