THE GOVERNOR'S SCHOOL for SCIENCE AND TECHNOLOGY

Course Descriptions for the 2010-2011 School Year

Advanced Chemical Analysis 4471: (2 weighted high school credits) This course focuses on the fundamental principles and laws of chemistry. Extensive laboratory work and problem solving will serve as the basic tools for students to explore kinetics, acid/base chemistry, and equilibrium. The course will provide insights into organic and inorganic chemistry. The students will explore advanced concepts such as thermochemistry, electrochemistry and organic chemistry. The course will emphasize problem solving through chemical calculations. *Advanced Chemical Analysis is a college-level course with a strong focus on laboratory work. It examines topics typically studied during the first year of college by science majors. Prerequisites: High school Chemistry and Algebra II/Trig.*

Calculus 3177: (1 high school credit) This course takes an integrated approach to learning calculus. Students will use skills developed earlier in their math courses to address real-world problems related to calculus. Students will solve problems graphically, analytically, and by applying advanced software technology. Students will gain an in-depth understanding of limits, continuity and asymptotic behavior of functions, differential calculus, integral calculus, the Fundamental Theorem of Calculus, advanced techniques of integration, first degree differential equations and modeling, the study of sequences and series, and the calculus of functions defined in the polar coordinate system. Successful completion of this course will prepare students to enroll in multivariable calculus/linear algebra.

Calculus-based Engineering Physics I: Foundations and Modeling 4570: (2 high school credits) **This** course explores classical mechanics and thermodynamics through in-depth discussion, project development, and experimental laboratory activities. The course emphasizes the modeling of physical processes and the application of knowledge. Laboratory experiments use apparatuses such as air-tracks, ballistic pendulums, and thermoelectric transfer devices to investigate fundamental physics and mathematical theories. Computer data acquisition software is utilized to collect, analyze, and graph experimental data. Error propagation analysis helps students to understand the limits of numerical approximations. Robotics is one of the applied topics in mechanics. Software applications range from *Interactive Physics* to *West Point Bridge* designer software to an interactive online technology developed at Berkeley University. Special activities include building multi-stage water rockets along with data analysis, building Rube Goldberg machines, outdoor vector orienteering, and the study of kinematics in baseball.

Calculus-based Engineering Physics II: Maxwell to Hawking and Beyond 4580: (2 high school credits) This course is a thorough investigation of electric and magnetic field theory, DC circuit theory, and geometric optics along with some modern topics such as quantum mechanics. 3-D visualization skills will be developed. The overarching themes of conservation and symmetry will be synthesized. Laboratory experiments use apparatuses such as optical benches, spectrometers, and lasers. *E&M Field* software will allow students to investigate electric and magnetic fields associated with different charge and current distributions. *Mathematica* is utilized as a math tool (e.g. integration).

Concepts and Controversies in Environmental Science and Ecology 4270: (2 high school credits) In the fall semester, students will integrate aspects of biology, chemistry, earth science, and physics in the study of the environment. Exploration of relationships between organisms and their biotic and abiotic environment at multiple levels of biological system hierarchy serves as the foundation for this course. Laboratory and fieldwork in various ecosystems are also integral components of the course. Students will undertake monthly sampling of a nearby pond ecosystem for water quality and biotic components. Field methods include quadrat and transect sampling, as well as various techniques for surveying animal communities and monitoring water quality. While analyzing their own data, students will become familiar with concepts such as spatial and temporal variation in natural systems, species diversity, and community similarity indices. Critical thinking, risk analysis, and cost-benefit analysis will be emphasized as students identify and analyze alternative solutions to complex environmental problems. Whenever possible, current or on-going environmental issues and/or case histories will be emphasized. Spring semester will emphasize ecological principals from physiological ecology to ecosystem ecology.

Honors Research and Mentorship 4611: (2 high school credit) The Honors Research and Mentorship program (HRM) involves students in concentrated research or project development in firms and laboratories throughout the Tidewater area. They are supervised by mentors who are accomplished scientists, engineers and other professionals. Students must plan, implement, document and present research/projects chosen in consultation with these mentors. Accordingly, the students develop and refine their research and presentation techniques, problem-solving, critical thinking and leadership skills. This experience provides students with an opportunity to integrate theory, knowledge and application through a research experience.

