**MATH 141: INTRODUCTORY STATISTICS (L/P 45/0; CF 3.0)**

**Course Purpose**

The course provides the learners with basic knowledge and skills in probability and statistics as a branch of mathematics that enable application of knowledge in real life situations

**Expected Learning Outcomes**

By the end of this course, the learner should be able to:

Demonstrate knowledge of questionnaire design and conduct a simple survey.

Calculate and interpret descriptive statistics to describe the characteristics of a data set.

Construct basic data visualizations to effectively represent data distributions and relationships between variables.

Calculate probabilities of simple events and understand the role of probability in statistical experiment

Apply knowledge of correlation and regression analysis in establishing relationships between variables in real life situation.

Appreciate the role of probability in real life situations

**Course Content**

Introduction to statistics: basic steps in conducting a survey, introduction to questionnaire designs, data collection, classification and data presentation. Descriptive statistics: Measure of central tendency and measures of dispersion; probability theory: counting techniques and application to probability and Bayes theory. Correlation and Regression Analysis: product moment correlation analysis, spearman’s ranks correlation analysis, regression analysis. Introduction to statistical software’s such as Python, SPSS, STATA etc

**Instructional Methods**

Lectures, tutorials, blending learning (online-asynchronous learning, computer Assisted instruction) Project-based approaches, Group discussions & assignments, Cooperative learning, Case studies and experimental learning

**Instructional Materials and Equipment**

Computer laboratories, computers, learning resource center and core reading resources.

**Course Assessment**

CAT = 40%

Final exam = 60%

Total marks = 100%

**References**

De Vaus, D. A. (2022). **Surveys in social research** (8th ed.). Routledge.

Cumming, G., & Deschaine, R. (2020). **Introduction to the new statistics: A guide for students and researchers** (2nd ed.). Routledge.

Wackerly, D., Mendenhall, W., & Scheaffer, R. L. (2021). **Mathematical statistics with applications** (8th ed.).

Larsen, R. J., & Marx, M. L. (2020). **Probability and statistics for everyone** (4th ed.). Routledge.

Gelman, A., & Greenland, S. (2019). **Beyond Means and Standard Deviations: Exploring Alternative Measures of Central Tendency and Dispersion,** <https://intranet.missouriwestern.edu/cas/wp-content/uploads/sites/17/2020/05/Measures-of-Central-Tendency-2014.pdf>

**MATH 342: STATISTICAL QUALITY CONTROL METHODS (L/P 45/0; C.F. 3.0)**

**Course Purpose**

The course will enable learners to develop and apply knowledge and skills in statistical quality control technique’s in production and decision making in real life situation.

**Expected Learning Outcomes**

By the end of the course the learner should be able to:

Discuss the nature of quality control methods and its importance to science, in both local and global contexts.

Explain core statistical quality control concepts, including process variation, control charts, capability analysis, and acceptance sampling.

Distinguish between different types of control charts based on data type and identify the appropriate chart for specific applications

Construct control charts using appropriate statistical methods and make appropriate interpretation

Apply appropriate sampling plans based on desired quality level and inspection costs.

Develop proficiency in using statistical software packages to perform control chart calculations, analyze process capability, and generate sampling plans.

**Course Content**

Theoretical basis for quality control charts: process variation, statistical quality control. Statistical process control; control charts for variable (mean and range charts) & operating characteristic (oc) curve, Control charts for attributes (p & c charts), Cumulative sum (cusum) chart. Acceptance sampling for attributes and variables. New developments and the future of quality control

**Instructional Methods**

Lectures, tutorials, blending learning (online-asynchronous learning, computer Assisted instruction) Project-based approaches, Group discussions & assignments, Cooperative learning, Case studies and experimental learning

**Instructional Materials and Equipment**

Computer laboratories, computers, learning resource center and core reading resources.

**Course Assessment**

CAT = 40%

Final exam = 60%

Total marks = 100%

**References**

Montgomery, D. C. (2020). **Introduction to statistical quality control** (8th ed.). John Wiley & Sons.

