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### **MTH 170 Statistics (3)**

This is an introductory course in descriptive and inferential statistics, approached through intuition, algebra, and problem solving. Understanding of central concepts and methods is stressed. Practical applications in the fields of social and physical sciences are studied. Real-world problems are solved through use of statistical computer packages such as SPSS, SAS, or MINITAB. Prerequisites: MTH 105 and computer literacy.

#### **Student Learning Outcomes**

*Students will:*

1. Be able to organize and present quantitative data in numerical and visual formats. Section 1: Chapters 1-3  
Organization and presentation of quantitative data.
2. Understand and apply the normal distribution. Section 2: Chapter 6
3. Sampling and statistical inference
4. Be able to compute confidence intervals using sample data
5. Be able to state appropriate hypotheses and test these hypotheses using sample data. Section 3: Chapters 7-8
6. Be able to perform the following tests: goodness of fit, regression and ANOVA. Section 4: Chapters 10-11

#### **Course Topics**

##### Section 1

1. Understand the difference between statistical significance and practical significance.
2. Analyze sample data relative to context, source, and sampling method.
3. Identify a voluntary response sample and know that conclusions from such a sample are not valid.
4. Distinguish between a parameter and a statistic.
5. Distinguish between quantitative data and categorical (or qualitative or attribute) data.
6. Distinguish between discrete data and continuous data.
7. Determine which level of measurement is most appropriate.
8. Determine whether basic statistical calculations are appropriate for a particular data set.
9. Understand the importance of sound sampling methods and good design of experiments.
10. Differentiate between an observational study and an experiment.
11. Understand the different types of sampling methods.
12. Determine whether an observational study used is cross-sectional, retrospective, or prospective.
13. Define and identify a simple random sample.
14. Determine whether a frequency distribution is approximately a normal distribution.
15. Summarize data in the format of a frequency distribution and a relative frequency distribution.
16. Construct a cumulative frequency distribution.
17. Identify values of class width, class midpoint, class limits, and class boundaries.
18. Understand the concepts related to distributions.
19. Picture the distribution of data in the format of a histogram and examine.
20. Develop an ability to graph data using a dotplot, stemplot, and Pareto chart.
21. Determine when a graph is deceptive.
22. Understand concepts related to scatterplots and correlation
23. Construct and analyze a scatterplot of paired data



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24. Find and interpret correlation coefficients
25. Develop the ability to measure the center of data by finding the mean, median, mode, and midrange.
26. Determine whether an outlier has a substantial effect on the mean and median.
27. Interpret values of the standard deviation by applying the range rule of thumb.
28. Find values of the range, variance, and standard deviation.
29. Understand the concepts related to measures of variation.
30. Find the coefficient of variation of two samples and then compare the results.
31. Use the empirical rule or Chebyshev's theorem to estimate the variation in a sample.
32. Compute a z score and use it to determine whether a value is significant.
33. Identify percentile values and quartile values from a set of data.
34. Develop the ability to construct a boxplot from a set of data.

#### Section 2

1. Understand the uniform distribution
2. Understand the normal distribution and its properties
3. Know the definition of a critical value
4. Understand how to use z-scores
5. Compute probabilities from inequalities
6. Compute z-scores from probabilities
7. Understand the empirical rule
8. Understand Chebychev's Theorem
9. Understand sampling distributions
10. Know the definition of an unbiased estimator
11. Know which estimators are unbiased

#### Section 3

1. Be able to compute confidence intervals for proportions and means
2. Be able to compute sample sizes
3. Be able to perform hypothesis tests on proportions and means

#### Section 4

1. Be able to perform goodness of fit tests
2. Be able to perform ANOVA
3. Be able to perform post-hoc testing
4. Be able to perform a test of correlation
5. Be able to (and know when to) apply regression
6. Make estimates using regression



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### **MTH 211 Calculus II (4)**

The calculus of vector functions and functions of several variables. Prerequisite: MTH 211.

#### **Student Learning Outcomes**

*Students will:*

1. Apply Riemann integration to the concepts of volume and work.
2. Demonstrate an understanding of common techniques of integration.
3. Test convergence of infinite series using common series tests.
4. Represent, differentiate, and integrate functions as power series.
5. Represent curves both parametrically and in polar coordinates.
6. Demonstrate an understanding of the calculus of curves defined both parametrically and in polar coordinates.

#### **Course Topics**

1. Apply Riemann integration to the concepts of volume and work.
2. Demonstrate an understanding of common techniques of integration.
3. Test convergence of infinite series using common series tests.
4. Represent, differentiate, and integrate functions as power series.
5. Represent curves both parametrically and in polar coordinates.
6. Demonstrate an understanding of the calculus of curves defined both parametrically and in polar coordinates.



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### MTH 212 Calculus III (4)

The calculus of vector functions and functions of several variables. Prerequisite: MTH 211.

