

Applied Mathematics [APMA] Program

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- The Applied Mathematics Program coordinates and administers applied mathematics instruction through its APMA courses to undergraduate and graduate students in all departments of SEAS.
- SEAS students constituted 2983 official APMA course registrants during 2008-09 and completed 71 sections of APMA courses during 2008-09, including seven APMA courses taught in the 2008 Summer Session (Course Offering Directory APMA enrollment figures).

- The mathematical tools and expertise developed through APMA courses are essential to the professional development of the future engineer and applied scientist.
- The APMA applied mathematics instruction forms the core of the analytical-mathematical component of an engineering education and lays the foundation for accelerated ongoing professional development.

- Extensive efforts have been made toward continual improvement of the APMA Program during 2008-09 and over the past five-year period 2004-09.
- Data for evaluating and assessing these APMA improvements are available from several sources.

- Summary Tables of Topics and Subtopics in APMA Courses (at the 100, 200, and 300 level). Information Exchange, today?
- Comprehensive Mathematics Instruction for SEAS students in APMA Courses?

APMA Program improvement, contributing to levels of excellence

Standardized APMA Course Summary Tables of Topics and Subtopics [CSTTS] and standardized APMA Beginning Of Course Memos [BOCs] and End Of Course Memos [EOCs] have been enhanced over the past five-year period 2004-09 and now constitute consistent, definitive criteria for assessing how well SEAS students learn the mathematics covered and how well the students are able to demonstrate that knowledge, topic by topic and subtopic by subtopic, by the times of the final examinations in all APMA courses. CSTTSs for APMA Courses are included in the following pages.

APMA 1090 (Section _) – Single Variable Calculus I Stewart’s Calculus 6th Ed

Section	Topic	Problem On Final Exam	Wgt %	Average %	Proficiency Rating	Objectives/ Outcomes Evaluated
2	Limits					
2.1	The Tangent and Velocity Problems					
2.2	The Limit of a Function					
2.3	Calculating Limits Using the Limit Laws					
2.4	The Precise Definition of a Limit					
2.5	Continuity					
3	Derivatives					
3.1	Derivatives and Rates of Change					
3.2	The Derivative as a Function					
3.3	Differentiation Formulas					
3.4	Derivatives of Trigonometric Functions					
3.5	The Chain Rule					
3.6	Implicit Differentiation					
3.7	Rates of Changes in the Natural and Social Sciences					
3.8	Related Rates					
3.9	Linear Approximations and Differentials					
4	Applications of Differentiation					
4.1	Maximum and Minimum Values					
4.2	The Mean Value Theorem					
4.3	How Derivatives Affect the Shape of a Graph					
4.4	Limits at Infinity; Horizontal Asymptotes					
4.5	Summary of Curve Sketching					
4.7	Optimization Problems					
4.9	Newton’s Method					
4.10	Antiderivatives					
5	Integrals					
5.1	Areas and Distances					
5.2	The Definite Integral					
5.3	The Fundamental Theorem of Calculus					
5.4	Indefinite Integrals and the Net Change Theorem					
5.5	The Substitution Rule					
6	Applications of Integration					
6.1	Areas Between Curves					
6.2	Volumes					
6.3	Volumes by Cylindrical Shells					
6.4	Work					
6.5	Average Value of a Function					
	Final Exam Average					
	Number of Students Who Passed Final Exam/Course	/				
	Number of Students Who Failed Final Exam/Course	/				

Excellent ($\geq 90\%$)

Good (75 – 89 %)

Fair (60 – 74 %)

Poor ($< 60\%$)

APMA 1110 (Section _) – Single Variable Calculus II

Stewart’s Calculus 6th Ed

Section	Topic	Problem On Final Exam	Wgt %	Average %	Proficiency Rating	Objectives/ Outcomes Evaluated
7	Inverse Functions					
7.1	Inverse Functions					
7.2	Natural Logarithmic Function					
7.3	Natural Exponential Function					
7.4	General Logarithmic and Exponential Functions					
7.5	Exponential Growth and Decay					
7.6	Inverse Trigonometric Functions					
7.7	Hyperbolic Functions					
7.8	Indeterminate Forms and L’Hospital’s Rule					
8	Techniques of Integration					
	Integration by Substitution					
8.1	Integration by Parts					
8.2	Trigonometric Integrals					
8.3	Trigonometric Substitution					
8.4	Integration of Rational Functions by Partial Fractions					
8.5	Strategy for Integration					
8.7	Approximate Integration					
8.8	Improper Integrals					
9	Further Applications of Integration					
9.1	Arc Length					
9.2	Area of a Surface of Revolution					
9.3	Applications to Physics & Engineering – Hydro Force					
9.3	Applications to Physics & Engineering – Moments					
6.4	Applications to Physics & Engineering – Work					
11	Parametric Equations & Polar Equations					
11.1	Curves Defined by Parametric Equations					
11.2	Calculus with Parametric Curves					
11.3	Polar Coordinates					
11.4	Areas & Lengths in Polar Coordinates					
11.5	Conic Sections					
11.6	Conic Sections in Polar Coordinates					
12	Infinite Sequences & Series					
12.1	Sequences					
12.2	Series – Geometric Series and Divergence Test					
12.3	Integral Test & p-Series					
12.4	Comparison Test					
12.5	Alternating Series					
12.6	Absolute Convergence and the Ratio & Root Tests					
12.7	Strategy for Testing Series					
12.8	Power Series					
12.9	Representation of Functions as Power Series					
12.10	Taylor and Maclaurin Series					
12.11	Applications of Taylor Polynomials					
	Final Exam Average					
	Number of Students Who Passed Final Exam/Course	/				
	Number of Students Who Failed Final Exam/Course	/				

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Section	Topic	Problem On Final Exam	Wgt %	Average %	Proficiency Rating	Objectives/ Outcomes Evaluated
13	Vectors and the Geometry of Space					
13.1	3-D Coordinate System					
13.2	Vectors					
13.3	Dot Product					
13.4	Cross Product					
13.5	Equations of Lines and Planes					
13.6	Cylinders & Quadric Surfaces					
14	Vector Functions					
14.1	Vector Functions & Space Curves					
14.2	Derivatives & Integrals of Vector Functions					
14.3	Arc Length & Curvature					
14.4	Motion in Space: Velocity & Acceleration					
15	Partial Derivatives					
15.1	Functions of Several Variables					
15.2	Limits & Continuity					
15.3	Partial Derivatives					
15.4	Tangent Planes & Linear Approximations					
15.5	Chain Rule					
15.6	Directional Derivatives & Gradients					
15.7	Max & Min Values					
15.8	Lagrange Multipliers					
16	Multiple Integrals					
16.1	Double Integrals over Rectangles					
16.2	Iterated Integrals					
16.3	Double Integrals over General Regions					
16.4	Double Integrals over polar Coordinates					
16.5	Applications of Double Integrals					
16.6	Triple Integrals					
16.7	Triple Integrals in Cylindrical Coord.					
16.8	Triple Integrals in Spherical Coord.					
16.9	Change of Variables in Multiple Integrals					
17	Vector Calculus					
17.1	Vector Fields					
17.2	Line Integrals					
17.3	The Fundamental Theorem for Line Integrals					
17.4	Green's Theorem					
17.5	Curl and Divergence					
17.6	Parametric Surfaces and Their Areas					
17.7	Surface Integrals					
17.8	Stokes' Theorem					
17.9	The Divergence Theorem					
	Final Exam Average					
	Number of Students Who Passed Final Exam/Course	/				
	Number of Students Who Failed Final Exam/Course	/				

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APMA 2130 (Section _) – Ord. Diff. Eqn.s Boyce & DiPrima’s Elem Diff Eqn.s & BVPs 8th Ed

Section	Topic	Problem On Final Exam	Wgt %	Average %	Proficiency Rating	Objectives/ Outcomes Evaluated
2	First Order Differential Equations					
2.1	Linear Equations					
2.2	Separable Equations					
2.3	Modeling with First Order Equations					
2.4	Differences between Linear and Nonlinear Equations					
2.5	Autonomous Equations					
2.6	Exact Equations					
2.7	Numerical Approximations: Euler’s Method					
2.9	Miscellaneous Problems: First Order Equations					
8	Numerical Methods					
8.1	The Euler or Tangent Line Method					
8.2	Improvements on the Euler Method					
8.3	The Runge-Kutta Method					
3 & 4	Higher Order Linear Equations					
4.1	General Theory of nth Order Linear Equations					
3.1, 4.2	Homogeneous Equations with Constant Coefficients					
3.2	Fundamental Solutions of Linear Homogeneous Equations					
3.3	Linear Independence and the Wronskian					
3.4	Complex Roots of the Characteristic Equation					
3.5	Repeated Roots; Reduction of Order					
3.6, 4.3	Method of Undetermined Coefficients					
3.7, 4.4	Variation of Parameters					
3.8	Mechanical and Electrical Vibrations					
3.9	Forced Vibrations					
5	Series Solutions of Second Order Linear Equations					
5.5	Euler Equations					
6	The Laplace Transform					
6.1	Definition of the Laplace Transform					
6.2	Solution of the Initial Value Problem					
6.3	Step Functions					
6.4	Diff. Equations with Discontinuous Forcing Functions					
6.5	Impulse Functions					
6.6	The Convolution Integral					
7	Systems of First Order Linear Equations					
7.1	Introduction					
7.2	Review of Matrices					
7.3	Systems of Linear Algebraic Equations					
7.4	Basic Theory of Systems of First Order Linear Equations					
7.5	Homogeneous Linear Systems with Constant Coefficients					
7.6	Complex Eigenvalues					
7.7	Fundamental Matrices					
7.8	Repeated Eigenvalues					
7.9	Nonhomogeneous Linear Systems					
	Final Exam Average					
	Number of Students Who Passed Final Exam/Course	/				
	Number of Students Who Failed Final Exam/Course	/				

