TAMALPAIS UNION HIGH SCHOOL DISTRICT
Larkspur, California

Course of Study

ENGINEERING PROJECTS

I. INTRODUCTION

Engineering Projects is a project-based course which provides an introductory experience in the areas of design, research, problem solving, teamwork and project manufacturing. It is designed as either a stand-alone elective course or as part of an interdisciplinary academy for upper division students who have developed the essential foundation skills in visual arts, science, and mathematics.

Students regularly apply scientific knowledge to the design and construction of complex projects, with consideration towards using appropriate technology and artistic creativity. Subject matter includes electronics, programming, mechanical systems, drafting, construction and manufacturing processes.

Engineering Projects meets the following district Student Learning Outcomes:

1. Communicate articulately, effectively and persuasively when speaking and writing.
2. Read/View and analyze material in a variety of disciplines.
3. Use technology to access information, analyze/solve problems and communicate ideas.
5. Apply mathematical knowledge and skills to analyze and solve problems.
6. Demonstrate scientific literacy.
11. Appreciate, interpret, experience, create and/or perform artistic work.
12. Demonstrate school-to-work/post-secondary transition skills and knowledge.

This course addresses the following Tam 21st Century goals:

- Student Success. Prepare our students for lives of personal, academic, and professional growth, achievement, and fulfillment.

  Set and maintain world-class academic standards and the highest expectations for student social behavior and personal performance: assess and communicate District performance in meeting those standards.

  Provide opportunities for, and encourage students to, demonstrate individual and collective responsibility, creativity, productivity, and initiative through class, school, and community projects and experiences.

Provide opportunities for meaningful adult/student contacts for each student.

Provide opportunities for students to acquire the technological skills needed for personal, educational, and employment success.

Provide a school environment which enhances and supports student success.

- Instruction. Prepare our students to think conceptually, solve complex problems, acquire knowledge, communicate ideals and work individually and collaboratively.

II. STUDENT LEARNING OUTCOMES

Within this course, students will:

1. Work as a constructive member of a design team, each student being fully engaged, openly communicating and taking shared responsibility for successful project completion.

2. Design an engineering project on AutoCAD, utilizing acquired drawing techniques and skills to better layout communicate design ideas. Finished plans should be communicate all required information, including dimensions and tolerances, in order for another group to successfully construct the project.

3. Design and manufacture projects in wood, steel and plastic using power tools and computer aided manufacturing equipment. Students should progressively demonstrate safe tool applications, confidence and craftsmanship. As the year progresses, increasingly complex projects should incorporate advanced craftsmanship skills and knowledge.

4. Effectively establish project goals and efficiently manage project time by maintaining open and constructive group communication and monitoring.

5. Efficiently utilize material resources and consider budgetary constraints.

6. Develop competence in engineering projects such as electronics, aeronautics structural and mechanical engineering and programming. Students develop analytical skills and troubleshooting strategies which can be applied to a myriad of complex projects.

7. Relate basic high school physics concepts, such as forces, velocity, acceleration, leverage, voltage, current, resistance, etc., to hands-on projects such as robots, motors, bridges and human-powered vehicles.

8. Demonstrate metacognition and growth by writing project summary papers. These papers include an outline of the problem at hand, skills acquired, various design approaches considered, an explanation of how problems were solved, group performance assessment and what would be done differently next time.

9. Maintain an organized digital portfolio which documents student progress and capabilities by including a personal statement, resume, interview evaluations, project summaries, teacher evaluations, writing samples and other relevant items.

III. ASSESSMENT

A. Student Assessment

Students will be assessed per the project scoring rubric found in the appendix. This rubric includes time management, concept and design, construction and performance and professionalism. Students are also assessed on their professional speaking skills per the Oral Communications Skills Evaluation Form in the appendix. Students compile all of their project descriptions into a digital portfolio, which is assessed using the Professional Skills Portfolio Assessment Worksheet and the Engineering Portfolio Scoring Guide. Student grades will be determined as follows:

Grade	%
A	90 and above
B	80 to 89
C	70 to 79
D	60 to 69
F	Below 59

Part of each student's grade is based on peer assessment of their project. This assessment includes the areas of craftsmanship, use of materials and design creativity. Project performance is generally assessed by means of class competition, with competition parameters varying with each project. For example, with the balsa wood bridge project, each bridge which meets design requirements is loaded incrementally to failure with the strongest bridge receiving the most project competition points.

