ADVANCED PLACEMENT CALCULUS
ADVANCED PLACEMENT PHYSICS

DESCRIPTION
In this integrated course students will be enrolled in both AP Calculus and AP Physics. Throughout the year, topics will be covered in one subject that will supplement, reinforce, enhance, introduce, build on and extend topics in the other. Some tests will be combined, as will the exams, and some of the classes will be team taught.

Calculus instruction is typically demanding and covers the topics included in the nationally approved Advanced Placement curriculum. Topics include the slope of a curve, derivatives of algebraic and transcendental functions, properties of limits, the rate of change of a function, optimization problems, Rolles and Mean Value Theorems, integration, the trapezoidal and Simpson’s Rules, parametric equations and the use of scientific calculators.

Physics instruction provides a systematic treatment of all of the topics required and recommended in the national AP curriculum as preparation for the AP "C" exam, specifically the mechanics part. The course is calculus based, and emphasizes not only the development of problem solving skills but also critical thinking skills. The course focuses on mechanics (statics, dynamics, momentum energy, etc.); electricity and magnetism; thermodynamics; wave phenomena (primarily electromagnetic waves); geometric optics; and, if time permits, relativity, modern and nuclear physics.

I. Functions, Graphs and Limits
   A. Analysis of graphs.
   B. Limits of functions, including one-sided limits
      2. Estimating limits from graphs or tables of data.
   C. Asymptotic and unbounded behavior.
      1. Understanding asymptotes in terms of graphical behavior.
      2. Describing asymptotic behavior in terms of limits involving infinity.
      3. Comparing relative magnitudes of functions and their rates of change.
   D. Continuity as a property of functions.
      1. Understanding continuity in terms of limits.
      2. Geometric understanding of graphs of continuous functions
         (Intermediate Value Theorem and Extreme Value Theorem).
   E. Parametric, polar and vector functions.
II. Derivatives

A. Concept of the derivative.
   1. Derivative defined as the limit of the difference quotient.
   2. Relationship between differentiability and continuity.

B. Derivative at a point.
   1. Slope of a curve at a point.
   2. Tangent line to a curve at a point and local linear approximation.
   3. Instantaneous rate of change as the limit of average rate of change.
   4. Approximate rate of change from graphs and tables of values.

C. Derivative as a function.
   1. Corresponding characteristics of graphs of $f$ and $f'$.
   2. Relationship between the increasing and decreasing behavior of $f$ and the sign of $f'$.
   3. The Mean Value Theorem and its geometric consequences.
   4. Equations involving derivatives.

D. Second derivatives.
   1. Corresponding characteristics of the graphs of $f$, $f'$, and $f''$.
   2. Relationship between the concavity of $f$ and the sign of $f''$.
   3. Points of inflection as places where concavity changes.

E. Applications of derivatives.
   1. Analysis of curves, including the notions of monotonicity and concavity.
   2. Analysis of planar curves given in parametric form, polar form and vector form, including velocity and acceleration vectors.
   3. Optimization, both absolute (global) and relative (local) extrema.
   4. Modeling rates of change, including related rates problems.
   5. Use of implicit differentiation to find the derivative of an inverse function.
   6. Interpretation of the derivative as a rate of change in varied applied contexts, including velocity, speed and acceleration.

F. Computation of derivatives.
   1. Knowledge of derivatives of basic functions, including $x^r$, exponential, logarithmic, trigonometric, and inverse trigonometric functions.
2. Basic rules for the derivative of sums, products and quotients of functions. 
\[ \int f'(x) \, dx = f(b) - f(a) \]
3. Chain rule and implicit differentiation.
5. Derivatives of parametric, polar and vector functions.

III. Integrals

A. Riemann sums
1. Concept of a Riemann sum over equal subdivisions.
2. Computation of a Riemann sum using left, right and midpoint evaluation points.

B. Interpretations and properties of definite integral
1. Definite integral as a limit of Riemann sums.
2. Definite integral of the rate of change of a quantity over an interval interpreted as the change of the quantity over the integral:
3. Basic properties of definite integrals.