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APMA 3080 (Section _) – Linear Algebra William’s Linear Algebra w. Appl.s 7th Ed

Section	Topic	Problem On Final Exam	Wgt %	Average %	Proficiency Rating	Objectives/ Outcomes Evaluated
1	Linear Equations and Vectors					
1.1	Matrices and Systems of Linear Equations					
1.2, 1.3	Gauss-Jordan Elimination, The Vector Space \mathbf{R}^n					
1.4	Basis and Dimension					
1.5	Dot Product, Norm, Angle and Distance					
1.6	Curve Fittings, Electrical Networks, ...					
2	Matrices and Linear Transformations					
2.1	Addition, Scalar Multiplication, and Multiplication of Matrices					
2.2	Properties of Matrix Operations					
2.3, 2.4	Symmetric Matrices, The Inverse of a Matrix, ...					
2.5	Matrix Transformations, Rotations, ...					
2.6	Linear Transformations, Graphics					
2.8	Markov Chains, Population Movements, ...					
3	Determinants and Eigenvectors					
3.1, 3.2	Introduction to & Properties of Determinants					
3.3	Determinants, Matrix Inverses, and Systems of Linear Equations					
3.4	Eigenvalues and Eigenvectors					
3.5	Google, Demography, Weather Prediction					
4	General Vector Spaces					
4.1	General Vector Spaces and Subspaces					
4.2	Linear Combinations					
4.3	Linear Dependence and Independence					
4.4, 4.5	Properties of Bases, Rank					
4.6	Orthonormal Vectors and Projections					
4.7	Kernel, Range, Rank/Nullity Theorem					
4.8	One-to-One Transformations and Inverses					
4.9	Transformations & Systems of Linear Eqn.s					
5	Coordinate Representations					
5.1	Coordinate Vectors					
5.2	Matrix Representations of Linear Transf.s					
5.3	Diagonalization of Matrices					
5.4	Quadratic Forms, Difference Equations, Normal Modes					
6	Inner Product Spaces					
6.1	Inner Product Spaces					
6.3	Approximation of Functions, Coding Theory					
6.4	Least Squares Curves					
7	Numerical Methods					
7.1, 7.2	Gaussian Elimination, LU Decomposition					
7.3	Practical Difficulties in Solving Systems					
7.4	Iterative Methods for Solving Systems of Linear Equations					
	Final Exam Average					
	Number of Students Who Passed Final Exam/Course	/				
	Number of Students Who Failed Final Exam/Course	/				

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APMA 3100 (Section _) – Probability Yates-Goodman’s Prob. & Stochastic Processes 2nd Ed

Section	Topic	Problem On Final Exam	Wgt %	Average %	Proficiency Rating	Objectives/ Outcomes Evaluated
1	Experiments, Models, and Probabilities					
1.1, 1.2, 1.3, 1.4	Set Theory, Probability Axioms					
1.5, 1.6	Conditional Probability, Independence					
1.7, 1.8	Sequential Experiments, Tree Diagrams, Counting Methods					
1.9, 1.10	Independent Trials, Reliability Problems					
2	Discrete Random Variables					
2.1, 2.2	Definitions, Probability Mass Function (PMF)					
2.3	Families of Discrete Random Variables (RVs)					
2.4, 2.5	Cumulative Distribution Function (CDF), Averages					
2.6	Functions of a RV					
2.7	Expected Value of a Derived RV					
2.8	Variance and Standard Deviation					
2.9	Conditional Probability Mass Function					
3	Continuous Random Variables					
3.1, 3.2	CDF, Probability Density Function (PDF)					
3.3	Expected Values					
3.4	Families of Continuous RVs					
3.5	Gaussian RVs					
3.7	Probability Models of Derived RVs					
3.8	Conditioning a Continuous RV					
4	Pairs of Random Variables					
4.1, 4.2, 4.3	Joint CDF, Joint PMF, Marginal PMF					
4.4, 4.5	Joint PDF, Marginal PDF					
4.6, 4.7	Functions of Two RV’s, Expected Values					
4.8, 4.9	Conditioning by an Event, Conditioning by a Random Variable					
4.10	Independent RVs					
5	Random Vectors					
5.1, 5.2	Prob. Models of N Random Variables, Vector Notation					
5.3, 5.4	Marginal Probability Functions, Independence					
6	Sums of Random Variables					
6.1, 6.2	Expected Values of Sums, PDF of the Sum of Two RVs					
6.6, 6.7	Central Limit Theorem (CLT), Applications of CLT					
7	Parameter Estimation Using the Sample Mean					
7.1	Sample Mean: Expected Value and Variance					
7.2	Deviation of a Random Variable from the Expected Value					
7.3, 7.4	Point Estimates of Model Parameters, Confidence Intervals					
8	Hypothesis Testing					
8.1, 8.2	Significance Testing, Binary Hypothesis Testing					
8.3	Multiple Hypothesis Test					
9	Estimation of a Random Variable					
9.1	Optimum Estimation Given Another Random Variable					
9.2	Linear Estimation of X given Y					
9.3	MAP and ML Estimation					
10	Stochastic Processes					
10.5	The Poisson Process					
10.6	Properties of the Poisson Process					
	Final Exam Average					
	Number of Students Who Passed Final Exam/ Course	/				
	Number of Students Who Failed Final Exam/Course	/				

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APMA 3110 (Section _) – Appl. Stat.s & Prob. Navidi’s Stat.s for Engr.s & Scientists 2nd Ed

Section	Topic	Problem On Final Exam	Wgt %	Average %	Proficiency Rating	Objectives/ Outcomes Evaluated
	Sampling and Descriptive Statistics					
1.1, 1.2	Sampling, Summary Statistics					
1.3	Graphical Summaries					
	Probability					
2.1	Basic Ideas					
2.2	Counting Methods					
2.3	Conditional Probability and Independence					
2.4	Random Variables					
2.5	Linear Functions of Random Variables					
	Propagation of Errors					
3.1	Measurement Error					
3.2	Linear Combinations of Measurements					
3.3	Uncertainties for Functions of One Measurement					
	Commonly Used Distributions					
4.1	Bernoulli					
4.2	Binomial					
4.3	Poisson					
4.5	Normal					
4.7	Exponential					
4.9	Some Principles of Point Estimation					
4.11	Central Limit Theorem					
4.12	Simulation					
	Confidence Intervals					
5.1	Large Sample – Mean					
5.2	Proportions					
5.3	Small Sample – Mean					
5.4	Difference Between Two Means					
5.5	Difference Between Two Proportions					
5.6	Small Samples – Difference Between Two Means					
5.7	Paired Data					
	Hypothesis Testing					
6.1	Large Sample – Mean					
6.2	Drawing Conclusions from Results					
6.3	Proportion					
6.4	Small Sample – Mean					
6.5	Large Sample – Difference Between Two Means					
6.6	Difference Between Two Proportions					
6.10	Chi-Square Test					
6.11	F test for Equality of Variance					
6.12, 6.13	Fixed Level Testing, Power					
	Correlation and Simple Linear Regression					
7.1	Correlation					
7.2	Least-Squares Line					
7.3	Uncertainties in Least Squares Coefficient					
	Factorial Experiments					
9.1	One-Factor Experiments					
9.4	Randomized Complete Block Design					
	Statistical Quality Control					
10.1	Basic Ideas					
10.2	Control Charts for Variables					
	Final Exam Average					
	Number of Students Who Passed Final Exam/Course	/				
	Number of Students Who Failed Final Exam/Course	/				

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APMA 3120 (Section _) – Statistics Devore’s Prob. & Statistics for Engr & Sci 7th Ed