B. Course Assessment

The Engineering Projects course is assessed on the four year Curriculum Cycle. In addition, twice per year a professional advisory committee comprised of professional engineers and interested parties meet to discuss the Engineering Projects curriculum, to review student work and to recommend course improvements.

IV. METHODS AND MATERIALS

A. Methods

When this course is taught as part of a two-year interdisciplinary academy the following methods may be used:

Students begin each new year with a relatively simple project assignment to become acquainted with the problem solving, project based approach taken in this class. New

students are paired with experienced students from the previous year to provide leadership and support. Basic concepts of mechanical drawing relating to scale size and orthographic projections are introduced during this first project. Responsibilities for project sketches and final design are shared by all members of the team. Construction is done with basic hand tools and grading is heavily weighted toward teamwork skills and on task behavior rather than project performance, creativity, and / or craftsmanship.

Subsequent projects throughout each year rapidly increase in complexity and technical skills with design requirements shifting to two and three dimensional CAD and construction methods incorporating power tools and machines as well as computer aided manufacturing (CAM) processes.

Subject content is varied from mechanical and structural devices to electrical and electronic projects especially relating to robotics. Sample projects may include designing and constructing a mechanical timer using a marble to activate a switch with as close to thirty seconds delay as possible.

The timer project may be followed by the design and construction of a human powered vehicle which introduces AutoCAD, welding, metal fabrication methods, and basic metallurgy and material properties instruction. Students become acquainted with power train, steering, braking and suspension systems in addition to structural frame design requirements to incorporate stability, rigidity and ergonomic considerations.

Students who wish to acquire architectural experience may elect to substitute the design and construction of a $1/16^{th}$ scale size house for the vehicle project. These students study local building codes, standard framing construction, and esthetic, environmental and practical considerations relating to house design and fabrication.

The final project of the year may be a balsa wood bridge project that requires CAD design and precision construction. Student teams evaluate the relative merits of various truss designs, glue strengths, joint configurations, compression, tension, and sheer loading, and material characteristics and report their findings to the class. Student design and construction teams are limited in the amount and type of materials used in their projects and performance evaluation is based on the strength to weight ratio of each bridge. Following the destruction of each bridge, the class is required to make a failure mode analysis to determine how and why the failure occurred and make recommendations to improve each design.

Year B may begin with designing and fabricating a hydraulically controlled robot capable of grasping a tennis ball, lifting it at least 6 inches, rotating at least 180 degrees, and dropping the ball into a container. Once again half the class is comprised of new students so this is a relatively simple project to introduce these new students to the engineering environment.

The second project may be a DC electric motor which introduces AutoCAD design, power tools and CAM machining. This project integrates principles of magnetism and Ohm's law relating to electrical current flow.

The final project of the year may be a microprocessor controlled autonomous robot, which requires a working knowledge of digital electronics, circuit trouble shooting techniques, programming, and additional AutoCAD design, CAM, and construction processes.

When this course is taught as a stand alone course, the following strategies/activities will be used:

Students begin the year with a relatively simple project assignment to become acquainted with the problem solving, project based approach taken in this class. Basic concepts of mechanical drawing relating to scale size and orthographic projections are introduced during this first project. Responsibilities for project sketches and final design are shared by all members of the team. Construction is done with basic hand tools and grading is heavily weighted toward teamwork skills and on-task behavior rather than project performance, creativity, and /or craftsmanship. Subsequent projects throughout the year rapidly increase in complexity and technical skills with design requirements shifting to three dimensional AutoCAD and construction methods incorporating power tools and machines as well as computer aided manufacturing (CAM) processes, if available.

Projects should include a broad scope in order to expose students to a variety of engineering options. These projects should include the following engineering areas and may be selected from the following suggestions:

- Mechanical: human powered vehicles, thirty second timers, balsawood gliders, rocket-powered cars, Rube Goldberg machines, watercraft design and construction, mechanical design solutions to competition-based challenges
- Electrical and electronic: robot design and construction, DC electric motor design and construction, radio controlled models, electronic control circuits
- Civil: balsawood bridge design and construction, scale house design and construction

B. Materials

- Industry manuals, architectural design and framing textbooks, trade journals, field trips, guest lecturers and instructional videos will be used to enhance the students' knowledge.
- Computers are used extensively in this program. Example uses include:
- AutoCAD for computer aided project design
- SpectraCAM for computer aided machining and parts fabrication
- Pbasic for computer controlled robots
- NASA's glider design program used for aeronautical stability analysis
- Bridge Builder software for bridge structural analysis

C. Technology

This course makes extensive use of computer technology including such applications as word processing, web page design programs such as Dreamweaver and AutoCAD. Other technologies, including engineering tools and computer-guided machining equipment are used as well.

