Course Description

A. COVER PAGE

1. Course Title
Auto Physics

2. Transcript Title / Abbreviation
PHYSIC Auto

3. Transcript Course Code / Number
D204 (Provisional)

4. School
Monrovia High School

5. District
Monrovia Unified School District

6. City
Monrovia, CA

7. School / District Web Site
www.monroviaschools.net

8. School Contact

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9. Subject Area

- [ ] History/Social Science
- [ ] English
- [ ] Mathematics
- [X] Laboratory Science
- [ ] Language other than English
- [ ] Visual & Performing Arts (for 2003)
- [ ] College Prep Elective

10. Grade Level(s)
10th through 12th

11. Seeking "Honors" Distinction?
[ ] Yes [X] No

12. Unit Value

- [ ] 0.5 (half year or semester equivalent)
- [X] 1.0 (one year equivalent)
- [ ] 2.0 (two year equivalent)
- [ ] Other: ____________________

13. Date of School Board Approval
February 14, 2007

14. Was this course previously approved by UC? [ ] Yes [X] No If so, year removed from list?
Under what course title?

15. Is this course modeled after an UC-approved course from another school? [ ] Yes [X] No
If so, which school(s)?

16. Pre-Requisites
Physics, Geometry

17. Co-Requisites
None

18. Brief Course Description

This is a second year physics course covering topics in mechanics, energy, fluid dynamics and thermodynamics using the many systems of the automobile as the focus for the students understanding, problem solving, lab experiments and other classroom activities. The unifying theme of this course is energy, which starts as the potential chemical energy in gasoline and ends up as the kinetic energy of a moving automobile. Emphasis will be on the development of an intuitive understanding of physics principles, solving theoretical problems using rigorous mathematics and applying them to practical real world problems relating to the automobile. The extensive laboratory work both in and out of the auto shop will help students develop reasoning power and the ability to use physics principles, as well as acquaint students with sound experimental techniques. At all stages, students are expected to use physics theory and models to describe and understand real automotive functions.

B. COURSE CONTENT

19. Course Goals and/or Major Student Outcomes

***The course goals are based on a subset of the AP Physics B content standards.*

I. NEWTONIAN MECHANICS

- A. Kinematics
  1. Constant Velocity Motion in one dimension
     - a) Students should understand the general relationships between position, and velocity for constant velocity motion of a particle along a straight line, so that:
       - (1) Given a graph of position or velocity as a function of time, they can recognize in what time intervals the other is positive, negative, or zero, and can identify or sketch a graph of each as a function of time.
       - (2) Given an expression for position or velocity as a function of time, they can determine the other as a function of time.

- B. Newton's laws of motion
  1. Static equilibrium (first law)
     - a) Students should be able to analyze situations in which a particle remains at rest, or moves with constant velocity, under the influence of several forces.
  2. Systems of two or more objects (third law)
     - a) Students should understand Newton's Third Law so that, for a given system, they can identify the force pairs and the objects on which they act, and state the magnitude and direction of each force.

- C. Work, energy, power
  1. Work and the work-energy theorem
     - a) Students should understand the definition of work, including when it is positive, negative, or zero, so they can:
       - (1) Calculate the work done by a specified constant force on an object that undergoes a specified displacement.
       - (2) Relate the work done by a force to the area under a graph of force as a function of position, and calculate this work in the case where the force is a linear function of position.
     - b) Students should understand and be able to apply the work-energy theorem, so they can:
       - (1) Calculate the change in kinetic energy or speed that results from performing a specified amount of work on an object.
       - (2) Calculate the work performed by the net force, or by each of the forces that make up the net force, on an object that undergoes a specified change in speed or kinetic energy.
       - (3) Apply the theorem to determine the change in an object's kinetic energy and speed that results from the application of specified forces, or to determine the force that is required in order to bring an object to rest in a specified distance.
  2. Conservation of energy
     - a) Students should understand the concepts of mechanical energy and of total energy, so they can:
       - (1) State and apply the relation between the work performed on an object by non-conservative forces and the change in an object's mechanical energy.
       - (2) Describe and identify situations in which mechanical energy is converted to other forms of energy.
       - (3) Analyze situations in which an object's mechanical energy is changed by friction or by a specified externally applied force.

- b) Students should understand conservation of energy, so they can:
  - (1) Identify situations in which mechanical energy is or is not conserved.
- c) Students should be able to recognize and solve problems that call for application of conservation of energy.