Section	Topic	Problem On Final Exam	Wgt %	Average %	Proficiency Rating	Objectives/ Outcomes Evaluated
CH 6	Point Estimation					
6.1	Some general concepts of Point Estimation					
6.2	Methods of Point Estimation					
CH 7	Statistical Intervals Based on a Single Sample					
7.1	Basic Properties of Confidence Intervals					
7.2	Large-Sample Confidence Intervals					
7.3	Confidence Intervals on a Normal Population					
7.4	Confidence Intervals for Variances and Stds					
CH 8	Tests of Hypotheses Based on a Single Sample					
8.1	Hypotheses and Test Procedures					
8.2	Tests about Population Mean					
8.3	Tests about Population Proportion					
8.4	P-Values					
8.5	Some Comments on Selecting a Test					
Ch 9	Inferences Based on Two Samples					
9.1	Two sample z-Tests and Confidence Intervals					
9.2	Two sample t-Test and Confidence Intervals					
9.3	Analysis of Paired Data					
9.4	Inferences concerning a Difference between Population Proportions					
9.5	Inferences concerning two Population Variances					
CH 10	Analysis of Variance					
10.1	Single-Factor ANOVA					
10.2	Multiple Comparisons in ANOVA					
10.3	More on Single-Factor ANOVA					
CH 12	Simple Linear Regression and Correlation					
12.1	Simple Linear Regression Model					
12.2	Estimating Model Parameters					
12.3	Inferences about the Slope Parameters					
12.4	Inferences about the Prediction of Future Y Values					
12.5	Correlation					
CH 15	Distribution-Free Procedures					
15.1	Wilcoxon Signed-Rank Test					
15.2	Wilcoxon Rank-Sum Test					
15.3	Distribution-Free Confidence Intervals					
15.4	Distribution-Free ANOVA					
	Final Exam Average					
	Number of Students who Passed Final Exam/Course	/				
	Number of Students who Failed Final Exam/Course	/				

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APMA 3140 (Sec 1) - Partial Diff. Eqn.s Haberman's Appl. PDEs .. 4th Ed

Section	Topic	Problem On Final Exam	Wgt %	Average %	Proficiency Rating	Objectives/ Outcomes Evaluated
1	Heat Equation					
1.1, 1.2	Derivation of the Conduction of Heat in a 1D Rod					
1.3	Boundary Conditions					
1.4	Equilibrium Temperature Distribution					
1.5	Derivation of the Heat Equation in 2D and 3D					
2	Method of Separation of Variables					
2.1, 2.2	Linearity					
2.3	Heat Equation with Zero Temperatures at Finite Ends					
2.4	Heat Equation: Other Boundary Value Problems					
2.5	Laplace's Equation: Solutions and Properties					
3	Fourier Series					
3.1, 3.2	Statement of Convergence Theorem					
3.3	Fourier Cosine and Sine Series					
3.4	Term-by-Term Differentiation of Fourier Series					
3.5	Term-by-Term Integration of Fourier Series					
4	Wave Equation: Vibrating Strings and Membranes					
4.1, 4.2	Derivation of a Vertically Vibrating String					
4.3	Boundary Conditions					
4.4	Vibrating String with Fixed Ends					
4.5	Vibrating Membrane					
5	Sturm-Liouville (SL) Eigenvalue Problems					
5.1, 5.2, 5.3	Examples, SL Eigenvalue Problems					
5.4	Heat Flow in A Nonuniform Rod without Sources					
5.5	Self-Adjoint Operators, SL Eigenvalue Problems					
5.6	Rayleigh Quotient					
5.7	Vibrations of a Nonuniform String					
5.8	Boundary Conditions of the Third Kind					
5.9	Large Eigenvalues (Asymptotic Behavior)					
5.10	Approximation Properties					
6	Finite Difference Numerical Methods of Partial Differential Equations					
6.1, 6.2	Finite Differences and Truncated Taylor Series					
6.3	Heat Equation					
7	Higher Dimensional Partial Differential Equations					
7.1, 7.2	Separation of the Time Variable					
7.3	Vibrating Rectangular Membrane					
7.4	Statements and Illustrations of Theorems					
7.5	Green's Formula, Self-Adjoint Operators, Multidimensional Eigenvalue Problems					
7.6	Rayleigh Quotient and Laplace's Equation					
7.7, 7.8	Vibrating Circular Membrane, Bessel Functions					
7.9	Laplace's Equation in a Circular Cylinder					
7.10	Spherical Problems and Legendre Polynomials					
8	Nonhomogeneous Problems					
8.1, 8.2	Heat Flow with Sources and Nonhomogeneous Boundary Conditions (BCs)					
8.3	Method of Eigenfunction Expansion - Homogeneous BCs (Differentiating Series of Eigenfunctions)					
	Final Exam Average					
	Number of Students Who Passed Final Exam/Course	/				
	Number of Students Who Failed Final Exam/Course	/				

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APMA 3340 – Complex Variables Saff & Snider’s ...Complex Analysis 3rd Ed

Section	Topic	Problem On Final Exam	Wgt %	Average %	Proficiency Rating	Objectives/ Outcomes Evaluated
1	Complex Numbers					
1.1	The Algebra of Complex Numbers					
1.2	Point Representation of Complex Numbers					
1.3	Vectors and Polar Forms					
1.4, 1.5	The Complex Exponential, Powers and Roots					
1.6, 1.7	Planar Sets, The Riemann Sphere					
2	Analytic Functions					
2.1	Functions of a Complex Variable					
2.2, 2.3	Limits and Continuity, Analyticity					
2.4, 2.5	The Cauchy-Riemann Equations, Harmonic Fct.s					
2.6	Steady-State Temperature as a Harmonic Function					
3	Elementary Functions					
3.1	Polynomials and Rational Functions					
3.2	The Exponential, Trigonometric, & Hyperbolic Fct.s					
3.3	The Logarithmic Function					
3.4	Washers, Wedges, and Walls					
3.5	Complex Powers and Inverse Trigonometric Fct.s					
4	Complex Integration					
4.1, 4.2	Contours, Contour Integrals					
4.3, 4.4	Independence of Path, Cauchy’s Integral Theorem					
4.5	Cauchy’s Integral Formula and Its Consequences					
4.6	Bounds for Analytic Functions					
5	Series Representations for Analytic Functions					
5.1	Sequences and Series					
5.2, 5.3	Taylor Series, Power Series					
5.4, 5.5	Convergence, Laurent Series					
5.6, 5.7	Zeros and Singularities, The Point at Infinity					
6	Residue Theory					
6.1	The Residue Theorem					
6.2	Trigonometric Integrals					
6.3,6.4,6.5	Improper Integrals, Indented Contours					
6.6	Integrals Involving Multiple-Valued Functions					
6.7	The Argument Principle and Rouche’s Theorem					
7	Conformal Mapping					
7.1	Invariance of Laplace’s Equation					
7.2,7.3,7.4	Geometric Considerations, Mobius Transformations					
7.5	The Schwarz-Christoffel Transformation					
7.6	Applications: Electrostatics, Heat Flow, Fluid Mech.s					
7.7	Further Physical Applications of Conformal Mapping					
8	The Transforms of Applied Mathematics					
8.1	Fourier Series (The Finite Fourier Transform)					
8.2, 8.3	The Fourier Transform, The Laplace Transform					
8.4	The z-Transform					
8.5	Cauchy Integrals and the Hilbert Transform					
	Final Exam Average					
	Number of Students Who Passed Final Exam/Course	/				
	Number of Students Who Failed Final Exam/Course	/				

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APMA 5070 – Numerical Methods Cheney & Kincaid’s Num. Math & Comp. 6th Ed

Section	Topic	Problem On Final Exam	Wgt %	Average %	Proficiency Rating	Objectives/ Outcomes Evaluated
1	Introduction					
1.1, 1.2	Preliminary Remarks, Review of Taylor Series					
2	Floating-Point Representation and Errors					
2.1	Floating-Point Representation					
2.2	Loss of Significance					
3	Locating Roots of Equations					
3.1,3.2, 3.3	Bisection, Newton’s, and Secant Methods					
4	Interpolation and Numerical Differentiation					
4.1	Polynomial Interpolation					
4.2	Errors in Polynomial Interpolation					
4.3	Estimating Derivatives and Richardson Extrapolation					
5	Numerical Integration					
5.1	Lower and Upper Sums					
5.2, 5.3	Trapezoid Rule, Romberg Algorithm					
6	Additional Topics on Numerical Integration					
6.1	Simpson’s Rule and Adaptive Simpson’s Rule					
6.2	Gaussian Quadrature Formulas					
7	Systems of Linear Equations					
7.1	Naive Gaussian Elimination					
7.2	Gaussian Elimination with Scaled Partial Pivoting					
7.3	Tridiagonal and Banded Systems					
10	Ordinary Differential Equations					
10.1,	Taylor-Series Methods					
10.2	Runge-Kutta Methods					
10.3	Stability and Adaptive Runge-Kutta and Multistep Methods					
11	Systems of Ordinary Differential Equations					
11.1	Methods for First-Order Systems					
11.2	Higher-Order Equations and Systems					
11.3	Adams-Bashforth-Moulton Methods					
13	Monte Carlo Methods and Simulation					
13.1	Random Numbers					
13.2	Estimation of Areas and Volumes by Monte Carlo Techniques					
13.3	Simulation					
14	Boundary-Value Problems for Ordinary Differential Equations					
14.1, 14.2	Shooting Method, A Discretization Method					
15	Partial Differential Equations					
15.1	Parabolic Problems					
15.2	Hyperbolic Problems					
15.3	Elliptic Problems					
	Final Exam Average					
	Number of Students Who Passed Final Exam/Course	/				
	Number of Students Who Failed Final Exam/Course	/				

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APMA 6410-Review.Beginning.Engr.Math.I Greenberg's Adv.Engr.Math.

