FREEHOLD REGIONAL HIGH SCHOOL DISTRICT

OFFICE OF CURRICULUM AND INSTRUCTION

SCIENCE ENGINEERING LEARNING CENTER

SCIENCE ENGINEERING RESEARCH & DESIGN

BOARD OF EDUCATION INITIAL ADOPTION DATE: AUGUST 25, 2008

FREEHOLD REGIONAL HIGH SCHOOL DISTRICT

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Science Engineering Research & Design

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Course Philosophy

Although content knowledge is a necessary prerequisite to success in both research and industrial settings, ultimate success depends on many other factors not normally developed in a typical classroom. The primary goal of the Science Engineering Research program is to develop these necessary additional skills.

Course Description

The Science Engineering Research program consists of two distinct parts: the development of the skills necessary to develop an independent research project from infancy to successful completion and to learn how to develop and understand a challenging research topic in science and/or engineering.

To reach these goals the students in this course will complete two semester long independent research projects selected from the following areas of study: astronomy, computer interfacing, fluid statics & dynamics, laser art & communication, mathematical modeling, magnetic forces & fields, and robotics.

At the end of the preceding school year students select three areas of interest from the approved curriculum. Every effort is made to accommodate student interest in assigning the students to the two semester projects.

All projects will include the following parameters:

- Students will usually be working in groups of 2-3
- Projects will be orally presented, defended and evaluated 2-3 times each marking period
- Each project team will maintain a fully documented log recording the development of the project
- A formal final presentation at the end of each semester will be assessed as the culminating activity [semester/final exam] for the semester

Each student will be expected to meet all of the criteria set out in the Research & Design portion of the curriculum as well as meeting the criteria delineated in two of the seven designated areas of study.

Evaluative criteria are provided as a part of the addendum located at the end of this curriculum document.

Grade Level: 12 Department: Science Engineering

Course Title: Science Engineering Research & Design Credits: 5

Course Code: 062000

Freehold Regional High School District

Science Engineering Research & Design – Curriculum Map

Relevant Standards	Enduring Understandings	Essential Questions	Assessments		
			Diagnostic (before)	Formative (during)	Summative (after)
SCI.9-12 5.2.A.1 5.2.B.1 5.2.B.2 5.2.B.3	Research requires the integration of many diverse fields of knowledge.	How do you decide what fields of study are needed for a particular topic of study?	Periodic discussions with individual groups	Daily debriefing with individual groups.	Periodic Assessment [3x/MP] Marking Period Evaluation
		How thoroughly should the diverse fields of study be integrated?			
		Should there be a limit on the number of topics that can be integrated for a particular area of research?			
		How does the order in which fields are integrated into the project impact the outcome of the research?			
TEC.9-12 8.1.A.5 8.1.B.4 8.1.B.12 SCI.9-12 5.1.A.1 5.1.A.3 5.1.A.4	Oral communication is a fundamental method of transferring knowledge.	What are the different ways in which oral communication is useful?	Periodic discussions with individual groups.	Interim Presentations [3x/MP]	Final Semester Presentation
		How does the organization of oral communication impact the efficiency with which information is being transferred?			
		To what degree does effective eye contact impact oral communication?			
		How can technology be used to improve oral communication?	Periodic discussions with individual groups	Interim Presentations [3x/MP]	Final Semester Presentation
		Why do some speakers inspire rapt attention while others are ignored?			
		What characteristics are essential for effective oral communication?			

Relevant Standards	Enduring Understandings	Essential Questions	Assessments		
			Diagnostic (before)	Formative (during)	Summative (after)
TEC.9-12 8.1.B.8 SCI.9-12 5.1.A.1 5.1.A.3 5.1.A.4	Research topics of study require the cooperation of many diverse individuals.	How should members of each project distribute the work load? Is there an ideal size for small research groups? Should a single individual in a research group assume a dominant leadership role?	Periodic discussions with individual groups	Periodic Assessment [3x/MP] Interim Presentations [3x/MP]	Marking Period Evaluation
TEC.9-12 8.1.B.1 8.1.B.5 8.1.B.6 8.1.B.7 8.2.B.1 SCI.9-12 5.2.B.1 5.2.B.2 5.2.B.3	Pursuit of a research topic often leads the researcher in unexpected directions.	What criteria should be considered before making a dramatic shift in the direction of a research project? How many changes in the direction of a research project are too many? What do you do with content in a project that no longer seems relevant after a significant change in direction?	Periodic discussions with individual groups	Daily debriefing with individual groups Ongoing log evaluation	Marking Period Evaluation
TEC.9-12 8.1.B.9 8.1.B.10 8.1.B.11 SCI.9-12 5.3.B.1 5.3.C.1 5.3.D.1	All research requires carefully maintained documentation.	What kinds of documentation are considered to be effective and reliable? How should the documentation be prepared in order to meet normal acceptable standards? What is more important in proper documentation; length or depth?	Preliminary written proposal [Each Semester] Periodic discussions with individual groups	Periodic Assessment [3x/MP]	Marking Period Evaluation Written abstract describing completed research [Each Semester] Periodic Assessment [3x/MP]
TEC.9-12 8.2.A.1 8.2.A.2 SCI.9-12 5.1.B.1 5.1.B.2	Cost considerations have significant affects on the direction of research.	Do the anticipated research results justify the expenses required? How is the financing for the research going to be supplied?	Periodic discussions with individual groups	Daily debriefing with individual groups Ongoing log evaluation	

Relevant Standards	Enduring Understandings	Essential Questions	Assessments		
			Diagnostic (before)	Formative (during)	Summative (after)
TEC.9-12 8.1.B.1 8.1.B.2	All research is potentially impacted by legal and moral considerations.	What are the moral implications of a particular research project?	Periodic discussions with individual groups	Daily debriefing with individual groups Ongoing log evaluation	Periodic Assessment [3x/MP]
		Is the project being done within the constraints applied by the law?			
TEC.9-12 8.1.B.2 SCI.9-12 5.1.A.2 5.1.B.1 5.1.C.1	Safety is a fundamental consideration in all research.	What safety equipment is required for a particular activity?	Periodic discussions with individual groups	Daily debriefing with individual groups Ongoing log evaluation	Periodic Assessment [3x/MP]
		What safety equipment is required for a particular activity?			
		Are all safety regulations being followed fully?			
		Is all research work being done with full cognizance of bystanders in the immediate area?			
		How are safety guidelines developed, evaluated & revised?			
TEC.9-12 8.2.B.1 8.2.B.2 8.2.B.3 8.2.B.4 8.2.B.5 8.2.B.6 8.2.C.2 8.2.C.3 SCI.9-12 5.1.A.1 5.1.A.2 5.1.A.3 5.3.B.1 5.3.C.1 5.3.D.1	Appropriately designed technologies meet the needs of the intended users.	What characteristics determine the usability of a particular technology?	Periodic discussions with individual groups	Daily debriefing with individual groups Ongoing log evaluation	Periodic Assessment [3x/MP]
		What kinds of testing procedures can be used to evaluate the suitability of a particular technology to its intended purpose?			
		Why is it sometimes better to test a technological concept on a small scale before producing a final product?			
		How can mathematical manipulations be used to predict the viability of a specific technology?			

Research Topic #1 – Astronomy

Relevant Standards	Enduring Understandings	Essential Questions	Assessments		
			Diagnostic (before)	Formative (during)	Summative (after)
SCI.9-12 5.4.A.1 5.9.A.1 5.9.B.1 5.9.C.1 5.9.D.1	The night sky provides a snapshot of the evolution of the universe.	How do you locate the position of a celestial object?	Periodic discussions with individual groups	Daily debriefing with individual groups Ongoing log evaluation	Marking Period Evaluation Periodic Project Assessment [3x/MP] Periodic Log Evaluation [3x/MP] Periodic Oral Presentation [3x/MP]
		How is the theoretical position of a celestial object defined?			
		How can the theoretical position of a celestial object be determined?			
		What factors affect your ability to observe a celestial object?			
		What different types of celestial objects can be observed?			
TEC.9-12 8.2.A.1 8.2.B.1 8.2.B.2 8.2.B.3 8.2.B.5 8.2.C.2 8.2.C.3 SCI.9-12 5.7.B.2 5.7.B.4	Evolving technologies have provided astronomers with many new tools for observing the universe.	What specialized equipment may be required for astrophotography?			
		What are the primary functions of a telescope?			
		What types of image sensors can be used in astrophotography?			

Research Topic #1 – Astronomy

Relevant Standards	Enduring Understandings	Essential Questions	Assessments		
			Diagnostic (before)	**Formative (during)**	**Summative (after)**
TEC.9-12 8.1.B.5 8.1.B.6 8.1.B.7 8.1.B.8 8.1.B.9 8.2.B.6 SCI.9-12 5.7.A.6 5.4.C.1	Evolving technologies have provided astronomers with many new tools for observing the universe.	What are the different types of telescopes?	Periodic discussions with individual groups	Daily debriefing with individual groups Ongoing log evaluation	Marking Period Evaluation Periodic Project Assessment [3x/MP] Periodic Log Evaluation [3x/MP] Periodic Oral Presentation [3x/MP]
		What are the advantages/disadvantages of each type of telescope?			
		What characteristics affect a telescope's usability?			
		Why use photography to observe the heavens?			
		What are the different ways that astrophotographs can be taken?			
		What is the principle advantage of astrophotography over direct visual observation?			
		What problems are encountered in taking astrophotographs?			
		How have recent developments in technology influenced the field of astrophotography?			