3. Power
   - a) Students should understand the definition of power, so they can:
     - (1) Calculate the power required to maintain the motion of an object with constant acceleration (e.g., to move an object along a level surface, to raise an object at a constant rate, or to overcome friction for an object that is moving at a constant speed).
   - b) Calculate the work performed by a force that supplies constant power, or the average power supplied by a force that performs a specified amount of work.

II. FLUID MECHANICS AND THERMAL PHYSICS

A. Fluid Mechanics

1. Hydrostatic pressure
   - a) Students should understand the concept of pressure as it applies to fluids, so they can:
     - (1) Apply the relationship between pressure, force, and area.
     - (2) Apply the principle that a fluid exerts pressure in all directions.
     - (3) Apply the principle that a fluid at rest exerts pressure perpendicular to any surface that it contacts.
     - (4) Determine locations of equal pressure in a fluid.
     - (5) Determine the values of absolute and gauge pressure for a particular situation.

B. Temperature and heat

1. Mechanical equivalent of heat
   - a) Students should understand the “mechanical equivalent of heat” so they can determine how much heat can be produced by the performance of a specified quantity of mechanical work.
2. Heat transfer and thermal expansion
   - a) Students should understand heat transfer and thermal expansion, so they can:
     - (1) Calculate how the flow of heat through a slab of material is affected by changes in the thickness or area of the slab, or the temperature difference between the two faces of the slab.
     - (2) Analyze what happens to the size and shape of an object when it is heated.
     - (3) Analyze qualitatively the effects of conduction, radiation, and convection in thermal processes.

C. Kinetic theory and thermodynamics

3. Ideal gases
   - a) Students should understand the kinetic theory model of an ideal gas, so they can:
     - (1) State the assumptions of the model.
     - (2) State the connection between temperature and mean translational kinetic energy, and apply it to determine the mean speed of gas molecules as a function of their mass and the temperature of the gas.
     - (3) State the relationship among Avogadro’s number, Boltzmann’s constant, and the gas constant R, and express the energy of a mole of a monatomic ideal gas as a function of its temperature.
     - (4) Explain qualitatively how the model explains the pressure of a gas in terms of collisions with the container walls, and explain how the model predicts that, for fixed volume, pressure must be proportional to temperature.

b) Students should know how to apply the ideal gas law and thermodynamic principles, so they can:
   (1) Relate the pressure and volume of a gas during an isothermal expansion or compression.
   (2) Relate the pressure and temperature of a gas during constant-volume heating or cooling, or the volume and temperature during constant-pressure heating or cooling.
   (3) Calculate the work performed on or by a gas during an expansion or compression at constant pressure.
   (4) Understand the process of adiabatic expansion or compression of a gas.
   (5) Identify or sketch on a PV diagram the curves that represent each of the above processes.

4. Laws of thermodynamics
   a) Students should know how to apply the first law of thermodynamics, so they can:
      (1) Relate the heat absorbed by a gas, the work performed by the gas, and the internal energy change of the gas for any of the processes above.
      (2) Relate the work performed by a gas in a cyclic process to the area enclosed by a curve on a PV diagram.
   b) Students should understand the second law of thermodynamics, the concept of entropy, and heat engines and the Carnot cycle, so they can:
      (1) Determine whether entropy will increase, decrease, or remain the same during a particular situation.
      (2) Compute the maximum possible efficiency of a heat engine operating between two given temperatures.
      (3) Compute the actual efficiency of a heat engine.
      (4) Relate the heats exchanged at each thermal reservoir in a Carnot cycle to the temperatures of the reservoirs.

20. Course Objectives

This is a 2nd year physics course intended to bridge the gap between conceptual physics taught at the freshman level at MHS and AP physics that is taught at the Junior/Senior level. This course will cover topics in thermodynamics and fluid mechanics that are not normally covered in the 1st year physics course, while deepening and strengthening the students understanding and problem solving abilities in mechanics and energy which are covered in the 1st year physics course. Throughout this course the automobile systems are leveraged to teach traditional physics topics. The automobile will be studied, described and analyzed using physics theory. Automotive subjects taught will focus on engine, brake, drive train, heat and air conditioning systems.

For the course goals we will use a subset of the AP Physics B content standards.