Section	Topic	Problem On Beginning Review Test	Average %	Proficiency Rating	Objectives/ Outcomes Evaluated
1	Introduction to Differential Equations				
1.1, 1.2, 1.3	Definitions, Introduction to Modeling				
2	Equations Of First Order				
2.1, 2.2, 2.3	The Linear Equation, Applications				
2.4	Separable Equations				
2.5	Exact Equations and Integrating Factors				
3	Linear Differential Equations of Second Order and Higher				
3.1, 3.2	Linear Dependence and Linear Independence				
3.3	Homogeneous Equation: General Solution				
3.4	Solution of Homogeneous Equation: Constant Coefficients				
3.5	Application to Harmonic Oscillator: Free Oscillation				
3.6	Solution of Homogeneous Equation: Nonconstant Coeff.s				
3.7	Solution of Nonhomogeneous Equation				
3.8	Application to Harmonic Oscillator: Forced Oscillation				
3.9	Systems of Linear Differential Equations				
4	Power Series Solutions				
4.1, 4.2	Power Series Solutions				
4.3	The Method of Frobenius				
4.4	Legendre Functions				
4.5	Singular Integrals; Gamma Function				
4.6	Bessel Functions				
5	Laplace Transform				
5.1, 5.2	Calculation of the Transform				
5.3	Properties of the Transform				
5.4	Application to the Solution of Differential Equations				
5.5	Discontinuous Forcing Functions; Heaviside Step Function				
5.6	Impulsive Forcing Functions; Dirac Impulse Function				
5.7	Additional Properties				
6	Quantitative Methods: Numerical Solution of Differential Equations				
6.1, 6.2	Euler's Method				
6.3	Improvements: Midpoint Rule and Runge-Kutta				
6.4	Application to Systems and Boundary Value Problems				
6.5	Stability and Difference Equations				
7	Qualitative Methods: Phase Plane and Nonlinear Differential Equations				
7.1, 7.2	The Phase Plane				
7.3, 7.4	Singular Points and Stability, Applications				
7.5	Limit Cycles, van der Pol equation, ...				
7.6	The Duffing Equation: Jumps and Chaos				
8	Systems of Linear Algebraic Equations: Gauss Elimination				
8.1, 8.2	Preliminary Ideas and Geometrical Approach				
8.3	Solution by Gauss Elimination				
9	Vector Space				
9.1, 9.2	Vectors; Geometrical Representation				
9.3	Introduction of Angle and Dot Product				
9.4, 9.5	n -Space, Dot Product, Norm, and Angle for n -Space				
9.6	Generalized Vector Space				
9.7	Span and Subspace				
9.8	Linear Dependence				
9.9	Bases, Expansions, Dimension				
9.10	Best Approximation				

APMA 6410-Review.Beginning.Engr.Math.I Greenberg's Adv.Engr.Math.

Section	Topic	Problem On Beginning Review Test	Average %	Proficiency Rating	Objectives/ Outcomes Evaluated
10	Matrices and Linear Equations				
10.1, 10.2	Matrices and Matrix Algebra				
10.3, 10.4	The Transpose Matrix, Determinants				
10.5	Rank; Application to Linear Dependence, to Existence and Uniqueness for $\mathbf{Ax} = \mathbf{c}$				
10.6	Inverse Matrix, Cramer's Rule, Factorization				
10.7, 10.8	Change of Basis, Vector Transformation				
11	The Eigenvalue Problem				
11.1, 11.2	Solution Procedure and Applications				
11.3, 11.4	Symmetric Matrices, Diagonalization				
11.5	Application to First Order Systems with Constant Coefficients				
11.6	Quadratic Forms				
12	Extension to Complex Case				
12.1, 12.2	Complex n -Space				
12.3	Complex Matrices				
13	Differential Calculus of Functions of Several Variables				
13.1,13.2	Preliminaries				
13.3	Partial Derivatives				
13.4	Composite Functions and Chain Differentiation				
13.5	Taylor's Formula and Mean Value Theorem				
13.6	Implicit Functions and Jacobians				
13.7	Maxima and Minima				
13.8	Leibniz Rule				
14	Vectors In 3-Space				
14.1, 14.2	Dot and Cross Product				
14.3	Cartesian Coordinates				
14.4	Multiple Products				
14.5	Differentiation of a Vector Function of a Single Variable				
14.6	Non-Cartesian Coordinates				
15	Curves, Surfaces, and Volumes				
15.1, 15.2	Curves and Line Integrals				
15.3	Double and Triple Integrals				
15.4	Surfaces				
15.5	Surface Integrals				
15.6	Volumes and Volume Integrals				
16	Scalar and Vector Field Theory				
16.1, 16.2, 16.3	Preliminaries; Divergence				
16.4, 16.5	Gradient; Curl				
16.6	Combinations; Laplacian				
16.7	Non-Cartesian Systems; Div, Grad, and Laplacian				
16.8	Divergence Theorem				
16.9	Stokes's Theorem				
16.10	Irrotational Fields				

APMA 6410 – Engineering Math. I Haberman’s Appl.PDEs...4th Ed

Section	Topic	Problem On Final Exam	Wgt %	Average %	Proficiency Rating	Objectives/ Outcomes Evaluated
1	Heat Equation					
1.1, 1.2	Derivation of the Conduction of Heat in a 1D Rod					
1.3	Boundary Conditions					
1.4	Equilibrium Temperature Distribution					
1.5	Derivation of the Heat Equation in 2D and 3D					
2	Method of Separation of Variables					
2.1, 2.2	Linearity					
2.3	Heat Equation with Zero Temperatures at Finite Ends					
2.4	Heat Equation: Other Boundary Value Problems					
2.5	Laplace’s Equation: Solutions and Properties					
3	Fourier Series					
3.1, 3.2	Statement of Convergence Theorem					
3.3	Fourier Cosine and Sine Series					
3.4	Term-by-Term Differentiation of Fourier Series					
3.5	Term-by-Term Integration of Fourier Series					
4	Wave Equation: Vibrating Strings and Membranes					
4.1, 4.2	Derivation of a Vertically Vibrating String					
4.3	Boundary Conditions					
4.4	Vibrating String with Fixed Ends					
4.5	Vibrating Membrane					
5	Sturm-Liouville (SL) Eigenvalue Problems					
5.1, 5.2, 5.3	Examples, SL Eigenvalue Problems					
5.4	Heat Flow in A Nonuniform Rod without Sources					
5.5	Self-Adjoint Operators, SL Eigenvalue Problems					
5.6	Rayleigh Quotient					
5.7	Vibrations of a Nonuniform String					
5.8	Boundary Conditions of the Third Kind					
5.9	Large Eigenvalues (Asymptotic Behavior)					
5.10	Approximation Properties					
6	Finite Difference Numerical Methods of Partial Differential Equations					
6.1, 6.2	Finite Differences and Truncated Taylor Series					
6.3	Heat Equation					
7	Higher Dimensional Partial Differential Equations					
7.1, 7.2	Separation of the Time Variable					
7.3	Vibrating Rectangular Membrane					
7.4	Statements and Illustrations of Theorems					
7.5	Green’s Formula, Self-Adjoint Operators, Multidimensional Eigenvalue Problems					
7.6	Rayleigh Quotient and Laplace’s Equation					
7.7, 7.8	Vibrating Circular Membrane, Bessel Functions					
7.9	Laplace’s Equation in a Circular Cylinder					
7.10	Spherical Problems and Legendre Polynomials					
8	Nonhomogeneous Problems					
8.1, 8.2	Heat Flow with Sources and Nonhomogeneous Boundary Conditions (BCs)					
8.3	Method of Eigenfunction Expansion - Homogeneous BCs (Differentiating Series of Eigenfunctions)					
	Final Exam Average					
	Number of Students Who Passed Final Exam/Course	/				
	Number of Students Who Failed Final Exam/Course	/				

Excellent ($\geq 90\%$)

Good (75 – 89 %)

Fair (60 – 74 %)

Poor (< 60 %)