#### Student Learning Outcomes

Students will:

1. Understand and calculate with vectors in three dimensional space
2. Understand, calculate and apply vector functions
3. Understand, calculate and apply partial derivatives
4. Understand, calculate and apply multiple integrals

#### Course Topics

Section 1:

1. Add and scalar multiply vectors
2. Geometric interpretation of vectors
3. Magnitude of vectors and unit vectors
4. Projection
5. Dot product and its applications
6. Cross product and its applications
7. Equations of lines and planes
8. Distance between lines, points, and planes

Section 2:

1. Parametric and vector functions
2. Derivatives of vector functions
3. Integrals of vector functions
4. Arc length
5. The tangent, normal and binormal vectors
6. Osculating planes and the TNB frame
7. Curvature
8. Projectile motion

Section 3:

1. Functions of several variables
2. Limits and continuity
3. Graphing surfaces
4. Partial derivatives
5. The chain rule
6. Directional derivatives
7. Maxima and minimums

Section 4

1. Double Integrals over Rectangles
2. Iterated Integrals
3. Double Integrals over General Regions



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4. Double Integrals in Polar Coordinates
5. Applications of Double Integrals: Density, Mass and Moments of Inertia
6. Surface Area
7. Triple Integrals
8. Triple Integrals in Cylindrical and Spherical Coordinates



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### **MTH 320 Financial Mathematics (3)**

Interest rate measurement, annuities, loan repayment, bond valuation, measuring rate of return of investment, term structure of interest rates, cash flow duration and immunization, and other topics as found on Actuarial Exam FM/2.

Prerequisite: MTH 211.

#### **Student Learning Outcomes**

*Students will:*

1. Understand interest and interest rates.
2. Understand annuities.
3. Understand debt retirement methods

#### **Course Topics**

##### Section 1

1. Define and recognize the definitions of the following terms: interest rate (rate of interest), simple interest, compound interest, accumulation function, future value, current value, present value, net present value, discount factor, discount rate (rate of discount), convertible m-thly, nominal rate, effective rate, inflation and real rate of interest, force of interest, equation of value.
2. Given any three of interest rate, period of time, present value, current value, and future value, calculate the remaining item using simple or compound interest. Solve time value of money equations involving variable force of interest.
3. Given any one of the effective interest rate, the nominal interest rate convertible m-thly, the effective discount rate, the nominal discount rate convertible m-thly, or the force of interest, calculate any of the other items.
4. Write the equation of value given a set of cash flows and an interest rate.

##### Section 2

1. Define and recognize the definitions of the following terms: annuity-immediate, annuity due, perpetuity, payable m-thly or payable continuously, level payment annuity, arithmetic increasing/decreasing annuity, geometric increasing/decreasing annuity, term of annuity.
2. For each of the following types of annuity/cash flows, given sufficient information of immediate or due, present value, future value, current value, interest rate, payment amount, and term of annuity, calculate any remaining item. Level annuity, finite term; Level perpetuity; Non-level annuities/cash flows; Arithmetic progression, finite term and perpetuity.

##### Section 3

1. Define and recognize the definitions of the following terms: principal, interest, term of loan, outstanding balance, final payment (drop payment, balloon payment), amortization.
2. Calculate: • The missing item, given any four of: term of loan, interest rate, payment amount, payment period, principal. • The outstanding balance at any point in time. • The amount of interest and principal repayment in a given payment. • Similar calculations to the above when refinancing is involved



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3. Define and recognize the definitions of the following terms: price, book value, amortization of premium, accumulation of discount, redemption value, par value/face value, yield rate, coupon, coupon rate, term of bond, callable/non-callable.
4. Given sufficient partial information about the items listed below, calculate any of the remaining items • Price, book value, amortization of premium, accumulation of discount. (Note that valuation of bonds between coupon payment dates will not be covered). • Redemption value, face value. • Yield rate. • Coupon, coupon rate. • Term of bond, point in time that a bond has a given book value, amortization of premium, or accumulation of discount



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## MTH 340 Probability (3)

Probability axioms, random variables, commonly used discrete and continuous distributions, expectation, moment generating functions, transformations, and multivariate distributions. Prerequisite: MTH 211 or instructor consent.

### Student Learning Outcomes

Students will:

1. Probability
2. Discrete distributions
3. Continuous distributions
4. Bivariate distributions
5. Distributions of functions of random variables

### Course Topics

1. Probability
2. Multiplication rule
3. Permutations
4. Combinations
5. Sets, Venn Diagrams
6. Conditional Probability
7. Bayes theorem
8. Discrete distributions
9. Bernoulli, Binomial, Geometric, Negative binomial, Hypergeometric
10. Applications of discrete distributions
11. Expected values
12. Special expectations
13. Moment generating functions
14. Continuous distributions
15. Uniform, normal, gamma, exponential
16. Expected values
17. Special expectations
18. Moment generating functions
19. Bivariate distributions
20. Marginal distributions
21. Correlation
22. Conditional distributions
23. Expectation
24. Functions of random variables
25. Functions of random variables
26. Central limit theorem
27. Transformations





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### **MTH 341 Applied Statistics (4)**

The concepts of sampling distributions with random sampling and statistical inference. The main methods of estimation and the properties of estimators: matching moments, percentile matching, and maximum likelihood. The construction of confidence intervals for the mean, differences of two means, variances, and proportions. Hypothesis testing for the mean, variance, contingency tables, goodness of fit, and regression models. Prerequisite: MTH 211 or instructor consent.