C. Applications of integrals.
1. Area of a region.
2. Volume of a solid with known cross section.
3. Average value of a function.
4. Distance traveled by a particle along a line.
5. Centroid

D. Fundamental Theorem of Calculus
1. Use of the Fundamental Theorem to evaluate definite integrals.
2. Use of the Fundamental Theorem to represent a particular antiderivative, and the analytical and graphed analysis of functions so defined.

E. Techniques of antidifferentiation.
1. Antiderivatives following directly form derivatives of basic functions.
2. Antiderivatives by substitution of variables (including change of variable for definite integrals), parts and simple partial fractions (nonrepeating linear factors only).
3. Improper integrals (as limits of definite integrals).

F. Applications of antiderivatives.
1. Finding specific antiderivatives using initial conditions, including applications to motion along a line.
2. Solving separable differential equations and using them in modeling. In particular, studying \( y' = ky \) and exponential growth.
G. Numerical approximation to definite integrals.
   1. Use of Riemann sums.
   2. Use of Trapezoidal Rule.

IV. Polynomial approximations and series.
   A. Concept of a series.
   B. Series of constants.
      1. Motivating examples including decimal expansion.
      2. Geometric series with applications.
      3. The harmonic series.
      4. Alternating series with error bound.
      5. Terms of a series as areas of rectangles and their relationship to improper integrals, including the integral test and its use in testing the convergence of the p-series.
      6. The ratio test for convergence and divergence.
      7. Comparing series to test for convergence or divergence.
   C. Taylor series.
      1. Taylor polynomial approximation with graphical demonstration of convergence.
      2. The general Taylor series centered at \( x=a \).
      3. MacLaurin series for the functions \( e^x, \sin x, \cos x \) and \( 1/(1-x) \)
      4. Formal manipulation of Taylor series and shortcuts to computing Taylor series, including differentiation, antidifferentiation and the formation of new series from known series.
      5. Functions defined by power series and radius of convergence.

AP PHYSICS

I. Foundations
   A. Idealized models.
   B. Standards and units.
   C. Conversions.
   D. Precision and significant figures.
   E. Order of magnitude.
   F. Vectors and vector addition.
   G. Component of vectors
II. Motion along a straight line
   A. Average velocity.
   B. Instantaneous velocity.
   C. Average and instantaneous acceleration.
   D. Constant acceleration.
   E. Graphical analysis of motion.
   F. Mathematical analysis of motion.
   G. Free falling bodies.
   H. Relative velocity.

III. Motion in a plane
   A. Average and instantaneous velocity
   B. Average and instantaneous acceleration.
   C. Components of acceleration.
   D. Projectile motion.
   E. Circular motion.
   F. Relative motion.

IV. Newton's Laws of Motion
   A. Force.
   B. Equilibrium and Newton's First Law.
   C. Systems of units.
   D. Mass and weight.
   E. Newton's Third Law.
   F. Inertial frames of reference.
   G. Friction.
   H. Particle equilibrium.

V. Circular motion and gravitation
   A. Forces in circular motion.
   B. Motion in a vertical circle.
   D. Gravitational fields.
   E. Satellite motion.
   F. Centrifuge.

VI. Work and energy
   A. Conservation of energy.
   B. Work.
   C. Work done by a varying force.
   D. Work and kinetic energy.
   E. Gravitational potential energy.
   F. Elastic potential energy.
   G. Power.
VII. Impulse and momentum
   A. conservation of momentum.
   B. Inelastic collisions.
   C. Elastic collisions.
   D. Center of mass.

VIII. Rotational motion
   A. Angular velocity and acceleration.
   B. Rotation with constant acceleration.
   C. Relation between angular and linear velocity and acceleration.
   D. Kinetic energy and moment of inertia.
   E. Torque.
   F. Moving axis.
   G. Angular momentum and its conservation.
   H. Vector representation of angular quantities.

IX. Equilibrium of a rigid body
   A. The second condition for equilibrium.
   B. Couples.

X. Periodic motion
   A. Simple harmonic motion.
   B. Angular simple harmonic motion
   C. Simple pendulum
   D. Physical pendulum
   E. Damped and forced oscillations.

XI. Elasticity
   A. Tensile strength and strain.
   B. Bulk stress and strain.
   C. Shear stress and strain.
   D. Elasticity and plasticity.