Research Topic #1 – Astronomy

Relevant Standards	Enduring Understandings	Essential Questions	Assessments		
			Diagnostic (before)	**Formative (during)**	**Summative (after)**
SCI.9-12 5.2.A.1 5.2.B.1 5.2.B.2 5.2.B.3	Astronomical observations can be used to investigate the very nature of the universe.	What are the different classifications of celestial objects?	Periodic discussions with individual groups	Daily debriefing with individual groups Ongoing log evaluation	Marking Period Evaluation Periodic Project Assessment [3x/MP] Periodic Log Evaluation [3x/MP] Periodic Oral Presentation [3x/MP]
		What observational characteristics determine the classification of celestial objects?			
		What have we learned about the universe from our observations of the heavens?			
SCI.9-12 5.2.A.1 5.2.B.1 5.2.B.2 5.2.B.3	Astronomy is one area of science where the contributions of amateurs continue to exceed the contributions of professionals.	What were the major milestones in astronomical observations?			
		Who were the most important players in our understanding of the universe?			
		What special resources are available to amateur astronomers?			

Research Topic #2 – Computer Interfacing

Relevant Standards	Enduring Understandings	Essential Questions	Assessments		
			Diagnostic (before)	Formative (during)	Summative (after)
TEC.9-12 8.1.B.1-3,6 8.2.B.1-3 8.2.C.2-3 SCI.9-12 5.1.A.1-3	Computers can be used to perform many valuable tasks.	What advantages does the use of a computer for data collection and analysis confer on the researcher?	Periodic discussions with individual groups	Daily debriefing with individual groups Ongoing log evaluation	Marking Period Evaluation Periodic Project Assessment [3x/MP] Periodic Log Evaluation [3x/MP] Periodic Oral Presentation [3x/MP]
		What are the different capabilities that computer usage brings to investigating the real world?			
		How does the researcher decide whether or not a computer is the best tool for a particular task?			
TEC.9-12 8.2.B.1-3 8.2.C.2-3	Computers can make measurements quickly and accurately.	What factors limit the capabilities of a computer when used to make measurements?	Periodic discussions with individual groups	Daily debriefing with individual groups Ongoing log evaluation	Marking Period Evaluation Periodic Project Assessment [3x/MP] Periodic Log Evaluation [3x/MP] Periodic Oral Presentation [3x/MP]
		What are the different technological pathways by which computers communicate with the physical world?			
		Is interface speed the most important characteristic of a computer interface?			
		What factors need to be considered when deciding which technological pathway to use when communicating with the physical world?			

Research Topic #2 – Computer Interfacing

Relevant Standards	Enduring Understandings	Essential Questions	Assessments		
			Diagnostic (before)	Formative (during)	Summative (after)
TEC.9-12 8.1.B.6-7 8.1.B.9-10 8.2.B.1-3 8.2.C.2-3	The speed with which computers process information is limited by both the choice of computer platform and the robustness of the interface between the computer and the outside world.	How does serial communication through a computer interface compare with parallel communication?	Periodic discussions with individual groups	Daily debriefing with individual groups Ongoing log evaluation	Marking Period Evaluation Periodic Project Assessment [3x/MP] Periodic Log Evaluation [3x/MP] Periodic Oral Presentation [3x/MP]
		What internal characteristics of a computer influence the rate at which a particular computer can process information?			
		How does the choice of the computer operating system influence the rate at which the computer can process information funneled through a particular interface?			
		What characteristics need to be taken into consideration when deciding what operating system is best suited for a particular research application?			
TEC.9-12 8.1.A.3-5,8 8.1.B.1-7 8.2.A.1-2 8.2.B.5-6 8.2.C.2-3	Computers can be used to model the physical world in ways that would otherwise be impractical or impossible.	What are the advantages and disadvantages of using a computer simulation rather than the physical world?	Periodic discussions with individual groups	Daily debriefing with individual groups Ongoing log evaluation	Marking Period Evaluation Periodic Project Assessment [3x/MP] Periodic Log Evaluation [3x/MP] Periodic Oral Presentation [3x/MP]
		How do cost and safety consideration influence the use of computer simulations rather than physical experimentation?			
		What are the significant limitations of computer simulations in studying the physical world?			
		How can the results of a computer simulation be best communicated to an audience?			

Research Topic #3 – Fluid Statics & Dynamics

Relevant Standards	Enduring Understandings	Essential Questions	Assessments		
			Diagnostic (before)	Formative (during)	Summative (after)
SCI.9-12 5.2.A.1 5.2.B.1 5.2.B.2 5.2.B.3 5.4.A.1 5.7.A.2 5.7.B.1 5.7.B.2 5.8.A.1	The flow of fluids is responsible for many important effects in the natural world.	What are the primary differences between fluid statics and fluid dynamics?	Periodic discussions with individual groups	Daily debriefing with individual groups Ongoing log evaluation	Marking Period Evaluation Periodic Project Assessment [3x/MP] Periodic Log Evaluation [3x/MP] Periodic Oral Presentation [3x/MP]
		What physical principles govern the behaviors of fluids?			
		How can the principles of fluid statics and dynamics be used to account for weather phenomena?			
SCI.9-12 5.2.A.1 5.2.B.1 5.2.B.3 5.4.A.1	Fluid flow can be generalized to many areas where its application may seem unlikely.	How does laminar flow differ from turbulent flow and why are these differences important?			
		How does fluid flow impact our transportation system?			
		How can the flow of fluids be used to explain everyday effects in the world of sports?			
		How can controlling the flow of fluids be used for the benefit of mankind?			

Research Topic #3 – Fluid Statics & Dynamics

Relevant Standards	Enduring Understandings	Essential Questions	Assessments		
			Diagnostic (before)	Formative (during)	Summative (after)
SCI.9-12 5.4.A.1 5.4.B.1 5.4.C.1 5.6.A.6 5.7.B.1 5.7.B.2 5.7.B.3	The properties of fluids are governed by the fundamental laws of physics.	What physical principles can be used to account for the behaviors of fluids both at rest and in motion?	Periodic discussions with individual groups	Daily debriefing with individual groups Ongoing log evaluation	Marking Period Evaluation Periodic Project Assessment [3x/MP] Periodic Log Evaluation [3x/MP] Periodic Oral Presentation [3x/MP]
		How do the behaviors of fluids at rest differ from fluids in motion?			
		What kinds of tools are used to measure the properties of fluids?			

Research Topic #4 – Laser Art & Communication

Relevant Standards	Enduring Understandings	Essential Questions	Assessments		
			Diagnostic (before)	Formative (during)	Summative (after)
SCI.9-12 5.2.A.1 5.2.B.1 5.2.B.2 5.2.B.3 5.4.A.1	Lasers have had and will continue to have significant impact on the evolution of our culture.	Why have lasers become ubiquitous throughout our culture?	Periodic discussions with individual groups	Daily debriefing with individual groups Ongoing log evaluation	Marking Period Evaluation Periodic Project Assessment [3x/MP] Periodic Log Evaluation [3x/MP] Periodic Oral Presentation [3x/MP]
		How have lasers changed the way we communicate, work and play?			
		In what ways has the potential of laser technology yet to be felt?			
		What hazards must be considered when using a laser for a particular application?			
SCI.9-12 5.4.B.1 5.7.A.6 5.7.A.7 5.7.A.8 5.7.B.1 5.7.B.2 5.7.B.3	Due to the unique properties of laser light, lasers can perform tasks that are otherwise difficult or impossible.	In what ways is the light generated by a laser different from other kinds of light?			
		In what diverse fields has the use of lasers become critical?			
		What are the different ways in which laser light can be generated?			

Research Topic #4 – Laser Art & Communication

Relevant Standards	Enduring Understandings	Essential Questions	Assessments		
			Diagnostic (before)	**Formative (during)**	**Summative (after)**
SCI.9-12 5.2.A.1 5.2.B.1 5.2.B.2 5.2.B.3 5.4.A.1 AR.9-12 1.2.D.2 1.3.D.1	Lasers can be used to create beautiful artwork.	How can the unique properties of lasers facilitate their use as an artistic medium?	Periodic discussions with individual groups	Daily debriefing with individual groups Ongoing log evaluation	Marking Period Evaluation Periodic Project Assessment [3x/MP] Periodic Log Evaluation [3x/MP] Periodic Oral Presentation [3x/MP]
		What special considerations must be made in using lasers to generate art?			
		What technologies can be used to manipulate laser light for artistic purposes?			

Research Topic #5 – Magnetic Forces & Fields

Relevant Standards	Enduring Understandings	Essential Questions	Assessments		
			Diagnostic (before)	Formative (during)	Summative (after)
SCI.9-12 5.7.A.7 5.7.A.8 5.7.B.1 5.7.B.2	Magnetic forces and fields have been responsible for much of the evolution of modern technology.	In what technologies is the effect of magnetism hidden from view?	Periodic discussions with individual groups	Daily debriefing with individual groups Ongoing log evaluation	Marking Period Evaluation Periodic Project Assessment [3x/MP] Periodic Log Evaluation [3x/MP] Periodic Oral Presentation [3x/MP]
		What are the theoretical underpinnings of magnetism?			
		What futuristic technologies make significant use of magnetism?			
SCI.9-12 5.7.A.7 5.7.A.8 5.7.B.1 5.7.B.2	Magnetic forces and fields are responsible for many unexpected effects.	What happens to a current carrying wire when it is placed in a uniform magnetic field?			
		What effect does a uniform magnetic field have on moving charged particles?			
		How can current be used to generate magnetic fields?			
		How can Faraday's Law and Lenz's Laws be used to make predictions about induced electromagnetic forces and fields?			