Inquiry Physics & Scientific Programming I 4510/3181: (2 high school credits) This course covers the fundamentals of structured and object-oriented programming (C/C++/UNIX) along with the following areas in physics (non-calculus based) - Newtonian mechanics and thermodynamics. A solid conceptual understanding of these topics will be developed. The following tools in programming will be presented – variable types, control structures, loops, arrays, strings, structures, pointers, dynamic memory, classes, inheritance and polymorphism, queues, stacks and trees. Hence, this course would provide an effective combination of two areas, namely, problem solving using programming and fundamental concepts in non-calculus based physics, resulting in <u>both</u> high school science and math credits.

Inquiry Physics & Scientific Programming II – Digital Devices 4520/3182: (2 high school credits) This course integrates the fundamentals of assembly language and C++ with the following areas in physics (non-calculus based) - electromagnetism, circuit theory, microprocessors, and digital logic. Additional topics such as optics, waves, and quantum mechanics will be covered. The following assembly language tools will be applied to microprocessor theory - Data Representation, Arithmetic and Logical Operations, System Organization, Memory Layout and Access, Variables and Data Structures, Opcodes, Control Structures, and Procedures and Functions. Laboratory experiments in the other topics will be supplemented by computer programming projects in C++.

Modern Pre-calculus 3162: (1 high school credit) This course is an intensive, reform approach to mathematics designed to prepare students for college calculus. Students will focus on discussion and mathematical problem solving in elementary vector analysis, explicitly defined exponential, polynomial, logarithmic and trigonometric functions, as well as functions that are defined recursively and parametrically. Student investigations into functions, bivariate data, and models will involve graphing calculators and computers. Both graphical and analytic approaches to problem solving will be emphasized and used to model practical applications. The course concludes with an introduction to calculus.

Multivariable Calculus/Linear Algebra 3178: (1 high school credit) In multivariable calculus, students extend their study of calculus from the plane into 3-dimensional space and beyond. After an initial examination of geometry and algebra of 3-space, students will use differential and integral calculus to study the nature of curves and surfaces in 3-space, Topics include linear approximations of curves and surfaces in 3-space, optimization of functions in several variables, and use of integral calculus to study area, volume, and other applications. The semester concludes with an examination of the calculus of vector fields. In linear algebra, students use matrix theory to solve systems of linear equations and apply knowledge of the determinant to describe the nature of those solutions. The algebra and applications of linear transformations will be studied in both real and general vector spaces. Students will calculate eigenvalues and eigenvectors of linear transformations and use these to diagonalize linear systems. Applications include best fit functions and solutions of systems of 1^{st} order, linear differential equations.

Research Methodology & Ethics 4610: (1 high school credit) This course provides students with a basic understanding of scientific research design, experimental design, and statistical analysis. In addition, a broader understanding of current technological applications in research communication will be explored. An understanding in research ethics will set the stage for pondering national and international codes of human subjects research, the role of the scientist in society, and the theory and practice of ethics in different disciplines. A major curricula emphasis will be on technical writing and communication of research findings. Utilization of statistical software *MiniTab* and BASIC computer programming will serve to enhance scientific understanding of research design. Students will complete a research project for presentation at the Tidewater Science Fair. This course will serve as a preparatory course for the Honor Research and Mentorship Program.

Statistical Research Methods 3190: (1 high school credit) This course is an introduction course to the study of statistics. The goal of the course is to give the science student a basic knowledge of the language and methods of statistics. Students will learn the basic techniques of statistical analysis, applications of these techniques in solving problems from a variety of areas, and the advantages and limitations of statistical methods. Students are encouraged to use calculators and software

(Minitab) that are available. The emphasis of the course is on the interpretation of the statistical results rather than the mere computation. Students will learn the basic techniques of statistical analysis including sampling, estimations, data analysis , probability, random variables, regression analysis (including linear, power and exponential fit, hypothesis testing for the slope of a linear model, confidence intervals for the slope of a linear model, and prediction), hypothesis testing for means, proportions, Chi-square, ANOVA, and several non-parametric tests (sign test, ranking strategies, Wilcoxon tests, Kruskal-Wallis and Spearmans Rank Correlation tests), additionally, students will learn epidemiology techniques such as relative risk and disease transmission.