D. School-to-Career

This course is designed to introduce students to a wide range of career options in engineering related fields. Guest presenters, project consultants, and student internships provide real world experiences.

E. Suggested Instructional Time Allocation

Project Schedule

3 weeks	Introductory project: hydraulic robot
3 weeks	Introduction to AutoCAD
1 week	Introduction to computer aided manufacturing
8 weeks	Design and Construction of a DC electric motor
3 weeks	Introduction to computer programming using QBASIC
3 weeks	Development of PBASIC robotic interface computer language
12 weeks	Design and construction of an autonomous robot
1 week	Resume development and mock professional interviews
2 weeks	Design and development of digital portfolios

V. GENERAL INFORMATION

Engineering Projects is a ten (10) credit course per year open to all juniors and seniors (sophomores considered on a case-by-case basis). It may be repeated for a second year as part of an interdisciplinary academy program.

A. Prerequisites

Integrated Science 1-2 and algebra are required and Integrated Science 3-4 is recommended. A passing grade of "C" or better or teacher approval is required for these courses.

B. Requirements Met

Engineering Projects is a two semester course, five units per semester, which can be used in partial fulfillment of the district's 220 unit requirement for graduation. *For each year taken, students receive 10 units of UC/CSU elective "g" requirement.*

Appendices:

Appendix A: Project Rubric
Appendix B: Oral Communication Rubric
Appendix C: Final Portfolio_1
Appendix D: Final Portfolio_2

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Revised: 6/99, 8/03, 6/23/04, 2/16/05

APPENDIX A: Project Rubric

	▪ Time and Task Management	▪ Concept and Design	▪ Construction and Performance	▪ Professionalism
Outstanding (A-B)	▪ Project development is clearly defined ▪ All project milestones are planned and completed on or before schedule ▪ All group members are always on task ▪ Distribution of work is very clear and effective ▪ Delegation of work is balanced and fair ▪ All team members share responsibility for project completion ▪ All team members use appropriate technology to achieve project goals	▪ Design documentation is neat, complete and clearly leads to the final product ▪ Creativity and innovation are clearly demonstrated ▪ Physics principles are incorporated into the design concept ▪ Effective use of materials and processes	▪ Excellent craftsmanship and attention to detail ▪ Project meets all dimensional specifications ▪ Performance exceeds all defined requirements	▪ Different concepts and ideas are always respected ▪ Group members are open to constructive criticism and show effort to correct deficiencies ▪ Group members regularly support and learn from each other ▪ Tools and equipment are always respected and used properly ▪ Everyone participates actively in cleanup and shop maintenance activities
Competent (B-C)	▪ Project development timeline is written and complete ▪ Most schedule deadlines are met ▪ On task behavior is the norm ▪ Distribution of work is generally effective ▪ Delegation of work is fair ▪ Most team members assume responsibility for project completion ▪ Team members usually apply appropriate technology to accomplish project goals	▪ Design documentation is legible, accurate and complete ▪ Creativity and innovation are evident but limited ▪ Some application of physics principles ▪ Reasonable use of materials and processes	▪ Satisfactory craftsmanship and attention to detail ▪ Project meets all dimensional specifications ▪ Performance complies with all defined requirements	▪ Different concepts and ideas are usually respected ▪ Group members are listen to constructive criticism ▪ Group members sometimes support and teach each other ▪ Tools and equipment are usually used properly ▪ Everyone participates in cleanup and shop maintenance activities
Emerging (C-F)	▪ Project development timeline is incomplete and/or unclear ▪ Work is late or missing ▪ Team members are off task ▪ Distribution of work is unclear or ineffective ▪ Some members are not trusted to complete tasks ▪ Responsibility for tasks is shirked ▪ Limited use of technology to attain project goals	▪ Design documentation is incomplete and/or inaccurate ▪ Little evidence of creativity or innovation ▪ No application of physics principles ▪ Improper or excessive use of materials and/or poor choice of processes	▪ Poor craftsmanship without attention to detail and little effort towards improvement ▪ Project does not meet dimensional specifications ▪ Performance fails to comply with defined requirements	▪ Different concepts and ideas are seldom respected ▪ Group members reject constructive criticism ▪ Group members rarely support or learn from each other ▪ Tools and equipment are not respected or used properly ▪ Team members rarely participate in cleanup and shop maintenance activities