Research Topic #5 – Magnetic Forces & Fields

Relevant Standards	Enduring Understandings	Essential Questions	Assessments		
			Diagnostic (before)	Formative (during)	Summative (after)
SCI.9-12 5.2.B.2 5.2.B.3 5.7.A.7 5.7.A.8 5.7.B.1 5.7.B.2	Some tasks can be performed more effectively making use of the unique properties of magnetism.	What are some of the special properties of magnetic forces & fields that enable them to be used to provide lift and propulsion?	Periodic discussions with individual groups	Daily debriefing with individual groups Ongoing log evaluation	Marking Period Evaluation Periodic Project Assessment [3x/MP] Periodic Log Evaluation [3x/MP] Periodic Oral Presentation [3x/MP]
		How might magnetic fields be used to facilitate the conversion of one form of energy into another?			
		How can magnetic materials be used as a medium for storing information?			

Research Topic #6 – Mathematical Models

Relevant Standards	Enduring Understandings	Essential Questions	Assessments		
			Diagnostic (before)	Formative (during)	Summative (after)
MA.9-12 4.3.C.1-3 4.4.A.1-3	Mathematical modeling is an invaluable tool for studying the universe.	How are systems simplified to permit practical modeling?	Periodic discussions with individual groups	Daily debriefing with individual groups Ongoing log evaluation	Marking Period Evaluation Periodic Project Assessment [3x/MP] Periodic Log Evaluation [3x/MP] Periodic Oral Presentation [3x/MP]
		What are limitations of models?			
		When is it appropriate to expand or reduce the scope of a model?			
MA.9-12 4.3.C.1-3 4.4.A.1-3 TEC.9-12 8.1.B.5-7 8.1.B.9 8.1.B.11	Mathematical modeling can be used to make predictions for the future based on data from the past.	What are the limitations of predictions?			
		What affects the accuracy of predictions?			
		How can the quality of a prediction be evaluated?			
MA.9-12 4.3.C.1-3 4.4.A.1-3 4.5.C.2-4 4.5.D.1-4 TEC.9-12 8.1.B.2-3 8.1.B.5-7	Systems can be modeled at several different levels of complexity	What advantages arise from keeping a model as simple as possible?			
		What limitations arise from keeping a model as simple as possible?			
		When is additional complexity in a model detrimental to the accuracy or utility of the model?			
		How can a balance between detail in a model, desired accuracy of results, and speed with which results are produced be achieved?			
		Why are some models without utility?			

Research Topic #6 – Mathematical Models

Relevant Standards	Enduring Understandings	Essential Questions	Assessments		
			Diagnostic (before)	Formative (during)	Summative (after)
MA.9-12 4.3.C.1-3 4.4.A.1-3 4.5.C.2-4 4.5.D.1-4	Mathematical models frequently make predictions that seem contrary to our everyday perceptions	When might these predictions be preferred to more intuitive methods?	Periodic discussions with individual groups	Daily debriefing with individual groups Ongoing log evaluation	Marking Period Evaluation Periodic Project Assessment [3x/MP] Periodic Log Evaluation [3x/MP] Periodic Oral Presentation [3x/MP]
		When is it appropriate to ignore these results?			
MA.9-12 4.3.C.1-3 4.4.A.1-3 4.5.C.2-4 4.5.D.1-4 4.5.F.1-6	Mathematical modeling can have surprising economic impacts.	What are some common models with economic impact?			
		What are common failures of models?			
		What errors are frequently made when using a mathematics model to make predictions?			
MA.9-12 4.5.B.1-4 4.5.C.2-4 4.5.D.1-4 4.5.E.1.1-4 4.5.F.1-6 TEC.9-12 8.1.A.5-8 8.2.A.1	Mathematical modeling can be done using a variety of tools.	What are the different tools available to the mathematical modeler?	Periodic discussions with individual groups	Daily debriefing with individual groups Ongoing log evaluation	Marking Period Evaluation Periodic Project Assessment [3x/MP] Periodic Log Evaluation [3x/MP] Periodic Oral Presentation [3x/MP]
		What criteria can be used to determine which technologies are best suited to a particular mathematical model?			
		How does cost influence the use of a particular technological tool?			
		How can technology best be used to communicate the results of mathematical modeling to an audience?			

Research Topic #7 – Robotics

Relevant Standards	Enduring Understandings	Essential Questions	Assessments		
			Diagnostic (before)	Formative (during)	Summative (after)
TEC.9-12 8.1.B.1-3 8.2.A.1-2 8.2.B.1-2	Robots have the potential to vastly improve the lives of the physically disabled.	What applications have already evolved for robotics in aiding the disabled?	Periodic discussions with individual groups	Daily debriefing with individual groups Ongoing log evaluation	Marking Period Evaluation Periodic Project Assessment [3x/MP] Periodic Log Evaluation [3x/MP] Periodic Oral Presentation [3x/MP]
		What disabilities are not amenable to assistance from robotic tools?			
		What societal and social implications arise from technological aids to the disabled?			
TEC.9-12 8.1.B.9-11 8.2.B.1-3 8.2.B.5-6	Robots can be used to perform many repetitive tasks with ease.	Why is it desirable to automate repetitive tasks?			
		What criteria need to be evaluated in determining the suitability of automating a task?			
TEC.9-12 8.1.B.9-11 8.2.B.1-3 8.2.B.5-6	Robots can be used to complete tasks otherwise too dangerous for humans.	Why is it desirable to automate hazardous tasks?			
		How can robots be used under direct human control to assist with hazardous tasks?			
		How can robots be used to improve the factor of safety in performing inherently hazardous tasks?			

Research Topic #7 – Robotics

Relevant Standards	Enduring Understandings	Essential Questions	Assessments		
			Diagnostic (before)	**Formative (during)**	**Summative (after)**
TEC.9-12 8.1.B.9-11 8.2.B.1-3 8.2.B.5-6	Robots can perform tasks impossible for humans to perform otherwise.	What societal implications come about from augmenting or replacing humans with robotic devices?	Periodic discussions with individual groups	Daily debriefing with individual groups Ongoing log evaluation	Marking Period Evaluation Periodic Project Assessment [3x/MP] Periodic Log Evaluation [3x/MP] Periodic Oral Presentation [3x/MP]
		What factors make a task impossible for unaided humans?			
		What characteristic of human performance can be augmented through the use of robotics?			
MA.9-12 4.3.C.1-7 4.5.F.6 TEC.9-12 8.1.B.9-11 8.2.B.1-3 8.2.B.5-6	Mathematical systems, electronic systems, computer models, and mechanical systems work together in any practical robotic system.	How is feedback used to maintain stable control of mechanical systems?			
		How are control commands used from a computer turned into physical action?			
		What electronic devices are used to interface with high power actuators?			
		What devices are used to provide feedback to control software?			
		What are common models for maintaining stable control and feedback loops?			
		How are mechanical systems modeled mathematically?			
		How is a computer protected from high power devices it interfaces with?			
		What are the constraints on available power for mechanical and control systems?			
		How do constraints differ between autonomous, semi-autonomous, and human controlled machines?			

Science Engineering Research & Design - Timeline

Unit Title	Unit Understandings and Goals	Recommended Duration
Universal: **Science Engineering Research & Design**	**Understandings** Research requires the integration of many diverse fields of knowledge. Oral communication is a fundamental method of transferring knowledge. Research topics of study require the cooperation of many diverse individuals. Pursuit of a research topic often leads the researcher in unexpected directions. All research requires carefully maintained documentation. Cost considerations have significant affects on the direction of research. All research is potentially impacted by legal and moral considerations. Safety is a fundamental consideration in all research. Appropriately designed technologies meet the needs of the intended users. **Goals** 1. The students in this course will develop the skills necessary to complete an independent research project from infancy to successful completion and to learn how to develop and understand a challenging research topic in science and/or engineering. 2. The students in this course will become proficient at presenting their developing projects to an audience using appropriate techniques and tools. 3. The students will maintain a thorough up to date log documenting all aspects of their projects in a manner consistent with accepted standards.	36 weeks
Unit #1: Astronomy	**Understandings** The night sky provides a snapshot of the evolution of the universe. Evolving technologies have provided astronomers with many new tools for observing the universe. Evolving technologies have provided astronomers with many new tools for observing the universe. Astronomical observations can be used to investigate the very nature of the universe. Astronomy is one area of science where the contributions of amateurs continue to exceed the contributions of professionals. **Goals** The students completing this project unit will be expected to demonstrate a general understanding of astronomy and will be expected to complete a semester long project highlighting a particular field of astronomy.	18 weeks

Unit Title	Unit Understandings and Goals	Recommended Duration
Unit #2: Computer Interfacing	**Understandings** Computers can be used to perform many valuable tasks. Computers can make measurements quickly and accurately. The speed with which computers process information is limited by both the choice of computer platform and the robustness of the interface between the computer and the outside world. Computers can be used to model the physical world in ways that would otherwise be impractical or impossible. **Goals** The students completing this project unit will be expected to demonstrate a general understanding of computer interfacing and will be expected to complete a semester long project which uses computer facing to study some facet of the physical world.	18 weeks
Unit #3: Fluid Statics & Dynamics	**Understandings** The flow of fluids is responsible for many important effects in the natural world. Fluid flow can be generalized to many areas where its application may seem unlikely. The properties of fluids are governed by the fundamental laws of physics. **Goals** The students completing this project unit will be expected to demonstrate a general understanding of fluid statics & dynamics and will be expected to complete a semester long project using these principles.	18 weeks
Unit #4: Laser Art & Communication	**Understandings** Lasers have had and will continue to have significant impact on the evolution of our culture. Due to the unique properties of laser light, lasers can perform tasks that are otherwise difficult or impossible. Lasers can be used to create beautiful artwork. **Goals** The students completing this project unit will be expected to demonstrate a general understanding of laser art & communication and will be expected to complete a semester long project using laser technology.	18 weeks