APMA 6420 – Engineering Mathematics II Haberman’s Applied PDEs ... 4th Ed

Section	Topic	Problem On Final Exam	Wgt %	Average %	Proficiency Rating	Objectives/ Outcomes Evaluated
6	Finite Difference Numerical Methods for Partial Differential Equations					
6.1, 6.2	Finite Differences and Truncated Taylor Series					
6.3	Heat Equation					
8	Nonhomogeneous Problems					
8.1, 8.2	Heat Flow with Sources and Nonhomogeneous Boundary Conditions (BCs)					
8.3	Method of Eigenfunction Expansion - Homogeneous BCs (Differentiating Series of Eigenfunctions)					
8.4	Method of Eigenfunction Expansion Using Green’s Formula (With or Without Homogeneous BCs)					
8.5	Forced Vibrating Membranes and Resonance					
8.6	Poisson’s Equation					
9	Green’s Functions for Time-Independent Problems					
9.1, 9.2	One-dimensional Heat Equation					
9.3	Green’s Functions for Boundary Value Problems for Ordinary Differential Equations					
9.4	Fredholm Alternative and Generalized Green’s Functions					
9.5	Green’s Functions for Poisson’s Equation					
10	Infinite Domain Problems: Fourier Transform Solutions of Partial Differential Equations					
10.1, 10.2	Heat Equation on an Infinite Domain					
10.3	Fourier Transform Pair					
10.4	Fourier Transform and the Heat Equation					
10.5	Fourier Sine and Cosine Transforms					
10.6	Worked Examples Using Transforms					
11	Green’s Functions for Wave and Heat Equations					
11.1, 11.2	Green’s Functions for the Wave Equations					
11.3	Green’s Functions for the Heat Equation					
13	Laplace Transform Solution of Partial Differential Equations					
13.1, 13.2	Properties of the Laplace Transform					
13.3	Green’s Functions for Initial Value Problems for Ordinary Differential Equations					
13.4	A Signal Problem for the Wave Equation					
13.5	A Signal Problem for a Vibrating String of Finite Length					
13.6	The Wave Equation and its Green’s Function					
13.7	Inversion of Laplace Transforms Using Contour Integrals in the Complex Plane					
13.8	Solving the Wave Equation Using Laplace Transforms (with Complex Variables)					
	Final Exam Average					
	Number of Students Who Passed Final Exam/Course	/				
	Number of Students Who Failed Final Exam/Course	/				

Excellent ($\geq 90\%$)

Good (75 – 89 %)

Fair (60 – 74 %)

Poor ($< 60\%$)

APMA 6430 – Statistics for Engr.s & Sci. Milton & Arnold’s Intr. Prob. & Stat.s

Section	Topic	Problem On Final Exam	Wgt %	Average %	Proficiency Rating	Objectives/ Outcomes Evaluated
1	Introduction to Probability and Counting					
1.1, 1.2, 1.3	Sample Spaces, Events, Permutations, Combinations					
2	Some Probability Laws					
2.1, 2.2	Axioms, Conditional Probability					
2.3, 2.4	Independence, Bayes’ Theorem					
3	Discrete Distributions					
3.1, 3.2	Random Variables, Discrete Probability Densities					
3.3, 3.4	Expectation, Geometric Distr., Moment Generating Fct.					
3.5 - 3.9	Binomial, Neg. Binom., Hypergeom., Poisson Distr.s, ...					
4	Continuous Distributions					
4.1, 4.2	Densities, Expectation, Distribution Parameters					
4.3, 4.4	Gamma, Exponential, Chi-Squared, Normal Distr.s					
4.5, 4.6, 4.7	Chebyshev’s Inequality, Weibull Distr. and Reliability					
4.8, 4.9	Transform. of Variables, Simulating a Continuous Distr.					
5	Joint Distributions					
5.1, 5.2	Joint Densities, Independence, Expectation, Covariance					
5.3, 5.4, 5.5	Correlation, Conditional Densities, Regression, ...					
7	Estimation					
7.1, 7.2	Point Estimation, Method of Moments, Max. Likelihood					
7.3, 7.4	Functions of Random Var.s, Interval Estimation, CLT					
8	Inferences on the Mean & Variance of a Distribution					
8.1	Interval Estimation of Variability					
8.2	Estimating the Mean, the Student- <i>t</i> Distribution					
8.3 - 8.6, 8.7	Hypothesis Testing, Significance Testing, ...					
9	Inferences on Proportions					
9.1, 9.2	Estimating & Testing Hypotheses on a Proportion					
9.3, 9.4	Comparing Proportions: Estimation, Hypothesis Testing					
10	Comparing Two Means and Two Variances					
10.1	Point Estimation: Independent Samples					
10.2	Comparing Variances: The <i>F</i> Distribution					
10.3, 10.4	Comparing Means: Variances Equal and Unequal					
10.5	Comparing Means: Paired Data					
10.6	Alternative Nonparametric Methods					
11	Simple Linear Regression and Correlation					
11.1, 11.2	Model - Parameter Estimation, Least-Squares Estimators					
11.3	Confidence Interval Estimation and Hypothesis Testing					
11.4 - 11.6	Rep. Meas.s, Lack of Fit, Residual Analysis, Correlation					
13	Analysis of Variance					
13.1	One-Way Classification Fixed-Effects Model					
13.2 - 13.4	Comparing Variances, Pairwise Comp.s, Test Contrasts					
13.5 - 13.9	Randomized Block Design, Random-Effects Models, ...					
16	Statistical Quality Control					
16.1 - 16.3	Control Charts					
16.4 - 16.7	Tolerance Limits, Acceptance Sampling, ...					
	Final Exam Average					
	Number of Students Who Passed Final Exam/Course	/				
	Number of Students Who Failed Final Exam/Course	/				

Excellent ($\geq 90\%$)

Good (75 – 89 %)

Fair (60 – 74 %)

Poor (< 60 %)

APMA-Math.Prep.for.Grad.Engr. Greenberg's Adv. Engr. Math. 2nd Ed

Section	Topic	Problem On Final Exam	Problem Average	Proficiency Rating	Goals Evaluated
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1.1, 1.2, 1.3	Definitions, Introduction to Modeling				
2	Equations Of First Order				
2.1, 2.2, 2.3	The Linear Equation, Applications				
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7	Qualitative Methods: Phase Plane and Nonlinear Differential Equations				
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7.5	Limit Cycles, van der Pol equation, ...				
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9.4, 9.5	n -Space, Dot Product, Norm, and Angle for n -Space				
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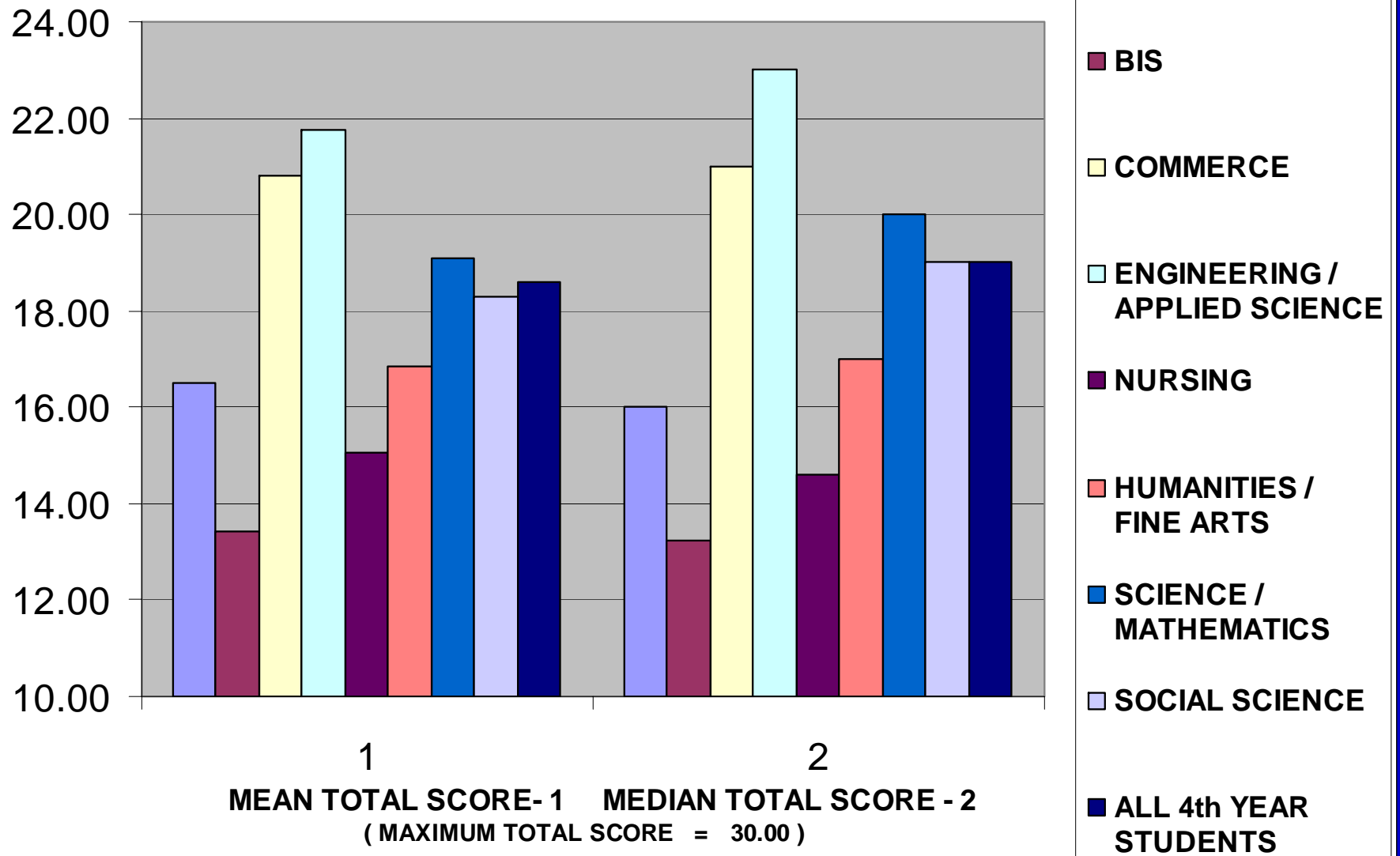
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14.5	Differentiation of a Vector Function of a Single Variable				
14.6	Non-Cartesian Coordinates				
15	Curves, Surfaces, and Volumes				
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15.6	Volumes and Volume Integrals				
16	Scalar and Vector Field Theory				
16.1, 16.2, 16.3	Preliminaries; Divergence				
16.4, 16.5	Gradient; Curl				
16.6	Combinations; Laplacian				
16.7	Non-Cartesian Systems; Div, Grad, and Laplacian				
16.8	Divergence Theorem				
16.9	Stokes's Theorem				
16.10	Irrotational Fields				
					PAGE 2 of 2
	Final Exam Average				
	Number of Students Who Passed Final Exam/Course	/			
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- Assessing mathematics ability / quantitative reasoning? How competent are our SEAS undergraduates?
- In the 2008 University-wide Mathematics Quantitative Reasoning Test / Assessment, SEAS students scored the highest and were Number 1 across the University (Office of Institutional Assessment and Studies).