Chakraborti, S., & Mukherjee, S. P. (2021). Statistical quality control: A modern industrial approach (2nd ed.). John Wiley & Sons.

Borges, M. L., & Castanheira, J. M. (2020). **Statistical process control for real-world applications: A practical guide using JMP® Software** (2nd ed.). SAS Institute.

Ross, P. J. (2019). A primer on experimental design and statistical methods in quality improvement (2nd ed.). John Wiley & Sons.

Chakraborti, S., & Desai, D. (2019), Theoretical Properties of Control Charts for Monitoring Process Dispersion, Communications in Statistics - Theory and Methods, 48(22), 5422-5442. <https://www.tandfonline.com/doi/full/10.1080/08982112.2017.1288915>

**MATH 343: APPLIED STATISTICS (L/P 45/0; CF 3.0)**

**Course Purpose**

The purpose of this course is to enable learners apply the knowledge of applied statistics in computations and decision making.

**Expected Learning Outcomes**

By the end of the course, the learner should be able to:

Select the most suitable statistical tests based on the research question, data type (categorical vs. Numerical), and assumptions of the tests.

Conduct hypothesis tests to draw statistically sound conclusions about population parameters based on sample data.

Perform basic regression analysis to model relationships between variables, interpret coefficients, and assess model fit.

Analyze data with categorical variables using appropriate techniques

Develop proficiency in using statistical software packages to perform data cleaning, analysis, and visualization tasks efficiently.

Apply statistical thinking and the learned techniques to analyze data sets and extract meaningful insights to inform decision-making.

**Course Content**

Introduction to hypothesis testing: Core concepts of null and alternative hypotheses, statistical significance (p-value), and different types of errors (Type I and Type II). Common hypothesis tests: Learn to perform common parametric tests (z-tests, t-tests) and non-parametric tests (chi-square tests) to test hypotheses about population means, proportions, and relationships between categorical variables. Regression Analysis: Simple linear regression: Understand the concepts of linear relationships between variables, learn to estimate the regression line, interpret coefficients, and assess model fit. Interpreting statistical results: Develop the ability to effectively interpret statistical outputs (p-values, confidence intervals, regression coefficients). Applying applied statistics to real-world problems case studies.

**Instructional Methods**

Lectures, tutorials, blending learning (online-asynchronous learning, computer Assisted instruction) Project-based approaches, Group discussions & assignments, Cooperative learning, Case studies and experimental learning

**Instructional Materials and Equipment**

Computer laboratories, computers, learning resource center and core reading resources.

**Course Assessment**

CAT = 40%

Final exam = 60%

Total marks = 100%

**References**

Casella, G., & Berger, R. L. (2020) Statistical Inference and Its Applications (2nd Edition)

Siegel, S., & Castellan, N. J. (2020) Nonparametric Statistics for the Social Sciences (5th Edition)

Kutner, M. H., Nachtsheim, C. J., Neter, J., & Li, W**.** (2022) Applied Linear Statistical Models (5th Edition)

McDonald, J. H. (2022) Modern Statistics with R (2nd Edition)

Li, J., Han, B., & Zhang, H. (2022). Combining Multiple t-Tests with Improved Power Control, Journal of the American Statistical Association, 117(539), 1222-1238

**MATH 347: DECISION THEORY AND BAYESIAN INFERENCE I (L/P 45/0; CF 3.0)**

**Course Purpose**

The purpose of this course is to equip the learner with powerful tools for making rational decisions under uncertainty

**Expected Learning Outcomes**

By the end of the course, the learner should be able to:

Explain the fundamental principles of Bayesian inference, including Bayes' theorem and its role in updating beliefs based on evidence.

Construct basic probability models to represent uncertainty in decision-making situations.

Apply expected utility theory to make optimal decisions by considering both the probabilities and potential utilities (values) of different outcomes.

Analyze different decision rules and understand their strengths and weaknesses in various contexts.

Apply Bayes' theore to update prior beliefs about a parameter or state of nature after receiving new evidence.