Unit Title	Unit Understandings and Goals	Recommended Duration
Unit #5: Magnetic Forces & Fields	**Understandings** Magnetic forces and fields have been responsible for much of the evolution of modern technology. Magnetic forces and fields are responsible for many unexpected effects. Some tasks can be performed more effectively making use of the unique properties of magnetism. **Goals** The students completing this project unit will be expected to demonstrate a general understanding of magnetic forces & fields and will be expected to complete a semester long project applying the principles of magnetism.	18 weeks
Unit #6: Mathematical Models	**Understandings** Mathematical modeling is an invaluable tool for studying the universe. Mathematical modeling can be used to make predictions based on data from the past. Systems can be modeled at several different levels of complexity Mathematical models frequently make predictions that seem contrary to our everyday perceptions Mathematical modeling can have surprising economic impacts. Mathematical modeling can be done using a variety of tools. **Goals** The students completing this project unit will be expected to demonstrate a general understanding of mathematical modeling and will be expected to complete a semester long project using mathematical modeling methods to study a physical or virtual system.	18 weeks
Unit #7: Robotics	**Understandings** Robots have the potential to vastly improve the lives of the physically disabled. Robots can be used to perform many repetitive tasks with ease. Robots can be used to complete tasks otherwise too dangerous for humans. Robots can perform tasks impossible for humans to perform otherwise. Mathematical systems, electronic systems, computer models, and mechanical systems work together in any practical robotic system. **Goals** The students completing this project unit will be expected to demonstrate a general understanding of robotics and will be expected to complete a semester long project applying robotic technology.	18 weeks

Freehold Regional High School District

Science Engineering Research & Design – Details

Overall Requirements for All Students

All students will be expected to meet the goals delineated in this section in combination with 2 of the semester long units listed afterwards!

Enduring Understandings:
Research requires the integration of many diverse fields of knowledge.
Oral communication is a fundamental method of transferring knowledge.
Research topics of study require the cooperation of many diverse individuals.
Pursuit of a research topic often leads the researcher in unexpected directions.
All research requires carefully maintained documentation.
Cost considerations have significant affects on the direction of research.
All research is potentially impacted by legal and moral considerations.
Safety is a fundamental consideration in all research.
Appropriately designed technologies meet the needs of the intended users.

Essential Questions:
How do you decide what fields of study are needed for a particular topic of study?
How thoroughly should the diverse fields of study be integrated?
Should there be a limit on the number of topics that can be integrated for a particular area of research?
How does the order in which fields are integrated into the project impact the outcome of the research?
What are the different ways in which oral communication is useful?
How does the organization of oral communication impact the efficiency with which information is being transferred?
To what degree does effective eye contact impact oral communication?
How can technology be used to improve oral communication?
Why do some speakers inspire rapt attention while others are ignored?
What characteristics are essential for effective oral communication?
How should members of each project distribute the work load?
Is there an ideal size for small research groups?
Should a single individual in a research group assume a dominant leadership role?
What criteria should be considered before making a dramatic shift in the direction of a research project?
How many changes in the direction of a research project are too many?
What do you do with content in a project that no longer seems relevant after a significant change in direction?
What kinds of documentation are considered to be effective and reliable?
How should the documentation be prepared in order to meet normal acceptable standards?
What is more important in proper documentation; length or depth?
Do the anticipated research results justify the expenses required?
How is the financing for the research going to be supplied?
What are the moral implications of a particular research project?

Is the project being done within the constraints applied by the law?
What safety equipment is required for a particular activity?
What safety equipment is required for a particular activity?
Are all safety regulations being followed fully?
Is all research work being done with full cognizance of bystanders in the immediate area?
How are safety guidelines developed, evaluated & revised?
What characteristics determine the usability of a particular technology?
What kinds of testing procedures can be used to evaluate the suitability of a particular technology to its intended purpose?
Why is it sometimes better to test a technological concept on a small scale before producing a final product?
How can mathematical manipulations be used to predict the viability of a specific technology?

Course Goals:

1. The students in this course will develop the skills necessary to complete an independent research project from infancy to successful completion and to learn how to develop and understand a challenging research topic in science and/or engineering.
2. The students in this course will become proficient at presenting their developing projects to an audience using appropriate techniques and tools.
3. The students will maintain a thorough up to date log documenting all aspects of their projects in a manner consistent with accepted standards.

Duration of Course: 36 weeks [18 weeks x 2]

NJCCCS: **SCI.9-12**.5.1.A.1-4,B,1-2,C;5.2.A.1;5.2.B.1-3;5.4.A.1,5.4.B.1,5.4.C.1
TEC.9-12.1.A.5,8.1.B.1-12,8.2.A.1-2,8.2.B.1-6, 8.2.C.2-3

Guiding / Topical Questions	Content, Themes, Concepts, and Skills	Instructional Resources and Materials	Teaching Strategies	Assessment Strategies
Why is safety essential for successful research investigation? What does "Safety First" demand of us in different settings and how does it indicate what rules are general and what are situation-specific? What practices and habits will insure safety in the laboratory? What is the difference between precision and accuracy? What constitutes valid evidence and when do you know you have enough and the	Demonstrate skills and work habits; such as work ethic, dependability, promptness and getting along with others. Demonstrate self-management skills; such as the ability to set short and long term goals, work cooperatively, use time efficiently and develop self-evaluation skills. Locate, develop, summarize, organize, synthesize, and evaluate information.	Laptop computers with internet access Laptop computers with operating system access Internet access [preferably wireless] Local laser printer access Email access Textbooks Electronics lab access	Daily discussion with individual project groups Continuous direct supervision Regular log evaluation	Marking Period Evaluation Periodic Project Assessment [3x/MP] Periodic Log Evaluation [3x/MP] Periodic Oral Presentation [3x/MP]

right kind of evidence? How can results be best justified and explained to others? To what extent do valuable test results depend upon accurate and precise laboratory skills? Why is a controlled experiment essential in obtaining significant results in a scientific investigation? What is necessary in order to test a scientific hypothesis? How is the scientific method used to answer questions and to solve problems? Why communication among the scientific community is essential for presenting findings? How do science and technology influence each other? Are there ways to circumvent physical and social constraints when using technology? How does scientific knowledge advance and build upon previous discoveries using the scientific method of problem solving? What is the importance of history in understanding scientific theories and the advancement of science?	Use scientific inquiry to ask scientifically-oriented questions, collect evidence, form explanations, connect explanations to scientific knowledge and theory, and communicate and justify explanations. Develop critical thinking, decision – making, and problem-solving skills. Properly and safely use technology and scientific equipment to collect and analyze data to help form scientific theories. Understand that the development of ideas is essential for building scientific knowledge.	Scientific calculators. Topic specific lab materials & equipment Topic specific reference books		

Freehold Regional High School District

Research Topic #1: Astronomy

Enduring Understandings: The night sky provides a snapshot of the evolution of the universe.
Evolving technologies have provided astronomers with many new tools for observing the universe.
Evolving technologies have provided astronomers with many new tools for observing the universe.
Astronomical observations can be used to investigate the very nature of the universe.
Astronomy is one area of science where the contributions of amateurs continue to exceed the contributions of professionals.

Essential Questions:
How do you locate the position of a celestial object?
How is the theoretical position of a celestial object defined?
How can the theoretical position of a celestial object be determined?
What factors affect your ability to observe a celestial object?
What different types of celestial objects can be observed?
What specialized equipment may be required for astrophotography?
What are the primary functions of a telescope?
What types of image sensors can be used in astrophotography?
What are the different types of telescopes?
What are the advantages/disadvantages of each type of telescope?
What characteristics affect a telescope's usability?
Why use photography to observe the heavens?
What are the different ways that astrophotographs can be taken?
What is the principle advantage of astrophotography over direct visual observation?
What problems are encountered in taking astrophotographs?
How have recent developments in technology influenced the field of astrophotography?
What are the different classifications of celestial objects?
What observational characteristics determine the classification of celestial objects?
What have we learned about the universe from our observations of the heavens?
What were the major milestones in astronomical observations?
Who were the most important players in our understanding of the universe?
What special resources are available to amateur astronomers?

Unit Goals: The students completing this project unit will be expected to demonstrate a general understanding of astronomy and will be expected to complete a semester long project highlighting a particular field of astronomy.