Excellence demonstrated by SEAS students: Highest Score and Number 1 Rating in the 2008 University-wide Mathematics Quantitative Reasoning Testing / Assessment

This past year in the 2008 University-wide Mathematics Quantitative Reasoning Testing / Assessment, the School of Engineering and Applied Science students scored the highest and excelled with the Number 1 rating among the students in all Schools across the University – spanning Architecture [ARCH], Continuing and Professional Studies [BIS], Commerce [COMM], Engineering and Applied Science [SEAS], Nursing [NU], Humanities and Fine Arts [CLAS], Science/Mathematics [CLAS], and Social Science [CLAS]. The bar graph, that follows, illustrates the “Mean” and “Median” total scores and the highest performance and Number 1 rating demonstrated by the SEAS students in comparison with other Schools’ students, such as Science/Mathematics majors in CLAS.

U.Va. Quantitative Reasoning, 2008



- In the student evaluations completed online at the end of each semester, are APMA courses and the professors teaching APMA courses rated highly on average?
- Final Exams in APMA Courses available (representative final exams), if requested? Information Exchange, after today?

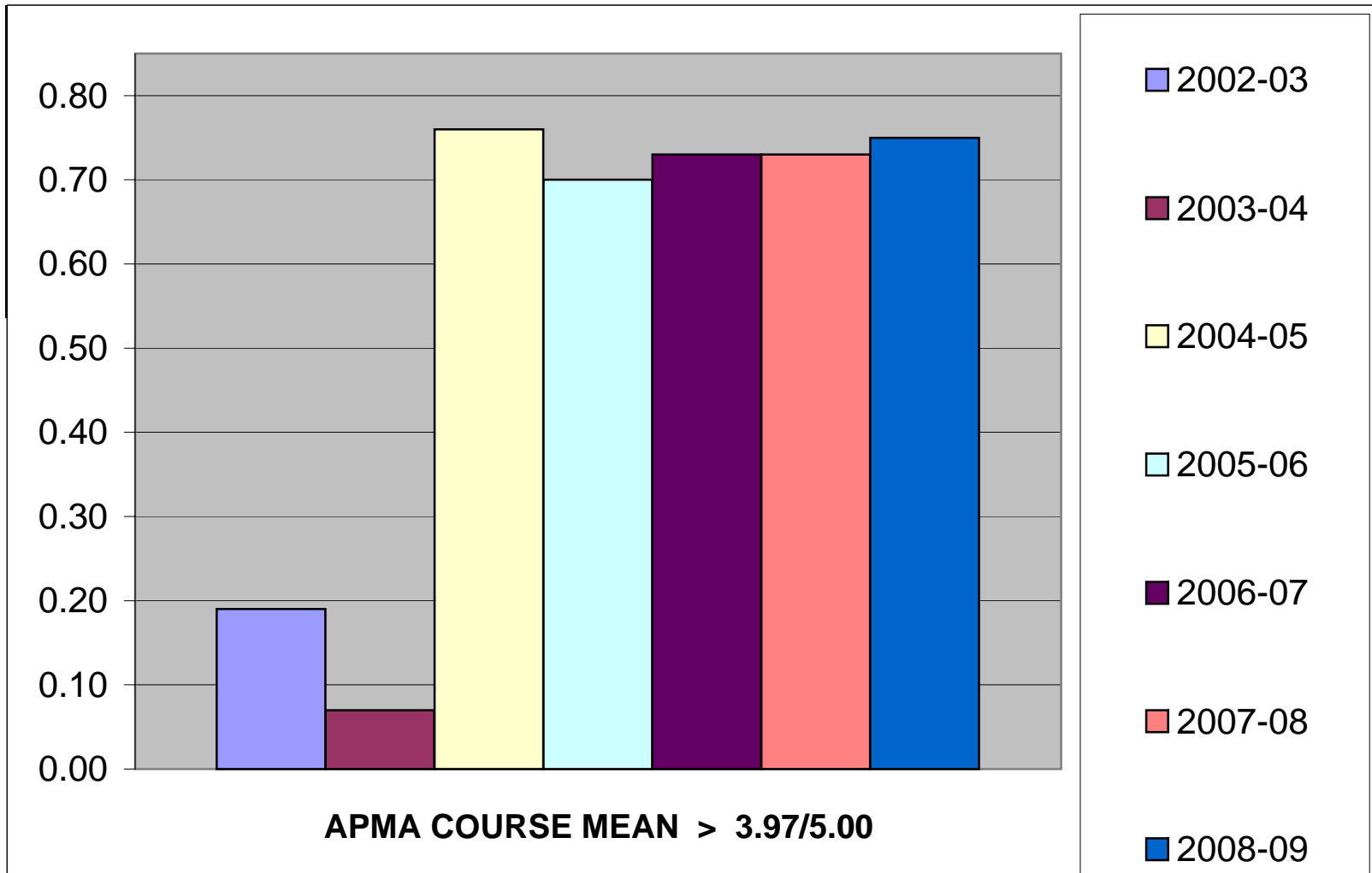
High Ratings of APMA Courses and the Professors teaching APMA Courses

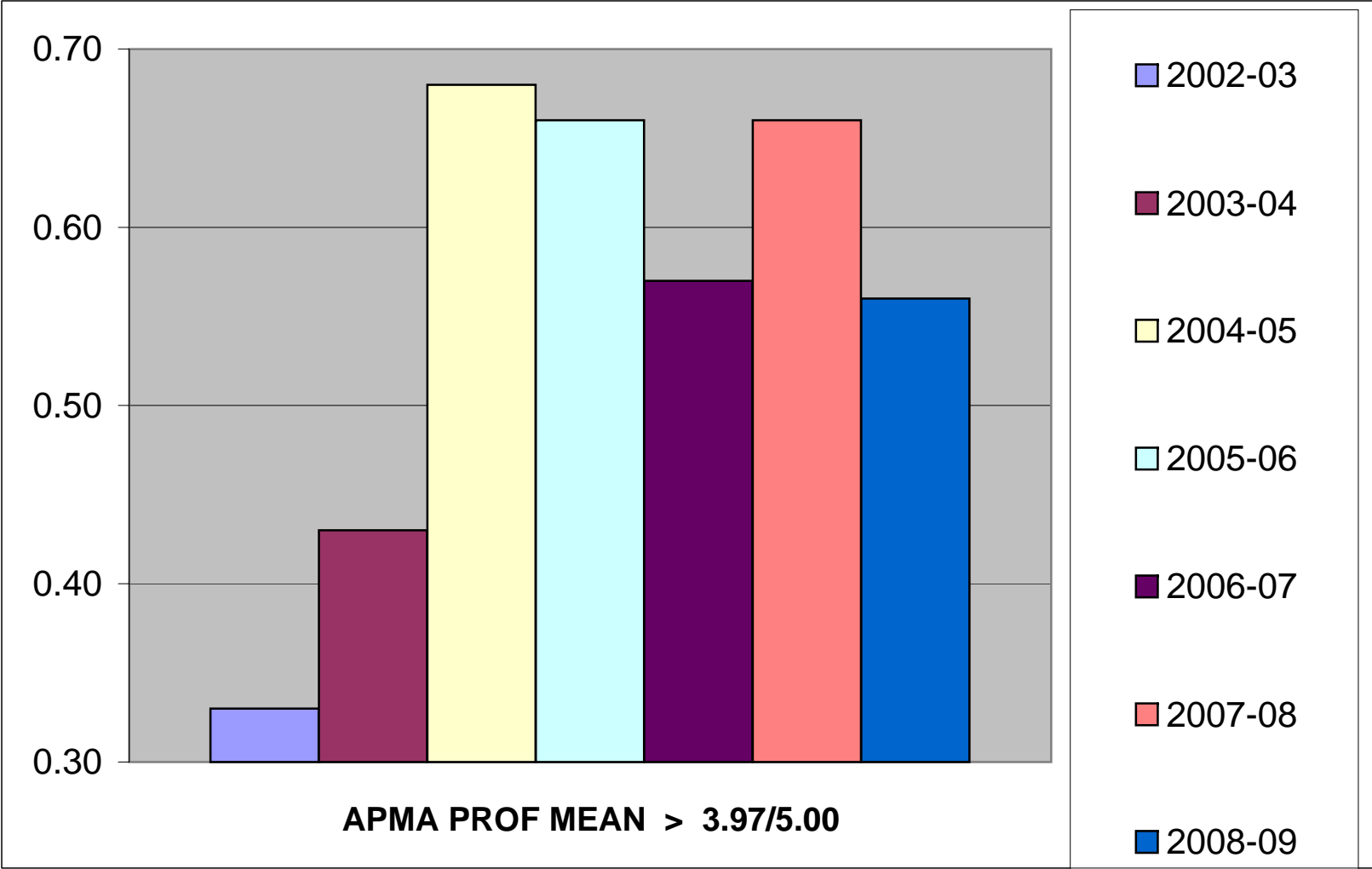
SEAS students generally seem to appreciate the APMA Program and on the whole give high ratings to the APMA Courses and to the Professors teaching APMA Courses in their course/instructor evaluations. The four bar graphs that follow, with data taken from the SEAS students' course/instructor evaluations, illustrate the high ratings of APMA courses and the Professors teaching APMA courses during 2008-09 and also over the five-year period 2004-09, since Summer of 2004 when considerable APMA improvements were initiated.