21. Course Outline

I. NEWTONIAN MECHANICS

Unit 1: Kinematics

- A. Constant Velocity Motion in One Dimension
  - 1. Position-time and velocity-time graphs
  - 2. Circular and Rotational Motion
- B. Automobile Applications
  - 1. Speedometer, Odometer,
  - 2. Tachometer (rpm's)

Unit 2: Newton's Laws

- A. Static Equilibrium (First Law)
  - 1. First Condition – translational equilibrium
  - 2. Second Condition – rotational equilibrium (torque)
- C. Systems of Two or More Bodies (Third Law)
- D. Friction
- E. Automobile Applications
  - 1. Rolling Friction of the automobile
  - 2. Changing reciprocating motion into rotational motion in the engine
  - 3. Lubrication system
  - 4. Forces on the piston
  - 5. Coefficient of friction of tires

Unit 3: Work, Energy, Power

- A. Work and Work-Kinetic Energy Theorem
- B. Conservative Forces and Potential Energy
- C. Conservation of Mechanical Energy
- D. Power
- E. Automotive Applications
  - 1. Changing reciprocating motion into rotational motion
  - 2. 4 stroke cycle
  - 3. Drive Train

II. FLUIDS MECHANICS & THERMAL PHYSICS

Unit 4: Fluid Mechanics

- A. Pressure
- B. Automobile Applications
  - 1. Brake systems
  - 2. Fuel systems
  - 3. Internal Combustion Engine
  - 4. Transmission
  - 5. Heating and Air Conditioning
  - 6. Tires

Unit 5: Thermal Physics

- A. Temperature and Thermal Effects
  - 1. Mechanical equivalent of heat
  - 2. Heat transfer and thermal expansion
    - a. linear expansion of solids
    - b. volume expansion of solids and liquids
- B. Kinetic Theory, Ideal Gases & Gas Laws
- C. Thermodynamics
  - 1. Processes and PV diagrams
    - a. isothermal
    - b. isobaric
    - c. isometric
    - d. adiabatic
    - e. cyclic

2. First Law of Thermodynamics
    a. Internal energy
    b. Energy conservation
    c. Molar heat capacity of a gas
3. Second Law of Thermodynamics
    a. Directions of processes
    b. Entropy
4. Heat Engines and Refrigerators
5. Automobile Applications
    a. Internal Combustion Engine
    b. Exhaust, emissions and cooling Systems
    c. Heating and Air Conditioning
    e. Stopping

22. Texts & Supplemental Instructional Materials

<u>Physics Its Methods and Meaning</u> (1992), Author: A. Taffel, Publisher: Prentice Hall

<u>Active Physics, Transportation</u> (2000), Author: A. Eisenkraft, Publisher: It’s About Time, Inc.

<u>Modern Automotive Technology</u> (2004), Author: J.E. Duffy, Publisher: Goodheart-Wilcox

23. Key Assignments

The assignments in this class will consist of regular physics assignments, regular automotive assignments and linking assignments. The physics assignments will be traditional in nature and will include problems sets, tests and laboratory experiments designed to introduce the relative physics in an uncluttered hands-on fashion. The automotive assignments will focus on the description and operation of the automobile. The assignments designed to connect physics and the automobile are broken down into linking projects and linking activities. Generally, these linking assignments will involve work done in both classrooms. These linking assignments will stress the treatment of various automotive systems using physics theory and then comparison of theory with real world observations. Linking projects are large multi-day assignments such as open-ended experiments or classroom presentations on various automotive systems. Linking Activities are short activities such as homework problems, in-class problems or examples or short group exercises designed to give practical automotive applications to traditional physics problems.

1. Linking Projects
    a. Lab to verify accuracy of odometer and speedometer
    b. Rolling Friction Lab
    c. Mechanical Energy Conversion Lab
    d. Power and Efficiency Lab
    e. Brake Lab (Fluid dynamics)
    f. Engine Cycle Presentation (Otto cycle)