Duration of Unit: 18 weeks

NJCCCS: **SCI.9-12**.5.2.A.1,5.2.B.1-3,5.4.A.15.4.C.1,5.7.2.2-4,5.9.A.1,5.9.B.1,5.9.C.1,5.9.D.1
TEC.9-12.8.1.B.5-9,8.2.A.1,8.2.B.1-6,B.2.C.2-3

Research Topic #1: Astronomy

Guiding / Topical Questions	Content, Themes, Concepts, and Skills	Instructional Resources and Materials	Teaching Strategies	Assessment Strategies
Why is safety essential for successful research investigations? How do you locate the position of a celestial object? How is the theoretical position of a celestial object defined? How can the theoretical position of a celestial object be determined? What factors affect your ability to observe a celestial object? What different types of celestial objects can be observed? What specialized equipment may be required for astrophotography? What are the primary functions of a telescope? What types of image sensors can be used in astrophotography? What are the different types of telescopes? What are the advantages/disadvantages of each type of telescope? What characteristics affect a telescope's usability? Why use photography to observe the heavens? What are the different ways that astrophotographs can be taken? What is the principle advantage of astrophotography over direct visual observation? What problems are encountered in taking	The student is expected to: Develop and maintain a research goals statement. Develop and maintain a log of work being performed. Demonstrate an understanding of the design of different types of telescopes, their advantages and their disadvantages. Use the internet to research topics in astronomy, reach out to the amateur astronomy community and locate computer software to help facilitate astronomical observations and analysis. Use computer software to study the properties of celestial objects. Demonstrate an understanding of the various characteristics of telescopes and how these characteristics affect their usefulness. Demonstrate an understanding of the various types of telescope eyepieces (oculars) , their applications, similarities, advantages and their disadvantages. Demonstrate knowledge of the alternative types of telescope mounts, their applications, advantages and disadvantages.	Laptop computers with internet access Laptop computers with operating system access Internet access [preferably wireless] Local laser printer access Email access Textbooks Electronics lab access Scientific calculators. Topic specific lab materials & equipment Topic specific reference books Star charts and tables	Daily discussion with individual project groups Continuous direct supervision Regular log evaluation	Marking Period Evaluation Periodic Project Assessment [3x/MP] Periodic Log Evaluation [3x/MP] Periodic Oral Presentation [3x/MP]

astrophotographs? How have recent developments in technology influenced the field of astrophotography? What are the different classifications of celestial objects? What observational characteristics determine the classification of celestial objects? What have we learned about the universe from our observations of the heavens? What were the major milestones in astronomical observations? Who were the most important players in our understanding of the universe? What special resources are available to amateur astronomers?	Understand how the heavens are laid out and be able to use this information to locate the position of a designated celestial object. Use star charts, catalogs and handbooks to designate and determine the locations of selected celestial objects. Properly use a telescope in the observation of the heavens. Understand the different types of celestial objects and be able Categorize celestial objects into their appropriate classes based on their special characteristics. Understand what characteristics interfere and/or affect telescope viewing and have an understanding of the measures which can be taken to compensate for these characteristics. Use a camera either with or without a telescope to take satisfactory and appropriate photographs of celestial objects.			

Suggested Project Activities

A. Research the different types of telescopes and selecting the type of telescope to be used in the project. B. Learn how to use star charts to locate the position of celestial objects. C. Use a telescope to locate the position of celestial objects including setting circles. D. Research the various types of celestial objects with emphasis on the special techniques needed for viewing each type of object. E. Use a telescope to locate and observe celestial objects. F. Use a camera to take photographs of selected celestial objects.	G. Evaluate the various types of specialized hardware available for celestial viewing. H. Construct a telescope. I. Construct a telescope mount. J. Hand grinding a telescope mirror. K. Use available computer software to analyze astrophotographs. L. Observe various celestial objects using binoculars. M. Build and use a “solar” telescope to observe solar activity.

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Research Topic #2: Computer Interfacing

Enduring Understandings: The night sky provides a snapshot of the evolution of the universe.
Computers can be used to perform many valuable tasks.
Computers can make measurements quickly and accurately.
The speed with which computers process information is limited by both the choice of computer platform and the robustness of the interface between the computer and the outside world.
Computers can be used to model the physical world in ways that would otherwise be impractical or impossible.

Essential Questions: How do you locate the position of a celestial object? What advantages does the use of a computer for data collection and analysis confer on the researcher?
What are the different capabilities that computer usage brings to investigating the real world?
How does the researcher decide whether or not a computer is the best tool for a particular task?
What factors limit the capabilities of a computer when used to make measurements?
What are the different technological pathways by which computers communicate with the physical world?
Is interface speed the most important characteristic of a computer interface?
What factors need to be considered when deciding which technological pathway to use when communicating with the physical world?
How does serial communication through a computer interface compare with parallel communication?
What internal characteristics of a computer influence the rate at which a particular computer can process information?
How does the choice of the computer operating system influence the rate at which the computer can process information funneled through a particular interface?
What characteristics need to be taken into consideration when deciding what operating system is best suited for a particular research application?
What are the advantages and disadvantages of using a computer simulation rather than the physical world?
How do cost and safety consideration influence the use of computer simulations rather than physical experimentation?
What are the significant limitations of computer simulations in studying the physical world?
How can the results of a computer simulation be best communicated to an audience?

Unit Goals: The students completing this project unit will be expected to demonstrate a general understanding of computer interfacing and will be expected to complete a semester long project which uses computer interfacing to study some facet of the physical world.

Duration of Unit: 18 weeks

NJCCCS: **SCI.9-12**.5.2.A.1,5.2.B.1-3,5.4.A.15.4.C.1,5.7.2.2-4,5.9.A.1,5.9.B.1,5.9.C.1,5.9.D.1
TEC.9-12.8.1.B.5-9,8.2.A.1,8.2.B.1-6,B.2.C.2-3

Research Topic #2: Computer Interfacing

Guiding / Topical Questions	Content, Themes, Concepts, and Skills	Instructional Resources and Materials	Teaching Strategies	Assessment Strategies
What advantages does the use of a computer for data collection and analysis confer on the researcher? What are the different capabilities that computer usage brings to investigating the real world? How does the researcher decide whether or not a computer is the best tool for a particular task? What factors limit the capabilities of a computer when used to make measurements? What are the different technological pathways by which computers communicate with the physical world? Is interface speed the only important characteristic of a computer interface? What factors need to be considered when deciding which technological pathway to use when communicating with the physical world? How does serial communication through a computer interface compare with parallel communication? What internal characteristics of a computer influence the rate at which a particular computer can process information? How does the choice of the computer operating system influence the rate at which the computer can process information funneled through a particular interface?	The student is expected to: Develop and maintain a research goals statement. Develop and maintain a log of work being performed. Demonstrate knowledge of the different types of computer interfaces. List the different properties of the various computer interfaces. Evaluate the suitability of the various computer interfaces for completing a particular task. Select the computer interface best suited for the project being developed. Evaluate and select the computer operating system most suitable for the long term goals of the project. Determine which software is best suited to a particular task. Integrate the selected software with the chosen computer interface. Use the computer interface along with the selected software to measure and/or manipulate the physical world.	Laptop computers with internet access Laptop computers with operating system access Internet access [preferably wireless] Local laser printer access Email access Textbooks Electronics lab access Scientific calculators. Topic specific lab materials & equipment Topic specific reference books	Daily discussion with individual project groups Continuous direct supervision Regular log evaluation	Marking Period Evaluation Periodic Project Assessment [3x/MP] Periodic Log Evaluation [3x/MP] Periodic Oral Presentation [3x/MP]

What characteristics need to be taken into consideration when deciding what operating system is best suited for a particular research application? What are the advantages and disadvantages of using a computer simulation rather than the physical world? How do cost and safety consideration influence the use of computer simulations rather than physical experimentation? What are the significant limitations of computer simulations in studying the physical world? How can the results of a computer simulation be best communicated to an audience?				

Suggested Project Activities

A. Object identification and edge detection B. Text recognition C. Network communication D. Web based services E. Automated weighing F. Vibration monitors G. Waveform analysis H. Effects processing I. Noise filtering J. Machine interpretation of handwriting	K. Three dimensional input devices L. Interpretation of 3-dimentional scenes M. Hand, head, arm, and body position sensing N. Sound cancellation system

Freehold Regional High School District

Research Topic #3: Fluid Statics & Dynamics

Enduring Understandings: The flow of fluids is responsible for many important effects in the natural world.
Fluid flow can be generalized to many areas where its application may seem unlikely.
The properties of fluids are governed by the fundamental laws of physics.

Essential Questions:
What are the primary differences between fluid statics and fluid dynamics?
What physical principles govern the behaviors of fluids?
How can the principles of fluid statics and dynamics be used to account for weather phenomena?
How does laminar flow differ from turbulent flow and why are these differences important?
How does fluid flow impact our transportation system?
How can the flow of fluids be used to explain everyday effects in the world of sports?
How can controlling the flow of fluids be used for the benefit of mankind?
What physical principles can be used to account for the behaviors of fluids both at rest and in motion?
How do the behaviors of fluids at rest differ from fluids in motion?
What kinds of tools are used to measure the properties of fluids?

Unit Goals: The students completing this project unit will be expected to demonstrate a general understanding of fluid statics & dynamics and will be expected to complete a semester long project that uses the nature of fluids as a primary focus.

