Curriculum Outline

Campbell High School
Character – Courage – Respect – Responsibility

Course & Level: **Principles of Engineering (Honors)**

Department: **Science**

Teacher: **Dr. Doherty**

Grade level: **11 and 12**

Description of Course:

Numerous studies report a national engineering recruitment shortage, or "silent crisis", that is only expected to deepen in the coming decades. Despite some of the highest job placement levels and starting salaries, many high school students elect not to pursue engineering and the applied sciences due to the misconception that they are dull. This course attempts to present the exciting reality of engineering and design through an array of dynamic project modules with a significant end-of-year capstone design project. In past years, students have explored underwater robotics and designed, built, and tested remotely operated vehicles (ROVs). In 2009 students built and tested a foam and fiberglass hovercraft powered by multiple engines. Topics of study include engineering graphics, principles of deterministic design, strength and materials, reverse engineering, robotics and automation, and mechanical and electrical principles and basic circuitry. Students will also explore different career fields within engineering, perhaps ultimately answering the question: "what kind of an engineer will I become?"

School – Wide Expectations:

The school-wide expectations are incorporated into all courses at Campbell High School. Underlined words in the following text illustrate this alignment between the school-wide expectations and the course curriculum.

Academic:
1. Read, write and speak effectively
2. Exhibit critical thinking and problem solving skills
3. Use resources to obtain information and facilitate learning

Civic/Social:
1. Exhibit personal responsibility
2. Work cooperatively in an atmosphere of mutual respect

Core Competencies and State Standards:

1. **Engineering Concepts:** Students will demonstrate a conceptual understanding of foundation principles in science and mathematics. Students will demonstrate their knowledge both orally and in writing.
   PS 1 *All living and nonliving things are composed of matter having characteristics properties that distinguish one substance from another.*
   PS 2 *Energy is necessary for change to occur in matter. Energy can be stored, transferred and transformed, but cannot be destroyed.*
   PS 3 *The motion of an object is affected by forces.*
   PS4 *The growth of scientific knowledge in Physical Science has been advanced through the development of technology and is used (alone or in combination with other sciences) to identify, understand and solve local and global issues.*

2. **Problem-Solving:** Students will effectively solve problems related to the engineering design cycle; they will demonstrate critical thinking skills as they solve engineering problems. Students will demonstrate their understanding with individual assignments and cooperatively in groups.
   SPS1 *– Scientific Inquiry and Critical Thinking Skills (INQ)* ***SPS2*** *– Unifying Concepts of Science* ***SPS3*** *– Personal, Social, and Technological Perspectives* ***SPS4*** *– Science Skills for Information, Communication and Media Literacy*

3. **Communication:** Students will research and communicate engineering design ideas. Students will demonstrate their knowledge both orally and in writing.
   SPS1 *– Scientific Inquiry and Critical Thinking Skills (INQ)* ***SPS2*** *– Unifying Concepts of Science* ***SPS3*** *– Personal, Social, and Technological Perspectives* ***SPS4*** *– Science Skills for Information, Communication and Media Literacy*

Suggested Texts and Media (Software, A/V, etc.):

1. Text/Reading: *Skunk Works*, Ben Rich & Leo Janos, 1994, Why Buildings Fall Down, Matthys Levy and Mario Salvadori, 2002
2. PASCO *Datastudio* software
3. NOVA DVD's**:** *Mission to Mars* (Engineering Design Cycle), *Power of the Sun* (Power Systems)

The science curriculum at Campbell High School is a dynamic document, reflecting the nature of the subject. It addresses ever-changing areas of study, such as genetics and quantum physics, as well as the fundamentals, such as the Periodic table and Newton's Laws of Motion. Scientific Research is an important component for each course at Campbell. The analysis and interpretation of recent scientific information and articles will vary appropriately with grade level and course difficulty.
We utilize a variety of instructional resources beyond the identified textbooks and materials throughout the school year to enhance your student's educational experience. Parents/Guardians are welcome to review the available resources throughout the school year by contacting their student's teacher. Due to religious or moral objections, alternative assignments may be available upon request. Please contact the classroom teacher for further details.