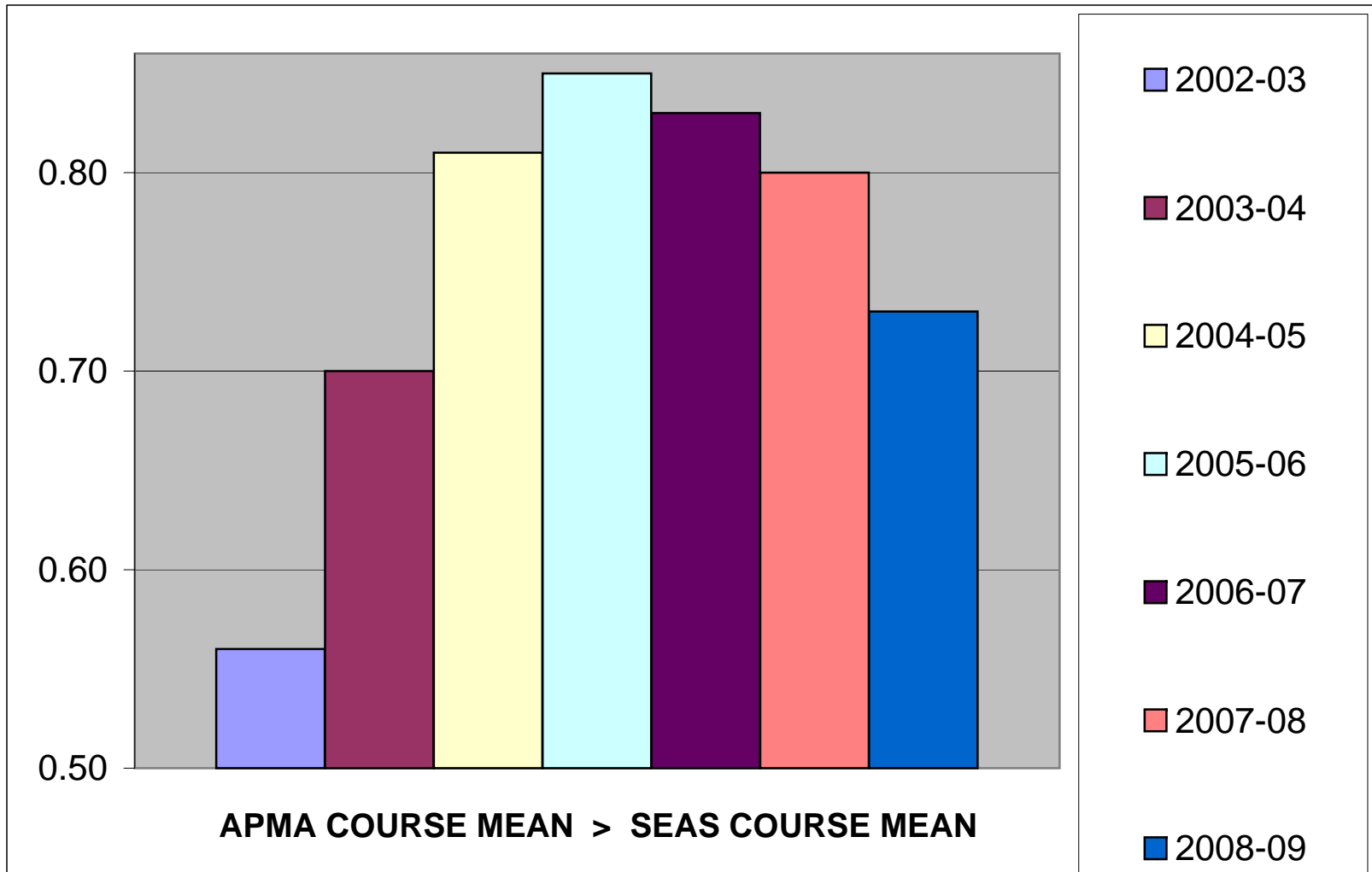
Specifically in the first bar graph that follows, a comparison of the "APMA Course Means" reveals that 75 percent, 73 percent, 73 percent, 70 percent, and 76 percent of the "APMA Course Means" were greater than or equal to the "long-term" average value of 3.97 / 5.00 for the 2008-09, 2007-08, 2006-07, 2005-06, and 2004-05 academic years respectively, compared to a corresponding 7 percent and 19 percent for the 2003-04 and 2002-03 academic years.

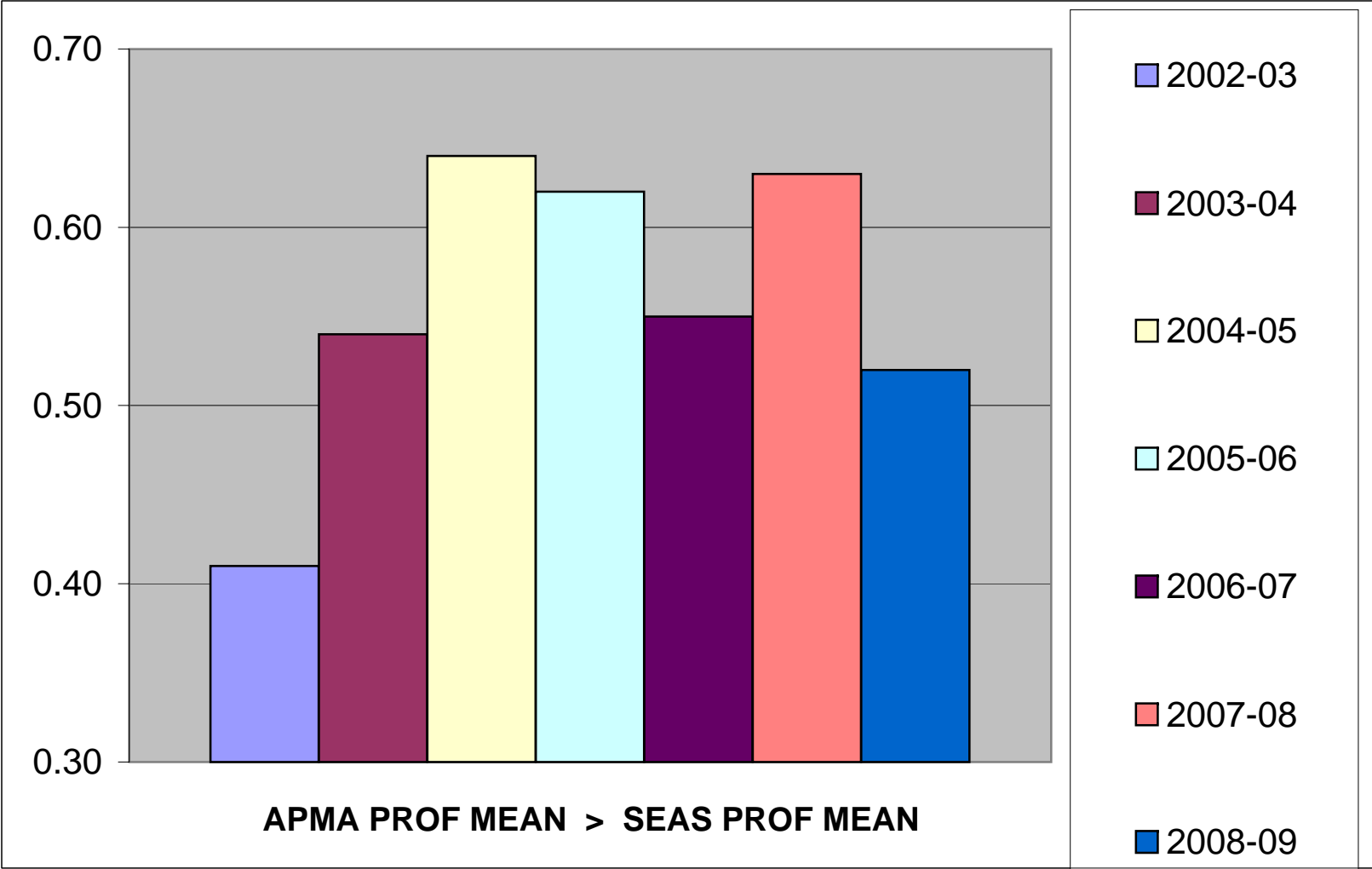
Similarly in the second bar graph that follows, a comparison of the "APMA Professor Means" reveals that 56 percent, 66 percent, 57 percent, 66 percent, and 68 percent of the "APMA Professor Means" were greater than or equal to the "long-term" average value of 3.97 / 5.00 for the 2008-09, 2007-08, 2006-07, 2005-06, and 2004-05 academic years respectively, compared to a corresponding 43 percent and 33 percent for the 2003-04 and 2002-03 academic years.

