



THE INFINITY PROJECT

Course Essential Knowledge and Skills

(1) Course Title: Engineering: Our Digital Future

(2) Course Requirements

(a) Description of the course and its essential knowledge and skills

i. General requirements.

Students can be awarded one-half to one credit for successful completion of this course. Recommended prerequisites: Algebra II (or concurrent enrollment in Algebra II) and one lab science course.

ii. Introduction.

The Infinity Project curriculum entitled “Engineering: The Digital Future” focuses on the fundamentals of modern engineering and technology in the information and communications age. To generate and maintain students and faculty interest, engineering and design examples are drawn from wireless and telecommunications, the Internet, electronic music, and other multimedia technologies popular in today's culture.

Upon completing the course, students will have an understanding of how modern engineers design and build new technologies using math and science, together with their ingenuity. In addition, students will have been exposed to new and relevant applications of mathematics, science, and technology to important engineering problems of the day and will have developed a deeper and broader set of computer skills. And as an additional component of the course, students unfamiliar with engineering will be exposed to a variety of current and future career opportunities in engineering and technology related fields.

iii. Knowledge and Skills.

(1) **The student develops an understanding of the engineering design process.** The student is expected to:

- (a) learn the history and vocabulary associated with engineering and digital technologies;
- (b) analyze and develop engineering design objectives and formulate concrete design procedures aimed at meeting those objectives;
- (c) analyze and design engineering systems through block diagrams;
- (d) understand and apply basic concepts behind modern digital technologies: digital hardware components, Moore's Law, the digitization of general forms of information, bit representations of data and information, data rates, storage capacities, processing speed, etc;
- (e) compare, contrast, and quantify the physical properties of various storage devices (tapes, floppy disks, CDs, DVDs) and video display devices (LCDs, CRTs, etc)
- (f) understand the role that uncertainty and approximations play in engineering design;

- (g) appreciate the role that digital technology plays in our daily lives, including both positive and negative effects of technology; and
 - (h) predict future technological advances through mathematical and scientific means.
- (2) **The student uses a variety of technological devices to design, build and test engineering concepts.** Projects include student-built digital synthesized musical instruments, real-time video special effects, audio loud-speakers, Internet security products, and basic cell phones, among others. The student is expected to:
- (a) use the Internet for research and to access interactive technology websites;
 - (b) execute labs and engineering designs on a PC computer supported by the Infinity Technology Kit; and
 - (c) collect and analyze data using available graphing calculator technology.
- (3) **The student applies mathematical knowledge to engineering and technology.** The student is expected to:
- (a) represent information bearing signals as discrete or continuous graphs, and classify signals as periodic or non-periodic;
 - (b) understand the mathematical conditions for when a sequence of numbers is precisely equivalent to information bearing signals;
 - (c) analyze sinusoidal signals by comparing amplitudes and frequencies, and apply transformations of functions to write equations of specific signals;
 - (d) investigate sums of sinusoids and Fourier series, understand how sums of sinusoids approximate general information bearing signals, and apply this to computer generated music;
 - (e) use logarithms to compare the relative loudness of speech, music, and other general forms of signals, and compute the signal-to-noise ratio of a signal and apply this to the understanding of real-world data;
 - (f) observe the effects of exponential growth in information accuracy as the number of bits used in storing information is increased and apply this to the design of digital information acquisition systems;
 - (g) use the fundamental counting principle and combinatorics to enumerate possible outcomes and apply this to network design for applications such as wireless and Internet communications;
 - (h) use composition of functions in a graphical representation to predict the effects of various engineering operations such as filtering;
 - (i) use measures of central tendency (mean, median) in engineering applications and apply this to improving the quality of digital videos and images;
 - (j) perform operations in other bases (binary, hexadecimal) and convert to and from base 10 and apply this to computer based mathematical operations;
 - (k) use the correct prefixes for both large and small numbers given in scientific notation (ex. kilo, mega, giga, micro) and apply this to presentations of engineering designs;
 - (l) use simple matrix operations in a variety of applications (filtering or extracting information from images, correcting errors in digital messages)
 - (m) use polynomials in a variety of applications including encrypting digital information and predicting technology trends; and
 - (n) encode and decipher digital messages: zip codes, and UPC symbols using modular arithmetic

- (4) **The student explores the connections between humans and technology to enhance the human utility of engineering designs.** The student is expected to:
- (a) understand the basic physiology of the human hearing, speech, and vision systems; and
 - (b) relate digital systems for hearing, speech production, and imaging to human systems to improve their design and function.