Suggested Instructional Strategies:

1. Lecture and Demonstration – Use of demonstration apparatus to guide student inquiry. For example, the "Discrepant Event" – students make predictions on what will happen when Event A occurs and are then required to explain it. The same rationale is applied to Event B in which the predicted outcome does not occur. In order to understand why, students must deconstruct some previously held understanding. This mode of lecture is effective at both including students and exposing misconceptions. Examples of Discrepant Event Demonstrations might be a copper tube drop (penny versus magnet) to investigate Lenz's Law, rolling a disc and a ring down an inclined plane to introduce moments of inertia, or variations of descent path to examine conservation of energy. Physically large demonstration devices also work well to impress new concepts such as using a sonotube with Meker burners (to drive convection currents) as an open tube resonator, a Rueben's Tube (using compressed gas and flame to illustrate standing waves), or freezing drops of falling water by matching frequencies with a stroboscope to examine the kinematics of freely falling bodies.

2. Labs – Exploratory or investigation labs allow students to ask their own questions about a particular concept. These labs have limited formal outcomes and are instead designed to elicit ideas from students. One example includes an Electromagnetic Spectrum Lab in which students predict and then perform qualifying tests to determine whether various frequency emissions within the E/M spectrum will penetrate through various materials (will radio frequencies pass through aluminum screen / UV through cotton / gamma through wood, etc.) Another example would be determining which factors effect the period of oscillation in a harmonic oscillator (such as a pendulum or a spring/mass system). Again, students are simply using labware to investigate and evaluate, not quantify or predict.

3. STEM (Science, Technology, Engineering, and Mathematics) Projects – Design projects in this course are the mainstay of instructional modalities. Students are required to synthesize and apply previous understandings and skills in math and science in exciting, performance-based, project modules. The course begins with a study in Strength and Materials which requires students to evaluate an array of different alloys by machining raw material into a test piece for a tensile stress analysis. Students operate machine lathes, tap and die, and gauge vernier calipers. In the Automation and Robotics unit of study, students construct microprocessor-controlled machines with a variety of capabilities which are programmed in a local visual basic code. The final project in this semester requires students to build a "marble sorting" device which uses optical sensors and a variety of motor controllers and feedback loops.

4. Capstone Design Projects – Major end-of-year design projects require students to tackle substantial engineering problems through a methodical design and planning cycle. Students are required to meet and keep to a design and prototype schedule, and are evaluated on their ability to creatively meet the design goal within given time constraints.

MIT "Sea-Perch" – a grant through NOAA allowed MIT to develop an underwater robotics program at the undergraduate level. This program has expanded and includes K-12 outreach and training. Students must design and build a fully controllable underwater remotely operated vehicle (ROV) that can dive, surface, and maneuver underwater. Additionally the ROV carries a scientific payload (thermistor, lighting, etc.) and video camera that enable it to be operated from the surface. Students will pilot the device in a variety of operational environments (pool, pond, etc.) and be evaluated on effectiveness of design.

Hovercraft Design Project – students will design, model (CAD), construct and test a gas-powered two-person hovercraft which contains a variety of interconnected systems (mechanical, electrical ,etc.)

Suggested Assessment Strategies:

1. Quiz / Test

2. Lab Report Rubric – In order to demonstrate competency in the Scientific Investigation requirement, students communicate lab outcomes that comply with a standard lab reporting framework.

3. Project Rubric – Unique to each project, these rubrics assist students to define specific requirements.

4. Informal Groupwork – Various modes of formative assessment in which students work on a particular problem in groups of two to four. Groupwork encourages peer learning, strengthens topical skill sets through teaching, and promotes collaboration and community. Examples of groupwork include whiteboarding / presentation and written problem sets.