Time and Task Management	Concept and Design	Construction and Performance	Professionalism
▪ Project development is clearly defined ▪ All project milestones are planned and completed on or before schedule ▪ All group members are always on task ▪ Distribution of work is very clear and effective ▪ Delegation of work is balanced and fair ▪ All team members share responsibility for project completion ▪ All team members use appropriate technology to achieve project goals	▪ Design documentation is neat, complete and clearly leads to the final product ▪ Creativity and innovation are clearly demonstrated ▪ Physics principles are incorporated into the design concept ▪ Effective use of materials and processes	▪ Excellent craftsmanship and attention to detail ▪ Project meets all dimensional specifications ▪ Performance exceeds all defined requirements	▪ Different concepts and ideas are always respected ▪ Group members are open to constructive criticism and show effort to correct deficiencies ▪ Group members regularly support and learn from each other ▪ Tools and equipment are always respected and used properly ▪ Everyone participates actively in cleanup and shop maintenance activities
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APPENDIX B: Oral Communication Skills Evaluation Form

Oral Communication Skills Evaluation Form

Presenter: _____

Topic: _____

Evaluator: _____

Skills Evaluation (check the box which applies):

	Emerging	Competent	Outstanding
Organization	☐ Uses somewhat unclear organization to present ideas	☐ Presents ideas in an organized manner	☐ Presents ideas in a polished, well organized manner
Approach	☐ Does not attempt an original approach	☐ Attempts an original approach	☐ Uses an original approach
Language	☐ Uses some inappropriate or imprecise language	☐ Uses well-chosen language	☐ Uses vivid, precise language
Visual aid	☐ Visual aid not present or inappropriate	☐ Visual aid present but underutilized	☐ Visual aid incorporated into the presentation and clarifies the subject matter
Delivery	☐ Uses limited delivery techniques, including a somewhat indistinct voice, occasional eye contact, ineffective body language	☐ Demonstrates skilled use of delivery techniques, including clear and distinct voice, consistent eye contact, positive body language	☐ Demonstrates ease in delivery techniques, including an appropriate and natural voice, excellent eye contact, congruent body language

Overall rating (circle one): **Emerging** **Competent** **Outstanding**

Comments: _____

APPENDIX C: FINAL PORTFOLIO RUBRIC

A. Engineering Portfolio Scoring Guide

☐ 1st Score ☐ 2nd Score ☐ 3rd Score	PROFESSIONAL PREPARATION • Personal skills • Interpersonal skills • Professional awareness 1	WORK-PLANNING • Thinking and problem-solving skills • Project management skills 2	TECHNOLOGY SKILLS • Making relevant choices about the application of technology • Use of technology 3	COMMUNICATION • Attention to audience • Using own ideas • Organization and clarity • Accuracy and completeness • Language mechanics, sentence structure and vocabulary 4	OVERALL
EMERGING (Not ready to show college or employer) 1	• Does not identify personal skills needed to be successful professionally • Interpersonal Skills Evaluation shows little evidence of working productively with others • Shows little evidence of professional awareness − ☐ +	• Reasoning is unclear, illogical, or superficial; interprets or calculates information inaccurately; makes statements with little explanation • Needs to show more evidence of the use of project planning skills to set and meet project goals − ☐ +	• Needs to recognize when to apply technology and what to use • Rarely uses technology to perform tasks or enhance work • Relies exclusively on most basic or simple technology tools − ☐ +	Written work and Oral Communication Skills Evaluation show that: • Student needs greater awareness of the audience • Ideas are not complex; copies others • Communication is disorganized • Work needs to be more accurate and complete • Errors in language make ideas difficult to understand − ☐ +	− ☐ +
COMPETENT (Ready to show employer or college) 2	• Identifies own personal skills needed to be successful professionally • Interpersonal Skills Evaluation shows ability to work productively with others • Shows evidence of professional awareness − ☐ +	• Reasoning is clear and logical; interprets or calculates information accurately; supports statements with explanation • Shows evidence of the use of project planning skills to set and meet project goals − ☐ +	• Recognizes when to apply technology and what to use • Uses technology to perform tasks • Competently uses a range of technology tools − ☐ +	Written work and Oral Communication Skills Evaluation show that: • Student effectively presents self and ideas to audience • Ideas are complex • Communication is clear and organized • Work is accurate and fully developed • Though minor language errors are evident, ideas are understandable − ☐ +	− ☐ +