In the third and fourth bar graphs that follow, similar comparisons are made with respect to the baseline of the SEAS means, which vary somewhat from semester to semester, rather than with respect to the baseline of the "long-term" average value of 3.97 / 5.00. Again striking are the high ratings for APMA courses and the Professors teaching APMA courses during 2008-09 and also over the five-year period 2004-09.









- Caution: What is the importance of insuring high quality VCCS mathematics instruction?
- Caution: Uncertainty in the quality of the mathematics instruction for some summer transfer credit courses, where the coverage is limited and sometimes compressed or crammed into as few as 10 to 12 meeting times of 3 to 4.5 hours each?

Cautions: Uncertainty

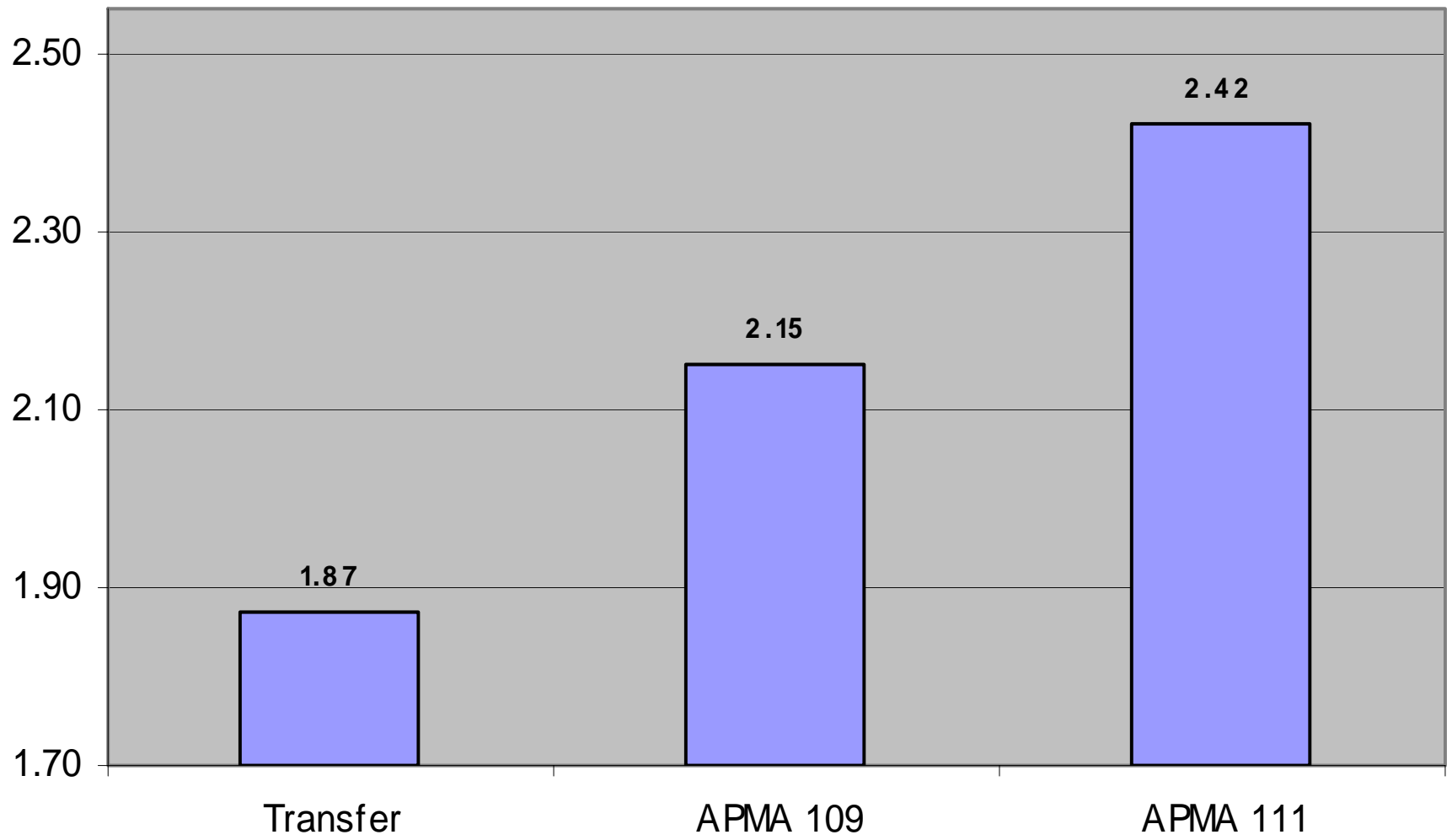
There is considerable uncertainty in the quality of the mathematics instruction provided by summer transfer-credit courses taken by SEAS students at a number of community colleges in VCCS and other institutions, particularly where in the summer the coverage is limited and the effective instruction is compressed into as few as 10 to 12 meeting times of crammed lecture sessions of 3 to 4.5 hours each. Complaints have been received from a number of our SEAS students, upon returning from such transfer-credit summer instruction, that they have found themselves not well prepared for our higher-level SEAS courses.

In efforts to look out for the best interests of our SEAS students and to avoid complaints on the weakness of their transfer-credit backgrounds both from these students and from our faculty teaching higher-level SEAS courses, there is some discussion toward asking (1) that all such compressed and crammed summer transfer-credit mathematics courses be removed from the transfer-credit-course approval list (where those courses referenced are actually corresponding academic-year courses, which are not the ones compressed and crammed during regular academic semesters and which are not the cause of concern) and (2) that such compressed and crammed summer transfer-credit mathematics courses not be granted approvals in the future starting with Summer 2010.

For those students who insist on taking such compressed and crammed summer mathematics courses or insist on taking summer mathematics courses online where the proctoring of Tests and Final Exams are not guaranteed to be proctored by the institutions, it requested that these students be asked to take, upon their return, one or another of the APMA Placement Exams and be required to pass in order to gain such transfer credit approvals.

As an example from a previous semester, one such complaint came from a SEAS faculty member who complained that the students in his MEC 321 Fluid Mechanics course were weak in their background in Vector Calculus. After calling a meeting of all instructors of APMA 212, where the Vector Calculus is taught, for the purpose of airing the complaint, the APMA Director's Office worked to revise the APMA 212 Course Summary Table and implemented it in future semesters with an additional extra week of focus on the Vector Calculus included. Also, in a follow-up effort to try to understand more fully the complaint, the APMA Director's Office retrieved the final letter grades received by the MAE 321 students at the end of that semester, converted them into equivalent MAE 321 GPAs for all the MAE 321 students, and then reordered the students into the following subgroups: (1) those SEAS students starting in APMA 109 (22 students), those SEAS students starting in APMA 111 (42; their somewhat stronger mathematics backgrounds qualified them to start with APMA 111 as entering first year students), and transfer students (33 students). The bar graph, that follows, illustrates the equivalent MAE 321 students' average GPA in each of these three subgroups.

MAE 321 Fluid Mechanics



Of the 33 transfer students, 22 had not taken APMA 212 in SEAS but instead had been granted approval for transfer-credit multivariable Calculus taken elsewhere, ten others had been granted transfer-credit approval for both APMA 109 and 111 taken elsewhere, and the remaining one had been granted transfer-credit approval for only APMA 111 taken elsewhere. It is evident that the group of students, who performed most weakly in MAE 321 Fluid Mechanics, was the group of transfer students (average GPA of only 1.87 / 5.00 in the D to C range).