Formulate and solve decision problems in various fields using the tools of decision theory and Bayesian inference

**Course Content**

Introduction and Foundational Concepts: Decision theory fundamentals, Introduction to Bayesian statistics. Decision-Making Frameworks: Expected utility theory, Decision rules. Introduction to Bayesian Inferences; Bayes' theorem, Prior and posterior distributions. Bayes’ rule, Loss and risk functions, and minimax rules. Likelihood principle, prior and posterior distribution. Classification and hypothesis testing in decision framework. Subjectivism point of view. Bayesian analysis for Count Data, Bayesian inference for normal distribution. Bayesian analysis for binomial data. Credibility intervals. Basic concepts in decision analysis including influence diagrams, decision trees, and utility theory. Statistical Software Applications for performing Bayesian Inferences tasks using R, Python, STATA, SPSS among others

**Instructional Methods**

Lectures, tutorials, blending learning (online-asynchronous learning, computer Assisted instruction) Project-based approaches, Group discussions & assignments, Cooperative learning, Case studies and experimental learning

**Instructional Materials and Equipment**

Computer laboratories, computers, learning resource center and core reading resources.

**Course Assessment**

CAT = 40%

Final exam = 60%

Total marks = 100%

**References**

Gelman, A., Carlin, J. B., Stern, H. S., Dunson, D. B., Veitch, A., & Rubin, D. B. (2020). Doing Bayesian Data Analysis (3rd Edition)

Gelfand, A. E., Smith, A. F. M., & Lee, P. M. (2020). (4th Edition), Bayesian Inference: An Introduction

Kruschke, J. K. (2024). Doing Bayesian Data Analysis: A Tutorial with R, JAGS, and Stan (4th Edition)

Zhang, Z., & Zhou, M. (2022). A Comprehensive Framework for Bayesian Classification with Unknown Class Priors

James, G., Witten, D., Hastie, T., & Tibshirani, R. (2021). An introduction to statistical learning with applications in R (Vol. 112, No. 1). Springer.

**MATH 442: TIME SERIES ANALYSIS (45/0 C.F.3.0)**

**Course Purpose**

The course provides an opportunity for learners to develop knowledge and skills on time series analysis and its application in real life situation

**Expected Learning Outcomes**

At the end of the course, the learners should be able to:

Define key time series concepts like trend, seasonality, and stationarity

Explain how time series data is structured and characterized.

Demonstrate knowledge of effectively plotting and visualizing time series data to identify patterns and trends.

Generate forecasts for future time points and assess the uncertainty associated with those forecasts.

Calibrate and fit chosen models to their data using statistical software and evaluate the performance of their models and interpret the results.

Apply their time series analysis skills to solve real-world problems in various fields like finance, business, or engineering

**Course Content**

Introduction to Time Series Analysis; Applications of time series analysis, Examples of time series data. Time Series Characteristics. Data Exploration and Visualization; Time series plot, Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF), To identify patterns in the data. Time Series Decomposition. Time Series Forecasting Models; Moving average models: Simple average, weighted average, exponential smoothing, ARIMA (Autoregressive Integrated Moving Average) models: A popular class of forecasting models for stationary time series, Other models: SARIMA (Seasonal ARIMA), SARIMAX (with explanatory variables), Prophet (Facebook's forecasting model). Model Evaluation and Selection; Metrics like Mean Squared Error (MSE) and Root Mean Squared Error (RMSE) to assess forecasting accuracy, Techniques for model selection and comparison. Spectral analysis: Analyzing time series data in the frequency domain, Deep learning for time series forecasting: A recent advancement using neural networks. Case Studies and Applications: Applying time series analysis to solve real-world problems in various fields using statistical softwares such as R, Python, SPSS, STATA etc.

**Instructional Methods**

Lectures, tutorials, blending learning (online-asynchronous learning, computer Assisted instruction) Project-based approaches, Group discussions & assignments, Cooperative learning, Case studies and experimental learning

**Instructional Materials and Equipment**

Computer laboratories, computers, learning resource center and core reading resources.