#### **Student Learning Outcomes**

*Students will:*

1. Point Estimation
2. Interval Estimation
3. Hypothesis Tests
4. More Tests

#### **Course Topics**

1. Point Estimation
2. Theoretical distributions
3. Histograms and other plots
4. Order statistics and other descriptive statistics
5. Maximum likelihood estimators, method of moments
6. Unbiased estimators (sampling distributions), sufficient statistics, and the Rao-Blackwell Theorem
7. Interval estimation
8. Confidence intervals for means
9. Confidence intervals for proportions
10. Confidence intervals for paired means
11. Confidence intervals for two populations
12. Confidence intervals for regression
13. Confidence intervals for variance
14. Distribution free confidence intervals
15. Sample sizes
16. Hypothesis Tests
17. Means
18. Proportions
19. Two means
20. Two proportions
21. Power and sample size
22. Wilcoxon signed rank test
23. More tests
24. Correlation
25. Regression
26. Goodness of fit
27. Test of independence



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28. 1 and 2 factor anova



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### **MTH 344 Statistical Learning (4)**

Multiple regression, classification and resampling methods. Linear model selection, tree-based methods, and unsupervised learning. Prerequisite: MTH 341 or instructor consent.

#### **Student Learning Outcomes**

*Students will:*

1. Linear Regression
2. Classification
3. Resampling and model selection
4. Non-linear Modeling
5. Unsupervised learning

#### **Course Topics**

1. Linear Regression
2. Simple linear regression
3. Multiple linear regression
4. Assessing model fit
5. Qualitative predictors
6. Extensions of the linear model
7. Diagnostics
8. Classification
9. Logistic regression
10. Linear discriminant analysis
11. Quadratic discriminant analysis
12. Comparison of the methods
13. K-nearest neighbors
14. Resampling and model selection
15. Subset selection
16. Shrinkage methods: the lasso and ridge regression
17. Dimension reduction: PCA
18. Considerations of high dimensional data
19. Non-linear Modeling
20. Polynomial regression
21. Step and Basis functions
22. Regression splines
23. Smoothing splines
24. Generalized additive models
25. Unsupervised learning and trees
26. Decision trees
27. Bagging, random forests, boosting
28. Support vector machines



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29. PCA and clustering



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### **MTH 360 Linear Algebra (3)**

An introduction to the techniques of linear algebra. Topics include vector spaces, linear independence, basis, dimension, linear transformations, eigenvalues, and eigenvectors. Prerequisite MTH 300 or instructor consent.

#### **STUDENT LEARNING OUTCOMES**

*Students will:*

1. Systems of equations
2. Matrix algebra
3. Vector spaces
4. Eigensystems
5. Dot product

#### **Course Topics**

1. Systems of equations
2. Row reduction
3. Reduced row echelon form
4. Vector equations
5. Matrix equations
6. Solution sets
7. Applications
8. Linear Transformations
9. Matrix Algebra
10. Matrix Multiplication
11. Inverses
12. Invertible characterizations
13. Determinants
14. Properties of determinants
15. Applications of determinants
16. LU factorization
17. Vector spaces
18. Null and column space
19. Basis
20. Dimension and rank
21. Change of basis
22. Eigensystems
23. Eigenvectors
24. Characteristic equations
25. Diagonalization
26. Applications
27. Dot product
28. Orthogonal sets



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29. Orthogonal projection
30. Gram Schmidt
31. SVD decomposition
32. Application: least squares



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### **MTH 375 Discrete Models (3)**

An introduction to the methods of discrete mathematics. Topics include linear and non-linear models. With a focus on recurrence relations, long term behavior, and the use of technology to model real-world phenomena. Prerequisite: MTH 210 or instructor consent.

#### **Student Learning Outcomes**

*Students will:*

1. Modeling and proportionality
2. Linear Models
3. Discrete Dynamical Systems
4. Simulations

#### **Course Topics**

1. Modeling and proportionality
2. Mathematical models (Process and definitions)
3. Proportionality
4. Fitting data to proportional models
5. Using proportionality to construct mathematical models
6. Linear Models
7. Least squares
8. Exponential models (linearizable model)
9. Logarithmic models (linearizable model)
10. Power models (linearizable model)
11. Residuals and  $R^2$
12. Polynomial models
13. Multivariable models
14. Adjusted  $R^2$
15. Fitting data
16. Discrete Dynamical Systems
17. Non-homogenous linear discrete dynamical systems
18. Financial models
19. Logistic Models
20. Modeling populations
21. Equilibrium values
22. Long term behavior analysis
23. Closed solutions
24. Two dimensional discrete dynamical systems
25. Predator-Prey models
26. Non-linear predator-prey models
27. SIR model
28. Simulations



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29. Random number generators
30. Estimating error
31. Simulation of the birthday problem
32. Simulation of the Monty Hall problem
33. Simulation of Buffon's Needle problem
34. Poker simulation
35. Simulation of random variables
36. Queuing Model