Duration of Unit: 18 weeks

NJCCCS: SCI.9-12.5.2.A.1,5.2.B.1-3,5.4.A.1,5.4.B.1,5.4.C.1,5.6.A.6,5.7.A.2,5.7.B.1-3,5.8.A.1

Guiding / Topical Questions	Content, Themes, Concepts, and Skills	Instructional Resources and Materials	Teaching Strategies	Assessment Strategies
What are the primary differences between fluid statics and fluid dynamics? What physical principles govern the behaviors of fluids? How can the principles of fluid statics and dynamics be used to account for weather phenomena? How does laminar flow differ from turbulent flow and why are these differences important? How does fluid flow impact our	The student is expected to: Develop and maintain a research goals statement. Develop and maintain a log of work being performed. Demonstrate an understanding of pressure relationships in a static fluid. Demonstrate an understanding of the forces between molecules in a fluid and the resulting contact forces.	Laptop computers with internet access Laptop computers with operating system access Internet access [preferably wireless] Local laser printer access Email access Textbooks Electronics lab access	Daily discussion with individual project groups Continuous direct supervision Regular log evaluation	Marking Period Evaluation Periodic Project Assessment [3x/MP] Periodic Log Evaluation [3x/MP] Periodic Oral Presentation [3x/MP]

transportation system? How can the flow of fluids be used to explain everyday effects in the world of sports? How can controlling the flow of fluids be used for the benefit of mankind? What physical principles can be used to account for the behaviors of fluids both at rest and in motion? How do the behaviors of fluids at rest differ from fluids in motion? What kinds of tools are used to measure the properties of fluids?	Demonstrate an understanding of and solve problems involving Archimedes principle. Demonstrate an understanding of the application of intermolecular forces to the concepts of surface tension and contact angle. Demonstrate the ability to apply Bernoulli's equation and its variations to the motion of objects of various shapes through a fluid in motion. Use Poiseuille's Law to describe the flow of various fluids of differing viscosities through restrictions and orifices; Determine the viscosity of a fluid. Determine the terminal and sedimentation velocity of a particle moving through a fluid. Demonstrate an understanding of turbulent vs. laminar flow. Use a wind tunnel to demonstrate the above concepts.	Scientific calculators. Topic specific lab materials & equipment Topic specific reference books		

Suggested Project Activities

O. Measure the volume of an irregularly shaped object by using Archimedes' principle.

P. Measure the density of solids through a variety of techniques.

Q. Measure the buoyancy force acting on an object floating and/or submerged in a liquid.

R. Measure the density of fluid with a self constructed hydrometer.

S. Measure the surface tension and/or contact angle of a fluid through capillary action.

T. Design, make and use an open ended manometer to measure the pressure in a moving fluid.

U. Calibrate the above manometer by measuring the pressure at various depths of a static fluid of known density

V. Use the above manometer to measure the speed of a moving fluid.

W. Use a manometer to verify the Law of Continuity and verify the Venturi effect.

X. Determine the validity of the Bernoulli equation.

Y. Verify Torricelli s theorem for moving fluids

Z. Measure the terminal velocity of an object falling through a dense fluid and verify Stoke's Law.

AA. Measure the frictional force acting on a variety of objects sitting in a moving fluid.

BB. Determine the Reynold's number for an object of a specific shape.

CC. Measure the frictional force acting on an object sitting in a moving fluid

DD. Measure the lift force produced on a wing shaped object placed in a moving fluid.

EE. Design variously shaped objects using appropriate computer software

FF. Construct wing cross sections of various sizes and/or designs and measure the resulting drag and lift.

GG. Construct some other type objects and measure the corresponding lift and/or drag.

Freehold Regional High School District

Research Topic #4: Laser Art & Communication

Enduring Understandings: Lasers have had and will continue to have significant impact on the evolution of our culture.
Due to the unique properties of laser light, lasers can perform tasks that are otherwise difficult or impossible.
Lasers can be used to create beautiful artwork.

Essential Questions:
Why have lasers become ubiquitous throughout our culture?
How have lasers changed the way we communicate, work and play?
In what ways has the potential of laser technology yet to be felt?
What hazards must be considered when using a laser for a particular application?
In what ways is the light generated by a laser different from other kinds of light?
In what diverse fields has the use of lasers become critical?
What are the different ways in which laser light can be generated?
How can the unique properties of lasers facilitate their use as an artistic medium?
What special considerations must be made in using lasers to generate art?
What technologies can be used to manipulate laser light for artistic purposes?

Unit Goals: The students completing this project unit will be expected to demonstrate a thorough understanding of lasers and will be expected to complete a semester long project where the laser serves a fundamental role.

Duration of Unit: 18 weeks

NJCCCS: **SCI.9-12**.5.2.A.1,5.2.B.1-3,5.4.A.1,5.4.B.1,5.7.A.6-8,5.7.B.1-3
AR.9-12.1.2.D.2,1.3.D.1

Guiding / Topical Questions	Content, Themes, Concepts, and Skills	Instructional Resources and Materials	Teaching Strategies	Assessment Strategies
Why have lasers become ubiquitous throughout our culture? How have lasers changed the way we communicate, work and play? In what ways has the potential of laser technology yet to be felt? What hazards must be considered when using a laser for a particular application? In what ways is the light generated by a	The student is expected to: Develop and maintain a research goals statement. Develop and maintain a log of work being performed. Demonstrate an understanding of the theory and operation of various laser types including gas lasers, chemical lasers and semiconductor lasers.	Laptop computers with internet access Laptop computers with operating system access Internet access [preferably wireless] Local laser printer access Email access	Daily discussion with individual project groups Continuous direct supervision Regular log evaluation	Marking Period Evaluation Periodic Project Assessment [3x/MP] Periodic Log Evaluation [3x/MP] Periodic Oral Presentation [3x/MP]

laser different from other kinds of light? In what diverse fields has the use of lasers become critical? What are the different ways in which laser light can be generated? How can the unique properties of lasers facilitate their use as an artistic medium? What special considerations must be made in using lasers to generate art? What technologies can be used to manipulate laser light for artistic purposes?	Demonstrate knowledge of the applications of lasers in medicine, industry, the military and research. Demonstrate an understanding of the possible hazards associated with laser use in the laboratory and the consequent safety procedures. Demonstrate an awareness of career opportunities involving lasers and laser technology. Demonstrate knowledge of the characteristics of laser light including but not limited to coherence, divergence, polarization, modulation, and shape. Demonstrate an understanding of laser applications in the laboratory and in industry.	Textbooks Electronics lab access Scientific calculators. Topic specific lab materials & equipment Topic specific reference books		

Suggested Project Activities

A. Measure the wavelength of laser light.

B. Measure the beam divergence of a laser.

C. Beam shaping using the Kogelnik criteria.

D. Beam splitting and measuring the phases relationship between the two beams after traveling different paths.

E. Polarize laser light and manipulating the resulting beam.

F. Modulate the intensity of a laser beam and use the resulting beam to transfer information.

G. Use a photo multiplier tube to measure the intensity of a laser beam.

H. Measure the speed of light as it passes through air by measuring the phase difference between two portions of a laser beam having traversed different paths.

I. Measure the speed of light through air through the uses of an interferometer.

J. Measure the speed of light through an optical cable by measuring the phase relationship between two different portions of the laser beam.

K. Use laser light to produce either a reflection or a transmission hologram.

L. Use a laser to measure the speed of a moving object.

M. Use laser light as a part of an optics based musical instrument.

N. Use a laser to decode the barcodes used on most consumer products.

O. Design and complete an experimental project using of lasers in a unique, original application.

Freehold Regional High School District

Research Topic #5: Magnetic Forces & Fields

Enduring Understandings: Magnetic forces and fields have been responsible for much of the evolution of modern technology.
Magnetic forces and fields are responsible for many unexpected effects.
Some tasks can be performed more effectively making use of the unique properties of magnetism.

Essential Questions:
In what technologies are the effects of magnetism hidden from view?
What are the theoretical underpinnings of magnetism?
What futuristic technologies make significant use of magnetism?
What happens to a current carrying wire when it is placed in a uniform magnetic field?
What effect does a uniform magnetic field have on moving charged particles?
How can current be used to generate magnetic fields?
How can Faraday's Law and Lenz's Laws be used to make predictions about induced electromagnetic forces and fields?
What are some of the special properties of magnetic forces & fields that enable them to be used to provide lift and propulsion?
How might magnetic fields be used to facilitate the conversion of one form of energy into another?
How can magnetic materials be used as a medium for storing information?

Unit Goals: The students completing this project unit will be expected to demonstrate a thorough understanding of magnetic forces and fields, and will be expected to complete a semester long project involving the application of magnetism.

Duration of Unit: 18 weeks

NJCCCS: SCI.9-12.5.2.B.2-3,5.7.A.7-8,5.7.B.1-2

Guiding / Topical Questions	Content, Themes, Concepts, and Skills	Instructional Resources and Materials	Teaching Strategies	Assessment Strategies
In what technologies are the effects of magnetism hidden from view? What are the theoretical underpinnings of magnetism? What futuristic technologies make significant use of magnetism? What happens to a current carrying wire when it is placed in a uniform magnetic field? What effect does a uniform magnetic field	The student is expected to: Develop and maintain a research goals statement. Develop and maintain a log of work being performed. Demonstrate a thorough understanding of magnetic fields and their effect on moving charged particles. Demonstrate an understanding of the effect of magnetic fields	Laptop computers with internet access Laptop computers with operating system access Internet access [preferably wireless] Local laser printer access Email access Textbooks	Daily discussion with individual project groups Continuous direct supervision Regular log evaluation	Marking Period Evaluation Periodic Project Assessment [3x/MP] Periodic Log Evaluation [3x/MP] Periodic Oral Presentation [3x/MP]

have on moving charged particles? How can electric current be used to generate magnetic fields? How can Faraday's Law and Lenz's Laws be used to make predictions about induced electromagnetic forces and fields? What are some of the special properties of magnetic forces & fields that enable them to be used to provide lift and propulsion? How might magnetic fields be used to facilitate the conversion of one form of energy into another? How can magnetic materials be used as a medium for storing information?	on permanent magnets placed in a field. Determine the direction of a magnetic field in the vicinity of both current carrying wires and permanent magnets. Apply the Biot-Savart Law to determine the magnetic induction vector in the vicinity of a current carrying wire. Demonstrate an understanding of ampere and coulomb based on their effects in a magnetic field. Apply Ampere's Law to determine the magnetic induction vector in the vicinity of a current carrying wire. Demonstrate an understanding of magnetic induction vector in the vicinity of a current carrying wire. Apply Faraday's Law so as to determine the EMF generated by a current carrying wire as it moves through a magnetic field. Apply Lenz's Law to both self and mutual induction. Demonstrate an understanding of diamagnetic, paramagnetic and ferromagnetic effects in matter.	Electronics lab access Scientific calculators. Topic specific lab materials & equipment Topic specific reference books		

Suggested Project Activities

A. Measure the magnetic force on a moving charged particle B. Measure the magnetic force between two current carrying wires C. Measure the magnetic force between a current carrying wire and a permanent magnet. D. Measure the magnetic field strength in the vicinity of various sources of magnetic energy using a Hall Effect probe. E. Measure the torque produced on a current carrying loop F. Use a system of permanent magnets to levitate an object.	G. Use magnetic forces and fields to accelerate an object from rest. H. Build an active levitation system using electromagnetism. I. Build a model maglev train. J. Design and build a unique (although possibly useless] device operating on the principle of magnetism.