XII. Mechanical waves
   A. Periodic waves
   B. Speed of transverse waves.
   C. Speed of longitudinal waves.
   D. Sound waves
   E. Schroedinger's representation of waves.

XIII. Reflections and normal modes
   A. Boundary conditions for a string
   B. Superposition and standing waves
   C. Normal modes of a string
   D. Longitudinal standing waves.
E. Interference waves.
F. Resonance.
G. Reflection and refraction.

XIV. Sound
A. Sound waves.
B. Hearing and musical toes.
C. Beats.
D. The Doppler Effect.
E. Acoustics.

XV. Coulomb's Law
A. Electric charges.
B. Electrical conductors and insulators.
C. Charging by induction and conduction.
D. Coulomb's Law.

XVI. The electric field
A. Electric fields and electrical forces.
B. Electric field calculations.
C. Gauss' Law
D. Distribution of charges.

XVII. Electric potential
A. Electric potential energy
B. Equipotential surfaces.
C. Gradient.
D. Capacitors.
E. Capacitors in series and parallel.
F. Dielectrics and induced charge.

XVIII. Ohm's Law and DC circuits
A. Current.
B. Resistance and resistivity.
C. Electromotive force.
D. Ohm's law.
E. Series and parallel circuits.
F. Kirchoff's Rules.
G. Resistance-capacitance circuits.

XIX. Electromagnetic waves
A. Maxwell's Equations.
B. Speed of an electromagnetic wave.
C. Energy of an electromagnetic wave.
D. The electromagnetic spectrum.
XX. The nature and propagation of light
   A. The nature of light.
   B. Reflection and refraction of light.
   C. Total internal reflection.
   D. Dispersion.
   E. Polarization.
   F. Scattering.
   G. Huygens’ Principle.

XXI. Images formed by single and multiple surfaces.
   A. Reflection at plane and spherical surfaces.
   B. Focal length.
   C. Refraction at plane and spherical surfaces.
   D. Thin lenses.
   E. Graphical methods.
   F. Optical instruments.

XXII. Interference and diffraction
   A. Interference and coherent sources.
   B. Two source interference.
   C. Thin film interference.
   D. Diffraction gratings.
   E. X-ray diffraction.
   F. Holography.

XXIII. Relativistic mechanics
   A. Invariance of physical laws
   B. Relative nature of simultaneity
   C. Relativity of time.
   D. Relativity of length.
   E. The Lorentz Transformation.
   F. Momentum

COURSE OBJECTIVES
The students will demonstrate:
1. A detailed understanding of the concepts, principles and processes as listed in the course outline.
2. An ability to distinguish between scientific evidence and personal opinion through inquiry and questioning.
3. The ability to interpret data, draw conclusions and/or make inferences from the accumulated data.
4. The ability to use mathematical relationships to describe results obtained by observation and experimentation.
5. An understanding of the role of observation and experimentation the
6. The skills of gathering scientific information through laboratory and field work.
7. The ability to select and apply mathematical relationships to scientific problems.
8. The ability to interpret, in mathematical terms, relationships presented in mathematical form.
9. The skills to make informed decisions about new technologies as they might affect the global environment.
10. An understanding of the concepts of calculus and experience with its methods and applications.
11. Become familiar with the format of the AP examination.
12. Gain an understanding of the appropriate use of scientific calculators in solving problems.

METHODS OF INSTRUCTION

1. Lectures
2. Text and outside resources
3. Teacher directed group activities
4. Homework assignments
5. Applied Physics Projects
7. Computer aided activities and labs.
8. Inquiry oriented laboratory activities.
9. Teacher presented laboratory demonstrations.
10. Student presentations.
11. Cooperative learning groups.
12. Student projects.

METHODS OF EVALUATION

1. Attendance in accordance with school policies.
2. Homework, class work, applied physics projects, laboratory reports and laboratory participation.
3. Results of tests and quizzes.
4. Results of mid-term and final exams.
5. Results of departmental examinations.
6. Appropriate keeping of a student journal (optional)

INSTRUCTIONAL MATERIALS


3. TI-85 Graphing Calculator

   Supplemental Materials: Video discs, Interactive Physics Films from Morris County Library. Magazines, newspapers, lab supplies and equipment, previous AP examinations
   Rev 2002