(b) Rationale and justification for the request in terms of student need

- i. Industry, academia, and parents are calling for children to be exposed to more engineering and technology in their formative high school years. There are many significant benefits to exposing high school students to engineering early: (1) engineering and technology serve as an ideal discipline for demonstrating the relevance of math and science in the modern world, (2) engineering teaches students how to problem solve by using math and science skills with human ingenuity, and (3) engineering uniquely offers students the necessary skills for succeeding in the information driven 21st century.
- ii. In response to this need, the Infinity Project has developed a complete engineering curriculum designed specifically for high school students. The authors of the curriculum are world-renown engineering professors teaching and conducting research at major universities across the country. The technology used in the course is state-of-the-art, low-cost, and robust to the classroom environment.

The purpose of the course is to teach students the basic math and science concepts of modern engineering and technology and to apply this knowledge to an array of interesting and interactive design projects so that students have a deep understanding of the mathematics, science, and technology underpinning the information age.

As an important by-product, this course motivates students to pursue additional advanced courses in technology, math and science at the high school and collegiate level and encourages underrepresented groups of students (women and minorities in particular) to pursue engineering and technology related majors in colleges and universities.

(c) Description of activities, major resources, and materials used

- i. *Description of Activities:* This innovative course allows students to learn how engineers create, design, and test the technologies and devices of the 21st century using their math, science, creative skills. In particular, students learn the “engineering design process” and put this proven problem-solving approach into regular practice by applying math and science to design and test an array of high-tech digital devices. In this innovative course, students learn from both regular classroom lectures, and from hands-on design projects. Moreover, they will have the opportunity to work in groups when undertaking their design projects.

While there are more than one hundred different design projects for the students, we list below a representative sample:

Students design futuristic engineering technologies and predict the year that engineering will be able to achieve their designs by analyzing current technologies and extrapolating to the future through the use of Moore's Law.

Students design, build, and test computer based color matchers to perfectly create digital colors that match those seen in student supplied art work or articles of clothing.

Students design, build, and test digital music synthesizers using the technology from the Infinity Technology Kit –and compare the performance of these design to other existing solutions. Students can select a wide variety of digital music from the Internet and play it on their individually designed digital instrument.

Students design, build, and test digital imaging systems to be used for blue screen applications in movies and TV or to be used in motion tracking applications in building security. Students can apply their designs to tracking motion in the school hallway or in determining the speed of moving objects in the school parking lot or playground such as cars or baseballs.

Students design, build, and test systems to aid the visually impaired in matching clothing.

Students design, build, and test Internet security and encryption systems for ensuring that digital messages on the Internet are transmitted with the highest degrees of security. Students send encrypted messages between each other in class.

Students design, build, and test classroom cell phones. Students make phone calls to each other in class on their own cell phones – and if desired, layer in encryption technology to ensure that their fellow students can't listen in to their conversations.

- ii. *Major Resources:* There are two primary curricular resources for teachers undertaking this innovative course. First, the book, Engineering Our Digital Future, Prentice-Hall, contains all the necessary materials for the instructors. Second, the Infinity Project web space (www.infinity-project.org) contains an extensive array of additional supporting documents such as our “on-line” library of engineering design projects and additional web sites with advanced materials. As part of this web space, we maintain password protected curriculum and technology discussion groups for our teachers. As an important element of these discussion groups, we maintain a 24-hour hotline to address any question from any of our teachers on course content or laboratory assignments.

And, as an additional key ingredient to support the teaching of this innovative curriculum, the Infinity Project offers comprehensive professional development to all

teachers. This program is 35 hours and is offered during the summer on college campuses across Texas.

- iii. *Materials Used:* To support the engineering designs to be undertaken in this course, the Infinity Project makes available to participating schools the Infinity Project Technology kit. This low-cost computer add-on converts standard classroom PC's into state-of-the-art engineering design workstations. It is highly robust to the rigors of the classroom and offers the students access to the future of technology. We make this technology available to ensure that every participating school has the necessary resources to undertake all of the designs that are part of this course.
- (d) Methods for evaluating student outcomes
- i. Homework assignments and tests are a fundamental component of this course and serve to evaluate the student's mastery of the course material and lecture content. These are scheduled at regular intervals with sufficient frequency to offer appropriate feedback to the students and to the teachers. Lab and engineering design assignments are given regularly and serve to develop the student's hands-on experience with the engineering design process and to give the teacher direct feedback on the student's mastery of the design process. In addition to homework, tests, and engineering designs, the Infinity Project will supply schools with a final assessment instrument (test) to evaluate the class performance as a whole. We will also conduct interviews with teachers during regular intervals of the school year.
- (e) Qualifications of teachers
- i. The teacher should be certified in any technology area, math, or science. The teacher should have a moderate to strong competency in computer hardware and software. The necessary teacher computer skills include the ability to send and receive email messages, search the Internet, and install software from a CD ROM.
 - ii. The teacher must be willing to attend a five-day 35-hour *Infinity Project Professional Development Institute* during the summer prior to offering this course. This professional development Institute covers all the basics of both the technology and the curriculum and prepares the new teacher for this course.