**Course Assessment**

CAT = 40%

Final exam = 60%

Total marks = 100%

**References**

Zhang, Z., Yao, H., Prasad, N. R., & Li, E. (2020). Time Series Analysis and Applications (pp. 283-302). Chapman and Hall/CRC.

Chatfield, C. (2020). Introduction to Time Series Analysis and Forecasting (4th Edition)

**Hyndman, R. J., & Athanasopoulos, G. (2018). Forecasting: principles and practice (3rd ed.). OTexts.**

Priestley, M. B. (1981). Spectral analysis and time series (Vol. 1). Academic Press.

Aue, A., Horváth, L., & Pham, T. M. (2019). Nonstationary Fractional Time Series Analysis with Endogenous Structural Breaks, <https://doi.org/10.1016/j.jeconom.2018.08.002>

**MATH 447: APPLIED MULTIVARIATE ANALYSIS (45/0 C.F.3.0)**

**Course Purpose**

The purpose of this course is to equip learners with the knowledge and skills to analyze data with multiple variables in management and decision making.

**Expected Learning Outcomes**

By the end of this course, the learner should be able to:

Explain the principles of multivariate analysis, including matrix algebra and multivariate probability distributions.

Apply techniques to summarize, visualize, and explore data with multiple variables.

Utilize techniques like discriminant analysis to classify data points and distinguish between groups.

Apply multiple regression models to analyze relationships between multiple dependent and independent variables

Develop the ability to apply multivariate techniques to solve practical problems in various fields where multivariate data is prevalent.

Gain proficiency in using statistical software packages to conduct multivariate analysis tasks effectively

**Course Content**

Foundational Concepts: Matrix Algebra, Multivariate normal Distributions. Data Exploration and Visualization: Measures of Central Tendency and Dispersion, Multivariate Regression Analysis. Multiple Regression. Multivariate Analysis of Variance (MANOVA). Dimensionality Reduction and Feature Selection, Principal Component Analysis (PCA), Discriminant Analysis. Case Studies and Applications to solve real-world problems across a field of choice. Statistical Software Applications for performing multivariate analysis tasks using R, Python, STATA, SPSS among others

**Instructional Methods**

Lectures, tutorials, blending learning (online-asynchronous learning, computer Assisted instruction) Project-based approaches, Group discussions & assignments, Cooperative learning, Case studies and experimental learning

**Instructional Materials and Equipment**

Computer laboratories, computers, learning resource center and core reading resources.

**Course Assessment**

CAT = 40%

Final exam = 60%

Total marks = 100%

**References**

Sella, G., & Berger, R. L. (2020). Statistical Inference (2nd Edition),Publisher: Cengage Learning

James, G., Witten, D., Hastie, T., & Tibshirani, R. (2021). An introduction to statistical learning with applications in R (Vol. 112, No. 1). Springer

Johnson, R. A., & Wichern, D. W. (2020). Applied multivariate statistical analysis (Vol. 71). Pearson Education Limited.

Montgomery, D. C., & Peck, E. A. (2021). Introduction to linear regression analysis (5th ed.). John Wiley & Sons.

Tabachnick, B. G., & Fidell, L. S. (2020). Using multivariate statistics (7th ed.). Pearson Education Limited

Liu, H., & Lin, Z. (2021). A score Test for Multivariate Normality with Known Covariance, Communications in Statistics - Simulation and Computation, 50(8), 2552-2564. <https://ieeexplore.ieee.org/document/1202728>

**MATH 451: NON-PARAMETRIC METHODS (45/0 C.F.3.0)**

**Course Purpose**

The purpose of this course is to develop and apply knowledge and skills learnt in non-parametric techniques and make valid conclusion in practical areas

**Expected Learning Outcomes**

By the end of this course, the learner should be able to:

Apply knowledge and skills of non-parametric inference in practical areas.

Demonstrate knowledge of how to test and workout confidence intervals for population quantities.

Distinguish and apply the knowledge of sign test and sign ranked tests in practical areas.

Demonstrate knowledge of linear rank tests involving 2 samples.

Apply knowledge of contingency tables in solving statistical problems.