Freehold Regional High School District

Research Topic #6: Mathematical Models

Enduring Understandings: Mathematical modeling is an invaluable tool for studying the universe.
Mathematical modeling can be used to make predictions for the future based on data from the past.
Systems can be modeled at several different levels of complexity
Mathematical models frequently make predictions that seem contrary to our everyday perceptions
Mathematical modeling can have surprising economic impacts.
Mathematical modeling can be done using a variety of tools.

Essential Questions:
How are systems simplified to permit practical modeling?
What are limitations of models?
When is it appropriate to expand or reduce the scope of a model?
What are the limitations of predictions?
What affects the accuracy of predictions?
How can the quality of a prediction be evaluated?
What advantages arise from keeping a model as simple as possible?
What limitations arise from keeping a model as simple as possible?
When is additional complexity in a model detrimental to the accuracy or utility of the model?
How can a balance between detail in a model, desired accuracy of results, and speed with which results are produced be achieved?
Why are some models without utility?
When might these predictions be preferred to more intuitive methods?
When is it appropriate to ignore these results?
What are some common models with economic impact?
What are common failures of models?
What errors are frequently made when using a mathematics model to make predictions?
What are the different tools available to the mathematical modeler?
What criteria can be used to determine which technologies are best suited to a particular mathematical model?
How does cost influence the use of a particular technological tool?
How can technology best be used to communicate the results of mathematical modeling to an audience?

Unit Goals: The students completing this project unit will be expected to demonstrate a general understanding of mathematical modeling and will be expected to complete a semester long project using mathematical modeling methods to study a physical or virtual system.

Duration of Unit: 18 weeks

NJCCCS: **MA.9-12**.4.3.C.1-3,4.4.A.1-3,4.5.B.1-4,4.5.C.2-4,4.5.D.1-4,4.5.E.1.1-4,4.5.F.1-6
TEC.9-12.8.1.A.5-8,8.1.B.2-3,8.1.B.5-7,8.1.B.9-11,8.2.A.1

Research Topic #6: Mathematical Models

Guiding / Topical Questions	Content, Themes, Concepts, and Skills	Instructional Resources and Materials	Teaching Strategies	Assessment Strategies
How are systems simplified to permit practical modeling? What are limitations of models? When is it appropriate to expand or reduce the scope of a model? What are the limitations of predictions? What affects the accuracy of predictions? How can the quality of a prediction be evaluated? What advantages arise from keeping a model as simple as possible? What limitations arise from keeping a model as simple as possible? When is additional complexity in a model detrimental to the accuracy or utility of the model? How can a balance between detail in a model, desired accuracy of results, and speed with which results are produced be achieved? Why are some models without utility? When might these predictions be preferred to more intuitive methods? When is it appropriate to ignore these results? What are some common models with economic impact? What are common failures of models? What errors are frequently made when using a mathematics model to make predictions? What are the different tools available to	The student is expected to: Demonstrate an understanding of how to express a model mathematically. Demonstrate the ability to express and interpret a model verbally. Express model concepts and detail at an appropriate level for a given context. Research prior art within a given field. Develop and maintain a research goals statement. Develop and maintain a log of work. Choose appropriate level of complexity for a model to obtain desired results in an appropriate timeframe. Implement models in an appropriate context. Identify applicable content areas and research them appropriately. Use appropriate standard tools such as statistical tools, to evaluate models. Develop appropriate visual explanations of mathematical concepts.	Laptop computers with internet access Laptop computers with operating system access Internet access [preferably wireless] Local laser printer access Email access Textbooks Electronics lab access Scientific calculators. Topic specific lab materials & equipment Topic specific reference books	Daily discussion with individual project groups Continuous direct supervision Regular log evaluation	Marking Period Evaluation Periodic Project Assessment [3x/MP] Periodic Log Evaluation [3x/MP] Periodic Oral Presentation [3x/MP]

the mathematical modeler? What criteria can be used to determine which technologies are best suited to a particular mathematical model? How does cost influence the use of a particular technological tool? How can technology best be used to communicate the results of mathematical modeling to an audience?				

Suggested Project Activities

A. Analyze of weather patterns for weather prediction. B. Examine chaotic physical systems. C. Implement neural networks to `find Waldo'. D. Examine the relationship between topology and relativity. E. Model fractal systems. F. Simulate an ant colony. G. Examine self-organizing systems. H. Investigate machine translation of language. I. Investigate machine interpretation of language.	J. Investigate machine interpretation of handwriting. K. Simulate and optimize physical systems [For example, a trebuchet]. L. Simulate gravitational interactions in multi-body systems. M. Visual perception. N. Statistical modeling and analysis.

Freehold Regional High School District

Research Topic #7: Robotics

Enduring Understandings: Robots have the potential to vastly improve the lives of the physically disabled.
Robots can be used to perform many repetitive tasks with ease.
Robots can be used to complete tasks otherwise too dangerous for humans.
Robots can perform tasks impossible for humans to perform otherwise.
Mathematical systems, electronic systems, computer models, and mechanical systems work together in any practical robotic system.

Essential Questions:
What applications have already evolved for robotics in aiding the disabled?
What disabilities are not amenable to assistance from robotic tools?
What societal and social implications arise from technological aids to the disabled?
Why is it desirable to automate repetitive tasks?
What criteria need to be evaluated in determining the suitability of automating a task?
Why is it desirable to automate hazardous tasks?
How can robots be used under direct human control to assist with hazardous tasks?
How can robots be used to improve the factor of safety in performing inherently hazardous tasks?
What societal implications come about from augmenting or replacing humans with robotic devices?
What factors make a task impossible for unaided humans?
What characteristic of human performance can be augmented through the use of robotics?
How is feedback used to maintain stable control of mechanical systems?
How are control commands used from a computer turned into physical action?
What electronic devices are used to interface with high power actuators?
What devices are used to provide feedback to control software?
What are common models for maintaining stable control and feedback loops?
How are mechanical systems modeled mathematically?
How is a computer protected from high power devices it interfaces with?
What are the constraints on available power for mechanical and control systems?
How do constraints differ between autonomous, semi-autonomous, and human controlled machines?

Unit Goals: The students completing this project unit will be expected to demonstrate a general understanding of robotics and will be expected to complete a semester long project applying robotic technology.

Duration of Unit: 18 weeks

NJCCCS: **MA.9-12**.4.3.C.1-7,4.5.F.6
TEC.9-12.8.1.B.1-3,8.1.B.9-11,8.2.A.1-2,8.2.B.1-3,8.2.B.5-6

Research Topic #7: Robotics

Guiding / Topical Questions	Content, Themes, Concepts, and Skills	Instructional Resources and Materials	Teaching Strategies	Assessment Strategies
What applications have already evolved for robotics in aiding the disabled? What disabilities are not amenable to assistance from robotic tools? What societal and social implications arise from technological aids to the disabled? Why is it desirable to automate repetitive tasks? What criteria need to be evaluated in determining the suitability of automating a task? Why is it desirable to automate hazardous tasks? How can robots be used under direct human control to assist with hazardous tasks? How can robots be used to improve the factor of safety in performing inherently hazardous tasks? What societal implications come about from augmenting or replacing humans with robotic devices? What factors make a task impossible for unaided humans? What characteristic of human performance can be augmented through the use of robotics? How is feedback used to maintain stable control of mechanical systems? How are control commands used from a computer turned into physical action? What electronic devices are used to	The student is expected to: Explore applications for robotic tools at various scales. Understand limitations of robotic solutions to real problems. State and analyze a problem amenable to robotic solution. Evaluate power and force considerations in a robotic system. Choose appropriate materials for the application. Choose appropriate sensors for the application. Apply the content from math, electronics and physics classes. Explain and interpret the considerations in robot design. Develop explanatory graphics. Develop design graphics (technical drawings, circuit schematics, etc). Develop appropriate control and power circuits. Select appropriate software for analysis of inputs and control. Design, perform, and analyze tests to verify appropriateness of design decisions. Design and implement appropriate safety devices to protect both the hardware and	Laptop computers with internet access Laptop computers with operating system access Internet access [preferably wireless] Local laser printer access Email access Textbooks Electronics lab access Scientific calculators. Topic specific lab materials & equipment Topic specific reference books	Daily discussion with individual project groups Continuous direct supervision Regular log evaluation	Marking Period Evaluation Periodic Project Assessment [3x/MP] Periodic Log Evaluation [3x/MP] Periodic Oral Presentation [3x/MP]

interface with high power actuators? What devices are used to provide feedback to control software? What are common models for maintaining stable control and feedback loops? How are mechanical systems modeled mathematically? How is a computer protected from high power devices it interfaces with? What are the constraints on available power for mechanical and control systems? How do constraints differ between autonomous, semi-autonomous, and human controlled machines?	persons that may interact with the robotic system.			

Suggested Project Activities

A. Balancing robot. B. Tic-tac-toe playing robot. C. Mobile root for exploration of an environment. D. Targeting robot (maintains orientation relative to a moving target). E. Robots that mutually interact cooperatively. F. Ping-pong playing robot. G. Robotic arm.	H. Waldoes - a mechanical device, such as a gripper arm, that follows the movements of a human limb. I. Automated 3-dimentional carving or modeling tool. J. Robot that automatically paints. K. Self-navigating all-terrain vehicle. L. Micro-positioning system. M. Robotic toys.