2. Linking Activities
    a. Measurement of tire RPM's at different speed (graph and predict)
    b. Calculation of rotational torque from piston forces and dimensions
    c. Calculation of coefficient of friction of new and bald tires
    d. Writing assignment describing the automobile lubrication system
    e. Calculation of the force on a piston given dimensions and pressure.
    f. Using conservation of energy and efficiency to solve various automotive problems, for example:
        1. Converting reciprocating motion into rotational motion
        2. Converting chemical energy into mechanical energy
        3. Converting mechanical energy to electrical through magnetic induction in the battery charging system
    g. Using engine rpms, gear ratio calculations of the drive train, tire circumference find linear speed of the automobile.
    h. Calculate the power output given the energy per cycle of the engine and its rpm's
    i. Calculate the interior force created by the air in a tire given dimensions and pressure
    j. Verify equal pressures in different points in the brake line
    k. Short essay describing the advantages of incompressible fluids in brake systems
    l. Calculation of linear and volume expansion of various engine components and compare to specified tolerances.
    m. Calculate conduction rates of solid engine components and discuss why convection cooling is important.
    n. Calculate behavior of gases in the engine using the ideal gas laws and compare theory to actual observations.
    o. Find approximate isothermal, isobaric, isometric, adiabatic processes in the automobile.
    p. Calculating ideal engine efficiencies and compare to actual efficiencies
    q. Calculating ideal refrigeration efficiencies and compare to actual efficiencies
    r. Calculate the rotational output torque of the engine given the force of the piston and actual engine dimensions.

24. Instructional Methods and/or Strategies

The basic structure of this class is for one-half of the students (50-60 students) to spend one week in the auto shop with the auto mechanics teacher followed by one week in physics classroom with the physics teacher. The other half of the students will follow the inverse schedule. Frequently, the two classes will meet together to leverage the fact that we have two teachers for one large class. Some activities which work best with a small teacher to student ratio will be combined with activities which work well with a large teacher to student ratio. For example, during the rolling friction lab one teacher will be cycling 10 kids at a time through the lab activity while the other teacher monitors group projects with the rest of the class. Other activities such as presentations and group projects will benefit from having both teachers in the same classroom at the same time with the entire class.

It is important to note that the two pieces of this course are not linearly linked. Due to the nature of physics instruction which is very linear and auto mechanics instructions which is intertwined and interconnected a linear step by step linkage is forced and unnatural. The actual integration of this course comes from the application and combining of knowledge and tools learned in the auto shop with concepts learned in the physics classroom and visa versa. This integration relies on linking activities, linking projects and those times both halves of the class are combined.

The first tool towards integrating the two pieces of this course will be the linking activities. These are activities where students use data gathered in the auto shop in the physics classroom. The students will be required to keep a detailed lab notebook. This notebook will contain data and notes from both the auto shop and the physics classroom. The auto mechanics portion of the lab book will be referenced regularly in the physics classroom as a source of data for in-class and homework problems. For example, an early auto mechanics unit is tire changing. In this unit students will learn how to change a tire, read the tire size code and learn about the structure of the rim and tire and how these interact with the hub and the wheel studs. In addition to this traditional auto mechanics content an added component for auto physics is that students will be taking and recording in their lab notebook measurements of the dimensions of the tire and wheel for use later on in the physics classroom.

In the physics classroom during the pressure unit the students will be tasked to calculate the force on the rim of an actual tire using actual measurements found in their lab notebook. This force will be compared to the material and structural requirements of tire rims. Then in a unit on rotational motion the students will determine the linear speed of the car given the revolutions per minute of the tires. This activity will require calculation of the circumference of the tire from the tire size code which combines standard and metric conventions (rims are measured in inches and tires are measured in millimeters).

The second tool towards integrating the two pieces of this course is the linking projects. These projects require the true integration of auto mechanics with physics. For example in the Mechanical Energy Conversion Lab students will need to calculate the linear speed of an automobile and from the engine rpms, gear ratios and tire size, which will require combining dimensional and structural knowledge of how the drive train is put together with mechanical energy transfer concepts.

Instructional Methods include:

- Direct Instruction: lecture, reading, in class research, problem sets, presentations, and guest speakers
- Instructional Materials: textbook; primary and secondary materials, experts from the field, and electronic media
- Team Teaching which will include business, university, and community based partners
- Community based applied concept projects
- Self-directed, cooperative, and collaborative learning projects
- Instruction adaptable to levels of learning
- Student oral presentations

25. Assessment Methods and/or Tools

Assessment of student performance is based on individual abilities, interests, and talents. Combinations of methods are used to assess student progress. The methods available include but are not limited to the following:

- Regular review of work/problem sets by science teacher
- Portfolios
- Teacher observation
- Student demonstrations
- Student work samples
- Written examinations
- Laboratory projects
- Applied concepts project