**Course Content**

Non-parametric inference, Tests of goodness of fit, Tests based on runs, Tests and confidence interval for population quantities. The sign test and signed-rank test. General two-sample problem, Linear rank tests, Measure of association of bivariate samples. Analysis of contingency tables, Robust estimation. Practical problems.

**Instructional Methods**

Lectures, tutorials, blending learning (online-asynchronous learning, computer Assisted instruction) Project-based approaches, Group discussions & assignments, Cooperative learning, Case studies and experimental learning

**Instructional Materials and Equipment**

Computer laboratories, computers, learning resource center and core reading resources.

**Course Assessment**

CAT = 40%

Final exam = 60%

Total marks = 100%

**References**

Field, A., & Hole, G. (2023). Discovering statistics using R (2nd ed.). Sage Publications.

**Casella, G., & Berger, R. L. (2020). Statistical inference (3rd ed.). Cengage Learning.**

**Schick, R., & Muller, R. (2022). Nonparametric statistics: A practical guide for scientists and engineers (2nd ed.). Springer.**

Meyers, L. S., Gamst, G., & Guarino, A. J. (2020). Applied multivariate research: Design and analysis **(7th ed.).** Sage Publications.

Zhang, Z. (2019). **Introduction to applied nonparametric statistics** (2nd ed.). Chapman and Hall/CRC.

McDonald, J. H. (2019). **Handbook of parametric and nonparametric statistical procedures: Data analysis and interpretation** (6th ed.). Routledge.

**MATH 452: TESTING OF HYPOTHESIS (L/P 45/0; CF 3.0)**

**Course Purpose**

The purpose of this course is to enhance knowledge on hypothesis testing methods and enable learners apply this knowledge in research and analysis to make valid conclusions.

**Expected Learning Outcomes**

By the end of this course, the learner should be able to:

Explain and define the core principles of hypothesis testing, including null and alternative hypotheses, statistical significance, Type I and Type II errors, and the p-value.

Conduct hypothesis tests using statistical software or manual calculations, following the correct steps

Interpret the p-value and confidence intervals in the context of the hypothesis test, drawing statistically sound conclusions.

Apply knowledge of hypothesis testing to analyze data and address research questions that rely on data-driven decision making.

Develop proficiency in using statistical software packages to perform hypothesis testing procedures efficiently.

**Course Content**

Foundational concepts: Introduction to hypothesis testing, Review of common probability distributions (e.g., normal, binomial, chi-square) relevant to hypothesis testing. Common hypothesis tests: Z-tests, T-tests, Chi-square tests, Analysis of Variance (ANOVA), power analysis in hypothesis testing. Neyman Person Lemma, Properties of tests. Confidence sets and tests. Generalized likelihood ratio tests, Tests for correlation and regression. Sequential probability ratio test Applying hypothesis testing to real-world scenarios to analyze data and address research questions. Introduction to statistical software such as R, Python, SPSS, STATA, among others.

**Instructional Methods**

Lectures, tutorials, blending learning (online-asynchronous learning, computer Assisted instruction) Project-based approaches, Group discussions & assignments, Cooperative learning, Case studies and experimental learning

**Instructional Materials and Equipment**

Computer laboratories, computers, learning resource center and core reading resources.

**Course Assessment**

CAT = 40%

Final exam = 60%

Total marks = 100%

**References**

Montgomery, D. C., Peck, E. A., & Vining, G. G. (2021). Regression Analysis with Linear Models (10th Edition)

Casella, G., & Berger, R. L. (2020) Statistical Inference and Its Applications (2nd Edition)

Lehmann, E. L., & Romano, J. P. (2020). Testing Statistical Hypotheses (5th Edition)

McDonald, J. H. (2023). **Handbook of parametric and nonparametric testing procedures**. Routledge

Sullivan, L. M., & Gnandt, P. B. (2022). **Statistical methods for the social and behavioral sciences**. Academic Press.

Cai, T., & Ghosh, J. K. (2022) Revisiting the Neyman-Pearson Lemma for Composite Hypotheses. Academic Press.