Senior Project – Evaluation Form

PROJECT TITLE _____ **DATE** _____

PRESENTERS _____

	PRESENTATION EVALUATIVE CRITERIA	**RATING [CIRCLE ONE]**
THE REPORT	1. Does the presentation include a clear statement of the short term and long term goals of the project?	1 2 3 4 5 6 7 8 9 10
	2. Does the presentation include clearly presented information explaining all new terms and/or ideas?	1 2 3 4 5 6 7 8 9 10
	3. Is the presentation organized in a logical manner?	1 2 3 4 5 6 7 8 9 10
	4. Does the presentation demonstrate that significant progress is being made towards achieving the stated goals?	1 2 3 4 5 6 7 8 9 10
	5. Was the presentation completed within the allotted time constraints?	1 2 3 4 5 6 7 8 9 10
DETAILS	6. Were the presentation slides carefully prepared with respect to color and layout?	1 2 3 4 5 6 7 8 9 10
	7. Were the ideas behind the project explained clearly and correctly?	1 2 3 4 5 6 7 8 9 10
	8. Was the project demonstrated in an appropriate manner?	1 2 3 4 5 6 7 8 9 10
	9. Were all new terms clearly explained before being used?	1 2 3 4 5 6 7 8 9 10
	10. Are all letters and diagrams large enough to be read easily from all locations?	1 2 3 4 5 6 7 8 9 10
PRESENTERS	11. Have all members of the group participated fully in the presentation?	1 2 3 4 5 6 7 8 9 10
	12. Have all presenters spoken loudly and clearly?	1 2 3 4 5 6 7 8 9 10
	13. Have all presenters faced the audience and made good eye contact?	1 2 3 4 5 6 7 8 9 10
	14. Were questions from the audience answered satisfactorily?	1 2 3 4 5 6 7 8 9 10
	15. Did all presenters demonstrate a thorough understanding of the subject matter?	1 2 3 4 5 6 7 8 9 10

Comments _____

_____

_____

_____

Oral Presentation Score = _____ /150 · 50 = _____

8/22/2009

PROJECT PROGRESS
EVALUATIVE CRITERIA

	RATING [CIRCLE ONE]
1. Has each member of the group demonstrated sufficient effort?	**1 2 3 4 5 6 7 8 9 10**
2. Have the members of the group made maximum use of the available resources?	**1 2 3 4 5 6 7 8 9 10**
3. Have the members of the group demonstrated creativity and originality?	**1 2 3 4 5 6 7 8 9 10**
4. Does each student in the group spend sufficient time "on task"?	**1 2 3 4 5 6 7 8 9 10**
5. What is the overall evaluation of the quality and progress of the project?	**1 2 3 4 5 6 7 8 9 10**

DAILY LOG
EVALUATIVE CRITERIA

	RATING [CIRCLE ONE]
1. Are the long and short term goals of the project clearly stated in the daily log on a regular basis?	**1 2 3 4 5 6 7 8 9 10**
2. Does the daily log include sufficient detail concerning the daily activities of the project?	**1 2 3 4 5 6 7 8 9 10**
3. Does the daily log include evidence of sufficient and appropriate outside research?	**1 2 3 4 5 6 7 8 9 10**
4. Is the daily log written with due regard to neatness, spelling, grammar and organization?	**1 2 3 4 5 6 7 8 9 10**
5. Has the daily log been kept up to date and has it been available for evaluation at all times?	**1 2 3 4 5 6 7 8 9 10**

Additional Comments

_____

_____

_____

_____

Presentation _____ + Project Progress _____ + Daily Log _____ = _____/150 = _____ %

Interim # _____ Projected Grade _____ Date _____

SCIENCE ENGINEERING ADVANCED STUDY AND RESEARCH

Marking Period – Final Evaluation Form

PROJECT TITLE_____

MEMBERS OF PROJECT GROUP_____

MARKING PERIOD EVALUATIVE CRITERIA	**RATING [CIRCLE ONE]**
1. Has every member of the group demonstrated sufficient effort throughout the marking period?	**1 2 3 4 5 6 7 8 9 10**
2. Has every member of the group spent sufficient time on task throughout the marking period?	**1 2 3 4 5 6 7 8 9 10**
3. Has there been sufficient progress toward the final goal during the marking period?	**1 2 3 4 5 6 7 8 9 10**
4. Have the members of the group continued the theoretical development of the project throughout the marking period?	**1 2 3 4 5 6 7 8 9 10**
5. Have the members of the group cooperated with one another throughout the marking period?	**1 2 3 4 5 6 7 8 9 10**
6. Have the members of the group used creativity and originality in the development of their project?	**1 2 3 4 5 6 7 8 9 10**
7. Has the work done throughout the marking period been of sufficiently high quality?	**1 2 3 4 5 6 7 8 9 10**
8. Have the members of the group made sufficient use of expertise from outside the school district?	**1 2 3 4 5 6 7 8 9 10**
9. Has the pace of the work done been sufficient to achieve the stated long term goal/goals?	**1 2 3 4 5 6 7 8 9 10**
10. What is the overall evaluation of the quality and progress of the project?	**1 2 3 4 5 6 7 8 9 10**

MARKING PERIOD GRADE DETERMINATION

FIRST INTERIM		**SECOND INTERIM**		**THIRD INTERIM**		**MARKING PERIOD EVALUATION**		**MARKING PERIOD TOTAL**		**MARKING PERIOD AVERAGE**
_____	+	_____	+	_____	+	_____	+	_____	=	_____%
150		**150**		**150**		**100**		**550**		

MARKING PERIOD AVERAGE + PARTICIPATION/EFFORT [Up to 3%] = _____%

MARKING PERIOD FINAL GRADE _____

8/22/2009

Senior Project - Class Attendance Form

DATE	STUDENT NAME	TIME LEFT	DESTINATION	TIME RETURN

8/22/2009

Hardware Resources

Internet Capable Laptop Computers [wireless if possible ~ 6]

Operating System Accessible Laptop Computers [minimum 1 per project group ~6]

Apple Compatible Laptop [at least 1]

Scanner and Camera with appropriate storage media

Local Networked Laser Printer [BW minimum, color preferred]

Data Projector and screen [preferably permanently mounted]

Video Camera – For recording presentations and self critique!

Holographic materials & supplies including, but not limited to: film, developing chemicals, trays, plates, HeNe Lasers [~ 5 milliwatts - at least 2]

Astronomical Telescope including but not limited to: eyepieces, filters, clock drive, heavy duty tripod, mirrors, etc.

Multimeters – capable of measuring current, voltage, capacitance, frequency, etc. over a wide range and covering both AC and DC.

Dual Channel Oscilloscopes [minimum 2] and leads

Audio Oscillators [minimum 2]

Speakers [various sizes and capabilities]

Shop Vacuum [capable of exhaust as well as suction]

Amplifiers [various types and capabilities]

Deep Vacuum Pump & Vacuum Gauge

Webcam and other computer input devices

Programmable microcontrollers and programming hardware

General supplies and materials

Due to the variable nature of the projects it is critical that a wide assortment of materials be available at all times including, but not limited to: wood, metals [sheets and forms of various shapes and sizes], plastics [sheets and forms of various sizes], screws, nuts, bolts, motors, gears, sprockets, ic chips, heat sinks and heat sink compound, capacitors, transistors, leds, photo resistors, phototransistors, motors [AC & DC], stepper motors, liquid pumps, vacuum pumps, tubing [of various sizes and capabilities], PVC tubing, tubing cutter, Dremel hand tool and accessories, fogger and fogging fluid, batteries of all sizes [AAA, AA, B, C, D, 9V, 6V watch type, etc.], inductors, resistors, hand tools [wire strippers, screw drivers, hammer, hand drill and accessories, drill bits, tap and die sets, wire of many different sizes and types, proto-boards, soldering materials and stations, glues & adhesives, clay, epoxy putty, electrical tape, masking tape, duct tape, measuring tools, clamps of all types, alligator clips and leads, laser pointers, sandpaper [many various grits], spray paints [various colors], brushes, banana plugs and leads, etc.

Budgeting

In order for these projects to be completed successfully it is very important that the budgeting process provides reasonable funds dispersed equitably between the two semester projects. Due to the open ended nature of these projects it is nearly impossible to predict exactly what will be needed for each project until the project begins. It is therefore suggested that funding for each semester's projects be disbursed approximately 6 weeks after each semester begins [~ October 15th for the fall semester and ~ March 15 for the spring semester].

Reference Materials

Physics – Tipler [as well as many other older and discontinued textbooks]
Honors Physics – Teaching Point
The Art of Electronics – Horowitz & Hill
Machinery's Handbook 25 – Green – Industrial Press
Manufacturing Engineering Handbook – Geng – McGraw Hill
The Master Handbook of IC Circuits – Powers – Tab Books
Uranometria 2000 – Tirion -Sky Charts – Willman Bell, Inc
Burnham's Celestial Handbook – Vol 1-3 – Burnham – Dover Books, Inc
Astronomical Handbook [set of 3]
Holographic Handbook
Other printed resources as needed by each project

Software Resources

Microsoft Office – Including: Word, Excel & PowerPoint
Open Office, Registax Software,
Photo Manipulation Software - Photoshop
Data Studio – Computer Interfacing Software
Java compiler, Python compiler, C++ compiler, and others as needed
Other software resources as needed by each project.